TUIASI doctorat

INTERNATIONAL CONFERENCE OF THE DOCTORAL SCHOOL

"Gheorghe Asachi" Technical University of Iasi, Romania

9TH INTERNATIONAL CONFERENCE OF THE DOCTORAL SCHOOL

BOOK OF ABSTRACTS

MAY 13–15, 2026
IASI, ROMANIA

Excellence in Doctoral Studies through Innovation, Convergence and Interdisciplinarity

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Welcome to CSD2026, wishing you a successful conference!

9th International Conference of the Doctoral School

“Gheorghe Asachi” Technical University of Iasi

Excellence in Doctoral Studies through Innovation, Convergence and Interdisciplinarity

May 13, 2026 -European Doctoral Day- first edition

BOOK OF ABSTRACTS

May 13 – 15, 2026

IAŞI, ROMÂNIA

Organizers

- “Gheorghe Asachi” Technical University of Iasi, Romania
- Council for Doctoral University Studies, CSUD
- Council of Doctoral School, CSD

Partner:

- “Gheorghe Asachi” University Foundation, Iasi, Romania

Conference Sections

- **Section 1.** Interdisciplinary studies (**held onsite and includes papers from all doctoral fields**)

- **Section 2.** Computers and information technology; Systems engineering; Electrical engineering; Energy engineering; Electronic engineering, telecommunications and information technology (**held online**)

- **Section 3.** Chemistry; Chemical engineering; Environmental engineering (**held online**)

- **Section 4.** Civil engineering and installations (**held online**)

- **Section 5.** Mechanical engineering; Industrial engineering; Materials engineering; Engineering and management (**held online**)

Organizer’s Message

Dear PhD Students,

Dear Colleagues and Guests,

Dear Participants,

The 9th edition of the International Conference of the Doctoral School at the “Gheorghe Asachi” Technical University of Iasi (TUIASI) is dedicated to all PhD students from Technical Universities from Romania included in the Romanian Alliance of Universities of Science and Technology (ARUST), but not only. The goal is to share their research, to exchange ideas, and to make new connections. The conference is a great chance for PhD students to refine their research methods, encourage interdisciplinary teamwork, and keep growing. For three days, there will be panel sessions where PhD students can talk about and discuss their research papers. The schedule also includes plenary conferences held by prominent professors from universities closely associated with TUIASI through collaborations.

This event aims to bring together different presentations covering important issues in the TUIASI thirteen doctoral fields, such as *Chemistry, Computers and Information Technology, Chemical Engineering, Civil Engineering, Electrical Engineering, Electronic Engineering, Telecommunications, Information Technologies, Energetic Engineering, Industrial Engineering, Materials Engineering, Mechanical Engineering, Environmental Engineering, Systems Engineering, and Engineering and Management*.

By connecting these scientific fields, encouraging innovation through teamwork, and focusing on international collaboration, the conference acts as a meeting point for new ideas and advancements in science. This approach ensures that doctoral programs provide PhD students with the right skills and knowledge for jobs in social institutions, contributing to a sustainable economy. For PhD students in the earlier stages of doctoral studies, the conference provides an opportunity to train for their first contributions to a certain scientific field, while for the PhD students in later stages, the communications held during conference can be seen as a scientific step towards the jobs market. This connects with the university’s commitment to making courses more international, increasing mobility for students and staff, and promoting understanding between different cultures. It also ties in with the university’s role as a partner in the European “Ingenium” project, which involves ten European institutions of higher education working together to improve study programs using digital tools shared within the INGENIUM Alliance.

Together, let’s bridge scientific fields, foster innovation through collaboration, and embrace the spirit of internationalization. Join us in creating an academic intersection where new ideas flourish and progress takes center stage. We look forward to your active participation and the joint impact we can make at this conference.

***Please visit* the conference website at: https://conferinta-csd.tuiasi.ro/**

Welcome to CSD2026, wishing you a successful conference!

Honorary President,
Professor **Dan CAȘCAVAL**
Rector TUIASI

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General information

About our university

“Gheorghe Asachi” Technical University of Iasi is one of the most prestigious universities in Romania, being classified as an advanced research and education university (according to the Order of Ministry of Education and Research, MECTS nr. 5262/2011), whose mission is to carry out specific activities of creation, innovative capitalization of knowledge and its transfer to society in the fundamental fields of engineering sciences, architecture and urbanism, as well as in interdisciplinary and complementary fields, in the local community, at regional, national and international levels.

“Gheorghe Asachi” Technical University of Iasi has the oldest tradition in engineering education in Romania, initiated by Gheorghe Asachi, a representative of the Romanian Enlightenment, and established within the Greek Academy in Iasi (Royal Academy) on November 15, 1813, by the decree signed by Scarlat Calimachi, the ruler of Moldova at that time. This school can be considered the nucleus of higher technical education in Moldova, continuing education between 1834-1847 at the Mihăilean Academy and later at the University of Iasi in the School of Industrial Electricity (since 1910), the Electrotechnical Institute (1912) and the Department of Technological Chemistry (since 1911).

On November 7, 1912, the Faculty of Sciences of the University of Iasi was transformed into an independent department of higher education for teaching electrical engineering, applied chemistry and agricultural sciences. This event represents the “birth certificate” of what later became the Polytechnic Institute of Iasi (“Gheorghe Asachi” Technical University of Iasi today), respectively of the Faculty of Electrical Engineering, Energy and Applied Informatics and the Faculty of Chemical Engineering and Environment Protection.

A crucial moment in the history of our university is the Decision no. 205.660/ 03.12.1937 of the Ministry of National Education, when, the technical higher education is taken out from the aegis of the University of Iasi by the establishment of the „Gheorghe Asachi” Polytechnic School of Iaşi, as a distinct institution of engineering higher education, the only higher education institution authorized to grant from that date the title of engineer. The University began its activity on October 1, 1938, within three faculties: Industrial Chemistry, Electrical Engineering and Agricultural Sciences, of which the first two were based in Iasi and the third in Chisinau. The first diplomas were issued in 1940.

Through the education reform of 1948, the “Gheorghe Asachi” Polytechnic Institute was established in Iaşi, with four faculties and ten specializations: Industrial Chemistry (mineral chemistry, leather), Civil Engineering, Electrical Engineering, Mechanics (thermodynamic engineering, hydrotechnics, machine building, aero-naval engineering) with a duration of studies of five years. The Polytechnic Institute of Iaşi functioned until 1990 with 6 faculties and many newly created specializations. In 1990, four new faculties were established, coming from the faculties of Electrical Engineering and Mechanics.

In 1993 the name of “Polytechnic Institute of Iasi” was replaced by “Gheorghe Asachi” Technical University of Iasi (TUIASI). In 2004 the Architecture department within the Faculty of Constructions and Installations became the “G.M. Cantacuzino” Faculty of Architecture and since then 11 faculties operate within TUIASI.

Today, TUIASI develops programs for undergraduate, master, doctoral, postdoctoral studies and scientific research in interdisciplinary research areas, out of which 10 areas were classified in category A, according to Law 1/2011 and HG 789/2011. The doctoral activity is organized within an interdisciplinary doctoral school including 13 doctoral fields established according to national and international research priority areas.

Plenary conferences

REPRODUCIBLE COMPUTATIONAL SCIENCE

Christian Ghiaus

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Abstract:

Computational science uses advanced numerical and data science methods. Reproducibility, the ability to obtain the same results by using the same data and methods, is essential in computational science research to ensure the reliability and validity of the results. The benefits of reproducible research include enhanced scientific integrity, faster scientific advancements, and valuable educational resources. Despite its importance, reproducibility is often overlooked due to technical complexities, insufficient documentation, and cultural barriers such as the lack of incentives for sharing code and data. This presentation encourages the reproducibility of articles on computational science and proposes to recognize reproductible code and data, with persistent Digital Object Identifier (DOI), as peer-reviewed archival publications. Practical workflows for achieving reproducibility are presented for the use of MATLAB and Python.

Key words: Computational science, Reproducibility, Reproducible research, Data science, Scientific integrity

GAS HYDRATES CONFINED IN HIGH-SURFACE AREA MATERIALS: A NATURE-INSPIRED APPROACH FOR GAS STORAGE AND SEPARATION

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Abstract:

Clathrate hydrate are crystalline solids formed in nature when water and gas molecules are in contact under favorable pressure and temperature conditions. Natural clathrates hydrates contain methane preferentially as a guest molecule, although carbon dioxide hydrates have also been identified in nature. Overall, clathrate hydrates can be considered the main reservoir on Earth for gas storage. Despite their abundance in nature, their nucleation and growth are associated with very slow kinetics due to the limited gas-liquid interphase in bulk conditions.
Nucleation and growth kinetics can be accelerated through the incorporation of nanoporous materials in the synthesis media. Taking advantage of the confinement effects in the inner cavities, nanoporous materials can act as nanoreactors promoting the formation of the initial nucleation centres, and their subsequent growth. These confined hydrates exhibit a high storage capacity, fast formation kinetics, and a roughly complete water-to-hydrate conversion. Among the different nanoporous materials, activated carbon materials and metal-organic frameworks (MOFs) have shown a very promising performance acting as nanoreactors, provided that the porous structure and surface chemistry are properly designed (preferentially for methane). Unfortunately, gas hydrate formation is restricted to molecules above 0.33-0.36 nm (e.g., CO_2, CH_4, etc.) due to the necessity to stabilize the 3D network through intra-crystalline non-bonding interactions. However, recent studies in the literature have shown that hydrogen molecules can also be encapsulated in clathrate cages, although at much higher pressures (ca. 2 kbar). These hydrogen clathrates exhibit multiple cage occupation, thus giving rise to a stoichiometry of 64 $H_2 \cdot 136\ H_2O$, i.e. up to 5 wt.% hydrogen storage capacity. These severe formation conditions can be moderated through the incorporation of a properly designed carbon materials and MOFs (e.g., PCN-222). In the specific case of PCN-222, this material combines a proper porous structure (unidirectional mesoporous channels) and a proper surface chemistry (slightly hydrophobic in nature), needed to promote the nucleation and growth of these confined hydrogen clathrates. Under these conditions, the formation pressure has been decreased to 1.35 kbar, with very fast kinetics (within minutes), using pure water, and with a nearly 100% water-to-hydrate conversion. Contrary to carbon materials, pressures above 1.35 kbar become detrimental for the formation process in PCN-222, most probably due to the deterioration of the MOF structure at these high pressures. These studies constitute the first experimental evidence of hydrogen clathrate formation in carbon materials and MOFs at moderate pressure and temperature conditions, and opens the gate towards the design of novel porous materials with tailored structural properties to promote the nucleation and growth at milder pressure conditions.

Key words: Gas hydrates, Confinement effects, Hydrogen storage, Methane storage

E-TEXTILES – APPLICATIONS AND PERSPECTIVES

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Abstract:

E-textile systems and devices have recently been developed for various application fields, including medical and healthcare, safety and security, and defense. Their reliability and testing, as well as their ability to meet sustainability and circularity requirements, must be carefully studied and evaluated. This presentation focuses on recent defense applications involving e-textiles, with particular emphasis on:
Parachute testing: Specifically, the assessment of performance and aging through the use of embedded textile strain gauges integrated into the parachute canopy.
Active textile structures for camouflage: Addressing both military and civil challenges. In the military sector, the development of adaptive optical systems for camouflage and stealth has become a major priority to protect soldiers and assets on the battlefield. Among the technologies under development, electrochromic materials are particularly relevant in the visible spectrum. The security, economic, and societal stakes in conflict situations are significant. These active textile structures are based on electrochromic yarns capable of controlled color change. However, significant challenges remain regarding micro-connections, reliability, and robustness.
Vital signs monitoring: The monitoring of soldiers’ physiological parameters on the battlefield, integrated into advanced soldier systems. This includes positioning, ballistic system monitoring, energy management, and human–machine interfaces.
These e-textile applications involve advanced textile structures designed to ensure high robustness and reliability, withstand harsh operational conditions, and comply with REACH regulations and sustainability principles. The standard for e-textile quality and reliability, necessary to facilitate their presence on the market, is also presented.

Key words: E-textiles, Defense applications, Smart textiles, Electrochromic materials, Reliability and testing

CONTROL CONCEPTS FOR AUTONOMOUS OF OFFROAD VEHICLES

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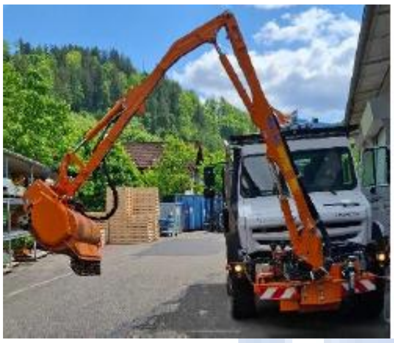
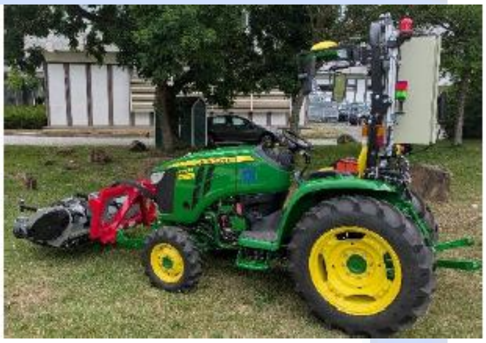
Abstract:





In the commercial vehicle sector, there are an increasing number of applications in which vehicles are to be automated with manipulators in order to achieve efficiency gains. For example, mowing work is to be automated using a manipulator installed on a truck in such a way that no operator is required, while at the same time taking highly complex environmental situations into account.
Controlling such off-road vehicles poses a major challenge. Due to highly complex but also very noisy sensor data, such as from lasers or cameras, the positions of objects in relation to the vehicle can only be recorded inaccurately. This sensor problem also affects localization, where highly accurate measurements must be fused with very noisy information. Since localization is central to map creation and navigation, the inaccuracies described above often lead to significant errors in the navigation of autonomous vehicles. As a result, the actual task cannot be performed adequately.
Using various robots from RRLabs, such as a Unimog, a tractor, or a rescue vehicle, we demonstrate in the presentation how a powerful control architecture can be designed. Examples are used to show how application-dependent, adequate controls can be implemented.

Key words: Autonomous vehicles, Off-road robotics, Sensor fusion, Localization, Control architecture

MANAGEMENT AND CONTROLLABILITY OF HOUSEHOLD APPLIANCES

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Abstract:

Electrification of the final uses is in rapid progress. In the residential sector, the progress of the technologies for data monitoring, control of the devices and communication with the users is increasing the opportunities of the users to make informed decisions on how to use or schedule their appliances. In this way, user engagement can be enhanced for providing services to the grid or to energy communities. On the technological side, major advances are expected to increase the controllability of household devices, with the possibility of sending commands directly from the users or through home energy management systems. However, there are not only technological aspects. The users are expected to play a key role in deciding how to manage and control their appliances. The user’s preferences must be included in the global reasoning on how to provide effective digital services. For this purpose, collecting the users’ opinion through dedicated surveys is a fundamental task. The elaboration of the responses of the users, linked to appliance monitoring, allows the characterisation of the individual and collective behaviour of residential users. The presentation will address the above indicated aspects, also with exemplificative results taken from the European project EU-DREAM currently in progress for promoting innovation of digital tools and providing enhanced digital services to the users. The first point considered is the partitioning of the residential demand into temperature-based with continuous operation, and controllable with limited operation in time and possible flexibility (deferrable, allowing shifting in time of the operation period, or curtailable, allowing changing the amplitude of the demand pattern in time). Then, it is presented how linking the measured power curves of the main household appliances with the results of a questionnaire on the starting time of the appliances can provide useful information on the aggregate demand pattern of individual types of household appliances, constructed with a Monte Carlo approach. Finally, it is discussed how the statistical characterisation of the demand curves from the main household appliances can provide useful hints on the formulation of demand response programmes that involve residential users.

Key words: Residential electrification, Demand response, Home energy management, User behavior, Smart appliances

FROM HARD COPY TO REMOTE SENSING: THE IMPORTANCE OF MAPS IN ENVIRONMENTAL APPLICATIONS

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Abstract:

Maps have always been integral to environmental management and decision-making. Traditionally, environmental studies relied on hard copy maps, field surveys, and manual data collection to understand ecological conditions and address challenges such as land degradation, pollution, floods, etc. However, the integration of remote sensing technologies has ushered in a new era of environmental monitoring. Satellite imagery, LiDAR, drones, and other remote sensing tools now provide real-time, high-resolution data that is transforming how environmental data is gathered, analyzed, and applied. These advanced mapping techniques offer unprecedented accuracy and the ability to monitor large-scale environmental changes, making them indispensable for tasks such as land restoration, biodiversity conservation, and climate change monitoring. This paper examines the shift from traditional to remote sensing-based mapping, exploring how these innovations improve our ability to assess and respond to environmental issues. Through case studies and practical examples, it highlights the transformative potential of remote sensing in enhancing environmental decision-making, improving sustainability, and supporting the restoration of degraded landscapes.

Key words: Remote sensing, Environmental monitoring, GIS mapping, Satellite imagery, Sustainability

SECTION 1.
Interdisciplinary studies

BENDING TESTING OF RODS MADE FROM RECYCLED POLYMERIC MATERIAL

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Abstract:

In the manufacturing industry, there are several types of permanent joints, including welded joints, riveted joints, shrink-fit joints, and adhesive joints. Adhesive bonding is a process used to create non-detachable joints. This type of joint is widely used, particularly for joining parts made of polymer materials, though this method can also be applied to other materials. Additionally, adhesive bonding is considered faster, more practical, and capable of distributing loads evenly across the entire joint surface. Furthermore, adhesive bonding does not damage or at least minimizes damage to the parts in the joined area. In the industrial world, there are many situations where plastic parts are recovered and reused after they have fulfilled their intended functional roles. One example of parts that can be recovered for reuse is tape made from durable material used to secure various products. Given the high durability of the tape, it is possible to reuse it for various purposes, including making small rigid rods. These rods are created by bonding segments of the recovered tape. Thus, they aligns with the circular economy movement, which is one of the key points of the SDGs (Sustainable Development Goals), specifically SDG 12. In this study, the rods were tested using a bending method on a universal tensile testing equipment. After all tests were completed, the test results were collected and processed using computer software to generate data that serves as a basis for additional information regarding their potential use in components requiring bending in certain future situations. The study aims also to analyse strength properties such as shear strength and tensile strength. This testing method follows the ASTM standard testing method with several modifications in accordance with the intended objectives. It is hoped that this study can contribute to sustainable alternatives in engineering applications that support environmental conservation and the reuse of industrial waste materials, as well as efforts to reduce industrial waste, particularly plastic-based waste.

Key words: Tapes for Packaging, Recovery, Bonding, Rigid Rods, Bending Testing.

SPECTRAL ANALYSIS OF METHYLENE BLUE SOLUTIONS TREATED WITH A GLIDING ARC PLASMA REACTOR

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Abstract:

Water-soluble dyes and organic compounds used in industries such as textiles, dyeing, paper production, and dye manufacturing have become a major environmental concern due to the massive volumes of contaminated wastewater discharged into rivers and natural water systems. When organic compounds and dyes are discharged into water bodies without adequate treatment, they can adversely affect the environment and human health by increasing the oxygen demand on aquatic ecosystems, inhibiting photosynthesis, and elevating the risk of mutagenic and carcinogenic effects in both humans and aquatic organisms.

Methylene blue (MB) is one of the most widely used dyes in the textile industry for fabric coloration, and its presence in water can lead to the formation of aromatic amines, such as benzidine and methylene derivatives, which possess carcinogenic potential. Non-thermal plasma (NTP) technology is an innovative and environmentally friendly approach for wastewater treatment, enabling the removal of dyes through advanced oxidation processes (AOPs) driven by the generation of hydroxyl radicals (•OH) and other reactive oxygen and nitrogen species (RONS) formed during plasma-induced molecular recombination.

This study investigates the spectral modifications of MB solutions following treatment in an NTP reactor. The NTP gas–liquid plasma discharge reactor generates hydrogen peroxide (H2O2) by converting water molecules (H2O and O2) through plasma induced reactions. The technology uses the high surface area of a liquid water film and water aerosol droplets in contact with the gas-phase plasma to produce •OH radicals, which subsequently recombine into H2O2. Argon (Ar) was used as the carrier gas in the experiments to minimize the formation of reactive nitrogen species (RNS) and to maximize AOPs driven by •OH radicals and H2O2. The influence of ROS on MB solutions was investigated under predefined reactor operating conditions. The initial MB solutions were prepared in distilled water at concentrations between 1 and 5 mg/L. A volume of 10 mL from each solution was subjected to plasma treatment. The solution flow rate varied between 0.1L/h and 0.3L/h in increments of 0.1L/h. The discharge frequency was fixed at 100Hz with a pulse width of 3ms, while the gas flow rate was maintained at 2L/min. The concentrations ROS in distilled water were determined as reference, UV–Vis spectra of the plasma-treated solutions were recorded, and the average discharge power was calculated.

The results indicate that non-thermal plasma treatment of MB solutions induces significant modifications in the UV–Vis absorption spectra.

Key words: Non-thermal plasma, organic compounds, water treatment, divergent electrodes, absorption spectra, methylene blue

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FROM COIN DEBASEMENT TO CRYPTO: THE EVOLUTION OF INFLATIONARY FORCES

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Abstract:

The study situates the concept of inflation within a broad historical and analytical context, challenging the conventional view that inflation is exclusively a modern macroeconomic phenomenon. While contemporary economics defines inflation as a sustained increase in the general price level, this paper demonstrates that inflationary dynamics—understood as processes leading to the erosion of purchasing power—have existed across diverse monetary and non-monetary systems long before the term itself emerged in the nineteenth century. The primary objective of the research is to provide a comparative and historically grounded classification of inflationary mechanisms, bridging pre-modern, early modern, and modern economic environments. The methodology combines historical-comparative analysis with interdisciplinary evidence drawn from economic history, numismatics, and macroeconomic theory. A wide range of case studies is examined, including commodity money systems (e.g., metal coinage, grain, livestock), fiat and paper currency regimes, and modern financial and cryptocurrency systems. These cases are systematically analyzed according to underlying drivers of price instability, including monetary expansion, supply shocks, fiscal pressures, financialization, and expectation dynamics. The study applies modern inflation typologies—such as cost-push, monetary, fiscal–military, and asset-price inflation—to both pre-conceptual and post-conceptual periods to enable structured comparison. The results indicate a strong continuity in the fundamental mechanisms driving inflationary outcomes across time. Both monetary disturbances (e.g., debasement, overissuance) and non-monetary shocks (e.g., wars, pandemics, climatic events) repeatedly produced sustained price increases. Additionally, the analysis identifies historically persistent forms of asset-driven and structurally induced inflation, particularly in urban and financially developed contexts. A key finding is that the defining feature of modern inflation is not the emergence of new mechanisms, but the increasing simultaneity and interaction of multiple inflationary forces within highly interconnected economies. The study concludes that inflation is best understood as a context-dependent and multi-dimensional phenomenon rather than a fixed analytical construct. It argues for a more flexible framework of inflation measurement, incorporating domain-specific and shock-sensitive indices. Such an approach allows for a more accurate and welfare-relevant assessment of inflationary pressures, particularly in periods of systemic disruption.

Key words: Inflation, monetary systems, price dynamics, economic history, supply shocks, asset-price inflation.

EXPERIMENTAL INVESTIGATION OF THE INFLUENCE OF ADDING SURFACTANTS ON THE PROPERTIES OF WATER-BASED TITANIUM OXIDE NANOFLUID

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Abstract:

This experimental study investigates the influence of surfactant addition on the stability and thermophysical properties of a water-based titanium dioxide (TiO_2) nanofluid with a fixed nanoparticle concentration of 2 wt%. The main objective is to evaluate how different types and concentrations of surfactants affect key properties such as thermal conductivity, viscosity, and density, as well as the overall stability of the nanofluid. To address existing gaps in the literature regarding the specific role of surfactants in TiO_2 nanofluids, a comprehensive experimental analysis was conducted on 14 samples containing various ionic, nonionic, and polymeric surfactants. The nanofluids were prepared using a multi-step dispersion method, including mechanical stirring, ultrasonication, and magnetic mixing, ensuring uniformity and reproducibility. Stability was monitored over a period exceeding 10 weeks using both visual observation and dynamic light scattering (DLS), focusing on the polydispersity index (PDI). The results indicate that surfactants successfully enhance the stability of TiO_2-water nanofluids by preventing nanoparticle agglomeration. Thermal conductivity showed a modest increase of approximately 1–2% compared to the base fluid, with minimal influence from surfactant addition at low concentrations. However, higher surfactant concentrations led to a decrease in thermal conductivity of up to 5%, likely due to micelle formation. In terms of viscosity, the addition of TiO_2 nanoparticles increased the base fluid viscosity by about 15%. While certain surfactants such as Tween 80 and Pluronic F127 exhibited only minor effects at low concentrations, others like CMCNa and the custom copolymer J12 significantly increased viscosity at higher concentrations, potentially hindering fluid flow. Density variations were relatively minor, with a slight increase observed upon nanoparticle addition and negligible influence from surfactants. Overall, the findings highlight that while surfactants improve nanofluid stability, their concentration must be carefully optimized to balance thermal performance and flow behavior. This study provides valuable insights into the design of stable and efficient nanofluids for heat transfer applications and emphasizes the importance of selecting appropriate surfactants for specific engineering requirements.

Key words: nanoparticles, surfactant, density, viscosity, thermal conductivity.

COMPARATIVE ANALYSIS OF DEEP LEARNING ARCHITECTURES FOR DEMAND FORECASTING WITHIN A DECENTRALIZED ECONOMIC MPC STRATEGY

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Abstract:

The application of machine learning for time-series regression has remained highly relevant for optimizing large-scale infrastructure, specifically the Barcelona Drinking Water Network (DWN). Utilizing historical sensor data, deep learning algorithms generate system state predictions to improve resource management and reduce operational costs. Historically, forecasting relied on statistical models like ARIMA, Double-Seasonal Holt-Winters or Artificial Neural Networks, primarily Long Short-Term Memory (LSTM) networks. Recent advancements introduced Gated Recurrent Units (GRUs) with a more efficient structure, and the Temporal Fusion Transformer (TFT), which combines attention mechanisms and recurrent layers for multi-horizon forecasting.
This paper evaluates the performance trade-offs, specifically accuracy versus computational latency, of the deep learning architectures integrated within a Decentralized Economic Model Predictive Control (MPC) loop. The methodology trains each network on historical data to operate in parallel with the MPC algorithm for real-time predictions. Performance is quantified using Symmetric Mean Absolute Percentage Error (SMAPE), Root Mean Square Error (RMSE), and computational analysis.
Literature indicates TFT achieves the highest prediction accuracy, demonstrating a 15-20% lower RMSE compared to LSTM, though it necessitates greater computational resources and exhibits a 10-20 times slower inference speed. Conversely, GRU provides an optimal balance, outperforming LSTM in training efficiency (30-40% faster) while maintaining comparable accuracy.
In discussion, the integration of deep learning estimators enhances the predictive capabilities of the Decentralized Economic MPC within the DWN. Because the DWN utilizes a standard 1-hour sampling interval, the real-time inference latency associated with the TFT is neutralized. Consequently, the architectural selection depends strictly on hardware constraints. Analysis concludes that the TFT provides maximum theoretical accuracy for multi-horizon forecasting when deployed with sufficient computational and data resources. Conversely, the GRU is the optimal architecture for deployment on resource-constrained edge devices within the decentralized framework. The GRU provides an effective compromise between local memory limitations, model retraining efficiency, and forecasting precision.

Key words: Drinking Water Network (DWN), Model Predictive Control (MPC), Long Short-Term Memory (LSTM), Gated Recurrent Unit (GRU), Temporal Fusion Transformer (TFT).

INFLUENCE OF VINEYARD ORGANIC BY-PRODUCT FERTILIZATION ON THE PHYSICO-CHEMICAL COMPOSITION AND SENSORY PROFILE OF RKATSITELI WINE

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Abstract:

The sustainable management of vitivinicultural by-products has emerged as a key priority in contemporary vineyard systems, particularly in regions characterized by intensive wine production. The valorization of winery residues through their transformation into organic fertilizers represents an environmentally sound strategy aimed at closing nutrient cycles, enhancing soil fertility, and mitigating environmental impacts. The present study investigates the effect of vineyard organic fertilization on the physicochemical composition and sensory profile of Rkatsiteli wine.

The experiment was carried out in a Rkatsiteli vineyard under controlled agronomic conditions. Two organic fertilization treatments were applied: grape pomace compost and a mixed compost derived from grape pomace and grape seeds. An unfertilized plot served as the control. All treatments were implemented under identical vineyard management practices to ensure experimental consistency. Grapes were harvested at technological maturity and vinified according to a standardized protocol in order to minimize the influence of winemaking variables. Alcoholic fermentation was conducted under controlled conditions, and all wines followed identical technological procedures. Following fermentation and stabilization, wines were subjected to physicochemical analysis, including determination of alcohol content, total acidity, volatile acidity, residual sugars, and pH. Sensory evaluation was performed by a trained panel of ten assessors using descriptive analysis, with particular emphasis on aroma intensity, freshness, balance, mouthfeel, and overall quality perception.

The results demonstrated that fertilization with vitivinicultural by-products induced measurable modifications in both physicochemical parameters and sensory attributes of the resulting wines. Experimental samples exhibited differences in acidity balance and aromatic expression relative to the unfertilized control. Sensory profiling revealed distinguishable characteristics among treatments, particularly regarding freshness, structural balance, and overall harmony. These findings suggest that organic fertilization strategies may influence grape biochemical composition, ultimately affecting wine expression.

Although the observed differences were moderate, the study provides evidence that winery-derived organic fertilizers can impact final wine characteristics under the given experimental conditions. The results should be interpreted as preliminary and variety-specific. Further investigations across multiple vintages, vineyard sites, and expanded analytical frameworks are necessary to validate the long-term effects of vitivinicultural by-product fertilization on wine quality and typicity.

Key words: Sustainable wine production, winery by-products, organic fertilizers, grape pomace compost.

CURRENT TRENDS IN THE DEVELOPMENT OF COLD SURFACE PLASTIC HARDENING TOOLS

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Abstract:

Cold surface plastic hardening represents a technology for enhancing the performance of metallic components with high quality requirements, ensuring superior resistance to wear, fatigue, corrosion and geometrical and dimensional tolerances. An important role in the efficiency and predictability of this process is played by specialized hardening tooling, which must be carrefoully designed for a wide range of industrial applications, including internal, external, flat surfaces or complex geometries. The complexity of these tools results from the requirements to ensure high dimensional precision, a controlled uniformity of the hardened superficial layer, and a robust adaptability to diverse component geometries and material hardness levels.

This paper provides an analytical overview of constructive solutions for hardening tools, directly correlated with the actual requirements of modern technological standards. The research focuses on the structural evolution of these instruments, highlighting current optimization trends, such as the transition from previous complex constructions to new simple and compact tools. The methodology employed in this study involves a comparative analysis of tooling architectures found in both solution suppliers and industrial patents.

Furthermore, the work proposes a comprehensive synthesis of the current status in hardening tooling by utilizing a specialized idea diagram (conceptual mapping). This visual and structural tool is designed to facilitate the systematic organization of various engineering solutions, allowing for a clearer evaluation of their functional advantages and limitations. By categorizing tools based on their contact geometry, loading mechanism, and degree of automation, the study provides a valuable decision-making framework for engineers.

The structural analysis of the hardening tools is systematically conducted based on the specific type of surface they are engineered to process. In this regard, the tooling is categorized into distinct groups, for internal and external cylindrical surfaces, flat planes, threaded profiles, and complex geometries that require specialized kinematics. Furthermore, the study examines multi-surface tools designed for higher universality, capable of processing not only one type of surface. This classification highlights how tool architecture must adapt to the application and accessibility constraints of each surface type, ensuring an increase of mechanical properties across various workpiece topographies.

Key words: Cold hardening solutions, concept mapping, advanced tooling designs.

AN EXPERIMENTAL EVALUATION OF THE OPERATIONAL CAPABILITIES OF A DIAMOND-TIPPED COLD SURFACE HARDENING TOOL

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Abstract:

Cold surface plastic hardening is a finishing technology designed to improve mechanical properties of metallic components without removing material. This process is remarkable for its ability to achieve surface integrity by using a very hard active element to compress and smooth the microscopic asperities of a machined surface. By inducing controlled residual compressive stress and increasing local surface hardness, this technology improves a component's durability, surface quality and tolerances. Among the various methods available, slide diamond burnishing (SDB) is highlighted by the properties of the diamond insert, such as its extreme hardness, low coefficient of friction, and high thermal conductivity, which allow for superior finishing results even on difficult-to-process materials.

The current paper provides a technical study focused on the efficiency and versatility of this technology. The primary objective is to investigate the performance of a diamond-tipped tool when processing an external cylindrical surface, using a minimum quantity lubrication (MQL) strategy for reducing the friction between the tool and the part and better results. The experimental methodology involves a systematic testing process where several key operational parameters are varied: spindle speed (RPM), feed rate, and working depth. By adjusting these variables, the research identifies an initial range of working parameters for the diamond-tipped instrument.

A critical component of this evaluation is the comparative analysis between the surface quality obtained through conventional turning and the quality achieved after the diamond burnishing process. The transition from a turned surface to a plastically deformed and smoothed profile is documented through precise measurements of the main roughness parameters, Ra and Rz. The results highlight the tool's superior capabilities in achieving mirror-like finishes, demonstrating a significant decrease in roughness values. This research proves that diamond burnishing is a robust solution for enhancing the functional quality of diverse external cylindrical parts, potentially serving as a more sustainable manufacturing alternative for the grinding or polishing operations.

Key words: Slide diamond burnishing, surface quality, rougness improvement.

AI ETHICS MATURITY AS AN INNOVATION CAPABILITY IN UNIVERSITY TECHNOLOGY TRANSFER: A TRL/ERL-Based Conceptual Framework

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Abstract:

The rapid diffusion of artificial intelligence (AI) into products and services emerging from universities heightens the need for responsible technology transfer, yet current research offers little guidance on how Technology Transfer Offices (TTOs) and innovation intermediaries can systematically align technology readiness with ethical readiness across transfer stages. Existing responsible AI or AI ethics maturity models are largely corporate-oriented, emphasise deployment-time governance, and seldom consider university–industry collaboration or the role of European Digital Innovation Hubs (EDIHs) in early-stage AI innovation. This paper positions AI ethics maturity as an innovation capability within university technology transfer and proposes a Technology Readiness Level/Ethical Readiness Level (TRL/ERL)-adapted structure for an “AI Ethics Maturity Framework for Technology Transfer” (AIEMF-TT).
Adopting an innovation-management lens, the study reviews four bodies of literature—responsible (research and) innovation and its transfer, technology transfer and TTO governance, responsible and trustworthy AI maturity/readiness models, and Living Lab or sandbox-based AI experimentation under emerging regulatory regimes such as the EU AI Act—to derive requirements for coupling TRL-based transfer gates with ERL-based ethical checkpoints. The review reveals three persistent gaps: the marginal treatment of TTOs and EDIHs as AI ethics governance actors, the lack of maturity models that explicitly integrate TRL and ERL in technology transfer decision points, and the absence of proportionate, minimum-viable governance artefacts suitable for SMEs and academic spin-offs.
Building on these insights, the paper conceptualises AIEMF-TT as a TRL/ERL-oriented model that embeds AI ethics as a measurable capability into university technology-transfer routines, mapping ethical readiness criteria and lightweight governance artefacts to key stages of disclosure, evaluation, licensing, and experimentation. Designed as a pre-validated conceptual artefact, the framework provides a reusable schema for structuring, assessing, and incrementally advancing AI ethics maturity in university technology transfer, to be operationalised and empirically refined in future Design Science Research and longitudinal EDIH-based and Living Lab studies.

Key words: AI ethics maturity; responsible innovation; technology transfer; Technology Transfer Office; European Digital Innovation Hub; Living Lab.

EXPERIMENTAL RESULTS ON ELECTRICAL CONDUCTIVITY AND PH OF SEVERAL NANOCOLLOIDS WITH POLY-ETHYLENE GLYCOL AS A BASE FLUID

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Abstract:

The present study summarizes the results of an experimental investigation on electrical conductivity and pH of several nanocolloids with poly-ethylene glycol as base fluid. The nanoparticle enhanced fluids are a novel type of materials with various potential uses in thermal applications such as heat exchangers, solar cells and cooling systems. The increased interest for nanofluids derive from their improved properties, chemical stability, low toxicity and long term stability upon multiple heating and cooling cycles. Low mass Poly-ethylene glycols are substances with molecular mass betweem 200 – 600 g/mol, with low viscosity and are widely used in pharmaceutical industry, bioengineering, cosmetics, food and chemical engineering. It is known that the addition of nanoparticles in a base fluid can improve the termophisical properties of the fluid by enhancing the thermal conductivity, improving the heat transfer coefficient and not ultimately increasing the electrical conductivity, a critical property which couples strongly with thermal, mechanical and functional behaviour of the fluid. Generally, a higher electrical conductivity can correlate with better heat transport pathways. In terms of pH, few studies were found in open literature that show a direct correlation between zeta potential (a parameter indicating the stability of a suspension) and pH. The present work presents the electrical conductivity and pH results of several samples manufactured by dispersing Copper (Cu), Silver (Ag), Alumina (Al2O3), Multi-walled Carbon Nanotubes (MWCNT), and Magnesium Oxide (MgO) nanoparticles in two mixtures between PEG 400 and PEG 200 as base fluids.

Key words: Nanocolloids, nanofluids, nanoparticles, thermal conductivity, electrical conductivity, PEG.

MECHANICAL AND TRIBOLOGICAL PERFORMANCE OF HYBRID METAL–COMPOSITE MATERIALS

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Abstract:

Hybrid metal–composite materials have emerged as a promising solution for modern engineering applications that require an optimal balance between mechanical strength, reduced weight, and long-term durability. By combining the high specific strength and stiffness of polymer-based composites with the toughness, ductility, and thermal conductivity of metals, these hybrid systems offer enhanced performance compared to their individual components. This unique combination allows engineers to design structures that are both lightweight and resistant to complex loading conditions, making them particularly attractive for high-performance industries. The present study examines the structural and mechanical characteristics of metal–composite hybrid systems, with a focus on how different design parameters influence their overall behavior. Key factors such as material selection, interface bonding quality, and stacking sequence play a crucial role in determining the efficiency and reliability of these materials. A strong interface between layers ensures effective load transfer, while an optimized stacking configuration can significantly enhance mechanical response under various stress conditions. Particular attention is given to the synergistic improvements observed in wear resistance, impact tolerance, and fatigue performance. These properties are essential in applications where components are subjected to repetitive loads, harsh environments, or sudden impacts. The integration of metallic and composite layers helps mitigate common weaknesses found in traditional materials, such as brittleness in composites or excessive weight in metals. The findings highlight that a carefully engineered hybrid structure can significantly improve both the performance and lifespan of components used in aerospace, automotive, and general mechanical engineering fields. Furthermore, this study emphasizes the importance of balancing performance with cost-effectiveness and manufacturability. By optimizing material combinations and production techniques, hybrid metal–composite systems can be tailored to meet specific functional requirements while remaining economically viable for large-scale industrial use.

Key words: Hybrid materials, Metal–composite, Mechanical performance, Wear resistance, Structural optimization.

CROSS-DATASET GENERALIZATION OF WEARABLE SENSOR-BASED PARKINSON’S DISEASE DETECTION USING INTERPRETABLE MACHINE LEARNING

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Abstract:

Wearable inertial sensors have enabled the development of machine learning approaches for Parkinson’s Disease (PD) detection based on objective analysis of motor symptoms such as tremor and movement variability. While numerous studies report promising classification performance, most models are evaluated on a single dataset, limiting their ability to generalize across different sensor configurations, acquisition protocols, and patient populations. This limitation is particularly relevant given the heterogeneity of wearable data and the need for reliable models that can operate across diverse real-world conditions. Previous research has demonstrated the feasibility of classifying PD using accelerometer derived statistical and frequency-domain features combined with machine learning models such as Gradient Boosting Machines . However, these approaches are typically validated within a single dataset, which may lead to overestimated performance and reduced robustness when applied to new data sources. This study addresses this limitation by investigating the cross-dataset generalization of PD detection models using multiple publicly available wearable and smartphone-based datasets. A unified feature extraction pipeline is applied across datasets, focusing on statistical and spectral descriptors that capture tremor characteristics and movement variability. Machine learning models, including ensemble-based approaches such as LightGBM and Random Forest, are evaluated under cross-dataset conditions, where models trained on one dataset are tested on others. The analysis emphasizes the impact of domain shift on classification performance and examines how differences in sensor placement, acquisition protocols, and data quality affect model transferability. The results highlight the challenges of achieving robust cross-dataset performance, with noticeable degradation observed when models are transferred between datasets. Nevertheless, a subset of features—particularly those related to tremor frequency and signal variability—demonstrates consistent predictive value across datasets. These findings support the existence of transferable digital biomarkers for PD detection and underline the importance of cross-dataset validation in developing reliable, clinically applicable wearable sensor-based diagnostic systems.

Key words: Parkinson’s Disease, wearable sensors, accelerometer data, cross-dataset generalization, machine learning, tremor analysis, feature extraction.

ARCHITECTURAL TRADE-OFFS IN MODERN VULNERABILITY MANAGEMENT SYSTEMS UNDER DORA AND NIS2

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Abstract:

The introduction of the EU's Digital Operational Resilience Act (DORA) and the NIS2 Directive has significantly expanded expectations toward vulnerability management (VM) systems. Beyond identifying and remediating technical weaknesses, organizations are now required to demonstrate auditable, traceable, and risk-based control over their ICT environments. As a result, the underlying architecture of VM platforms becomes a critical factor in achieving regulatory compliance. This paper examines the architectural implications of modern VM systems, with a particular focus on event sourcing and data retention strategies. Event sourcing, which models system state as a sequence of immutable events, enhances traceability and enables full reconstruction of historical states, thereby strengthening auditability and forensic capabilities. However, this approach introduces structural tensions with regulatory requirements such as data minimization, retention limits, and the right to erasure. Similarly, extended data retention improves evidentiary quality but increases legal and operational risks related to excessive data persistence. The study frames these tensions as a multi-objective problem involving three competing dimensions: auditability, regulatory compliance, and operational efficiency. It argues that architectural choices (such as event-based persistence models, encryption at rest, and key management strategies) directly influence the position of a system within this trade-off space. In particular, the paper highlights a fundamental paradox: design decisions that maximize traceability and evidentiary strength may simultaneously constrain selective data deletion and complicate compliance with regulatory requirements. Building on this analysis, the paper proposes a conceptual framework for evaluating VM architectures under DORA and NIS2, emphasizing the need for transparent prioritization, controlled data lifecycle management, and auditable decision-making processes. The findings suggest that effective vulnerability management cannot be reduced to scanning capabilities alone, but must be understood as a function of deeper architectural and governance design choices. This work contributes to the intersection of cybersecurity engineering, regulatory compliance, and systems theory by providing a structured perspective on how architectural design shapes risk management outcomes in regulated digital environments.

Key words: Vulnerability Management; Event Sourcing; Auditability; Data Retention; Multi-Objective Optimization; DORA.

THERMAL PERFORMANCE EVALUATION OF LIQUID COOLED AUTOMOTIVE ELECTRONIC CONTROL UNITS WITH DIFFERENT INTERNAL COOLING GEOMETRIES

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Abstract:

The continuous increase in integration density and power dissipation of automotive Electronic Control Units (ECUs) has made thermal management a critical design challenge, directly influencing reliability and performance stability. In modern automotive applications, ECUs are required to operate under difficult environmental conditions while maintaining functionality, which significantly limits passive heat dissipation capabilities and motivates the evaluation of advanced cooling solutions, for example liquid cooling, presented in this paper. The thermal performance is strongly influenced by the effectiveness of the integrated liquid cooling design. In addition to coolant flow conditions, the internal geometry of the cooling structure plays a significant role in heat transfer enhancement by affecting surface area, flow distribution, and local convection. This work presents a comparative experimental evaluation of different internal cooling geometries designed for liquid-cooled automotive ECU housings, with the objective of identifying their influence on overall thermal performance. An experimental cooling setup was developed, consisting of testing samples 3D metalic printed with a closed-loop liquid cooling system equipped with a water pump and temperature sensors. Five internal configurations were investigated: straight ribs, diamond-shaped ribs, wavy ribs, circular ribs, and a smooth channel configuration without ribs. All geometries were tested under identical operating conditions, including controlled heat generation, constant coolant flow rate, and repeatable boundary conditions. Temperature measurements were collected at key locations on the heat-generating component. The experimental results reveal distinct differences in cooling effectiveness among the investigated geometries, highlighting the strong impact of internal rib design on heat transfer performance. Ribbed configurations generally provide improved thermal performance compared to the smooth channel case, with variations observed depending on rib shape and flow interaction. The comparative analysis enables direct identification of the most effective internal cooling geometry under the tested conditions. The findings of this study provide practical insight for the thermal design of liquid-cooled automotive ECUs and support informed decision-making during early cooling design stages, where thermal performance, geometric complexity, and manufacturability must be carefully balanced.

Key words: Thermal management, cooling solutions, liquid cooling, internal cooling geometry, heat transfer enhancement.

ANALYSIS OF FACTORS AFFECTING THE GENERATION OF 3D MODELS THROUGH GENERATIVE DESIGN AND AI ALGORITHMS

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Abstract:

The paper aims to analyze the cause-effect of the factors that influence the process of generating and evaluating 3D models through generative design, in the context of using optimization algorithms and artificial intelligence-assisted tools. The study starts from the premise that the final result of a generated 3D model is not determined exclusively by the performance of the algorithm used, but by the complex interaction between a set of factors that act in different stages of the workflow. To highlight these relationships, the Ishikawa-type cause-effect diagram was used, adapted to the particularities of the modeling and analysis process specific to the generation of shapes through generative design. In the paper, the analysis is structured on several functional categories of factors, defined in relation to the real stages of the studied process. Thus, the influences associated with the configuration of the generation process, the input data of the geometric model, the artificial intelligence and optimization algorithms, the simulation and evaluation conditions, the problem definition parameters, the digital environment and the software used, as well as the stages of interpretation and selection of the results are investigated. For each category, the main components are highlighted and how they can affect the final geometric configuration, the material distribution, the structural performance and the relevance of the generated solutions. The analysis carried out highlights the fact that the 3D model generation process has a systemic character, in which each component directly or indirectly influences the final result. Also, a high sensitivity of the process to variations in the input parameters, simulation conditions and evaluation criteria is found, which can lead to significant differences between the solutions obtained. In this context, the paper emphasizes the need for an integrated approach in the definition, analysis and validation of the generated models. The main contribution consists in establishing a theoretical model for understanding the generative process and in identifying the critical points that influence the quality, consistency and applicability of the obtained 3D models.

Key words: 3D model generation, generative design, optimization algorithms, geometric modeling, Ishikawa diagram, cause–effect analysis.

SECTION 2.

Computers and information technology; Systems engineering; Electrical engineering; Energy engineering; Electronic engineering, telecommunications and information technology

IDENTIFYING ENERGY POVERTY ZONES BASED ON EXPLAINABLE CLUSTERING

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Abstract:

Rapid advances in Artificial Intelligence (AI) have opened new avenues for analysing complex socio-economic challenges, such as energy poverty. While these tools are increasingly used in decision-making, their lack of transparency can undermine decision-makers' trust and understanding of the outcomes. In this context, integrating Explainable Artificial Intelligence (XAI) with unsupervised learning methods offers a promising strategy for identifying hidden patterns while keeping models understandable.

In the paper, the authors proposed a data-driven framework that uses clustering techniques to identify and analyse zones affected by energy poverty. The methodology employs various distance metrics, such as Euclidean and city-block distances, to better understand the dataset's structure. Additionally, it uses multiple cluster validation indices, including Silhouette, Calinski-Harabasz, Davies-Bouldin, and Gap Statistic, to assess the quality and stability of the output partitions. This multi-criteria strategy ensures a thorough analysis and minimizes reliance on any single evaluation method.

The proposed framework is applied to a database containing key socio-technical indicators. Its goal is to cluster regions with similar traits and to reveal differences in energy access, consumption habits, and infrastructure. By evaluating clustering results using various distance measures and validation methods, the study provides thorough insight into the data's underlying structure. Furthermore, explainability techniques are used to analyze the clustering outcomes and identify the key factors driving each cluster's formation. The approach helps clarify the characteristics that define energy poverty regions. The findings show that the proposed framework successfully differentiates regions by vulnerability level and identifies critical zones requiring intervention. Overall, the study emphasizes the value of integrating clustering algorithms, multiple assessment metrics, and explainability tools to enable informed decision-making. The framework can support policymakers and stakeholders in developing targeted strategies to reduce energy poverty and enhance energy access.

Key words: Energy Poverty, Clustering Analysis, Explainable Artificial Intelligence, Distance Metrics, Unsupervised Learning, Regional Analysis

THE EVOLUTION OF ZERO TRUST: ARCHITECTURAL PRINCIPLES AND PRACTICAL IMPLICATIONS

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Abstract:

The increasing decentralization of IT infrastructures, driven by cloud computing, remote work, and highly interconnected systems, has fundamentally challenged traditional perimeter-based security models. In response to these shifts, the Zero Trust concept has emerged as a prominent architectural paradigm that rejects implicit trust and promotes continuous verification of users, devices, and applications.

This paper examines the evolution of Zero Trust from its early conceptual origins to its current role as a guiding framework for modern security architectures. It explores the core architectural principles underpinning Zero Trust, including identity-centric access control, least privilege enforcement, continuous authentication and authorization, and the assumption of breach as a baseline security condition. Rather than framing Zero Trust as a singular technology or product, the analysis positions it as an overarching security philosophy that redefines how trust is established and maintained within distributed systems.

In addition to outlining its theoretical foundations, the presentation critically evaluates the practical implications of adopting Zero Trust architectures in real-world environments. Key challenges such as implementation complexity, organizational readiness, policy management, and the integration of legacy systems are discussed alongside the potential benefits of improved security posture, visibility, and resilience.

By bridging conceptual analysis with practical considerations, this work aims to provide a nuanced understanding of Zero Trust as both an architectural evolution and an operational strategy. The presentation concludes by reflecting on the limitations of Zero Trust and outlining open research directions relevant to its continued development in increasingly dynamic and risk-driven computing ecosystems.

Furthermore, the presentation situates Zero Trust within the broader landscape of emerging security trends, including risk-adaptive access control, policy automation, and the growing influence of artificial intelligence in threat detection and decision-making. By examining Zero Trust as a dynamic and context-aware security model, the discussion highlights how trust decisions are increasingly informed by real-time risk signals rather than static credentials. This perspective underscores the relevance of Zero Trust beyond enterprise environments, extending to large-scale distributed systems and research infrastructures, while emphasizing the need for continuous evaluation, formalization, and empirical validation of its underlying assumptions.

Key words: zero trust architecture, security architecture, identity-centric access control, continuous authorization, least privilege, enforcement, context-aware trust

DEEP LEARNING-BASED ALGORITHMS OR THE CLASSIFICATION AND SEGMENTATION OF FETAL ULTRASONOGRAPHIC IMAGES

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Abstract:

The high prevalence of pathologies such as obesity and arterial hypertension negatively impacts pregnancy outcomes within the childbearing population, causing intrauterine developmental anomalies. In this context, the rigorous monitoring of fetal development serves as a fundamental procedure for prenatal care, facilitating comprehensive health assessments, the early detection of congenital anomalies, and the precise determination of biometric parameters essential for establishing gestational age. Ultrasonography represents the main method used for fetal monitoring, being a non-invasive and accessible imaging procedure. However, the interpretation of ultrasonographic imaging is marked by multiple technical challenges, including the presence of artifacts, such as speckle noise, shadowing, and reverberation, as well as substantial inter-operator variability, diagnostic accuracy being strictly dependent on the expertise of the medical personnel. These limitations can compromise clinical precision, justify the necessity of implementation of automated systems to assist in diagnosis.
Recent advances in the field of Deep Learning offer new ways to develop automated processing solutions for fetal ultrasonographic images. Algorithms based on convolutional neural networks (CNN), encoder-decoder architectures (U-Net), and Transformer-based models have demonstrated their effectiveness in complex tasks of anatomical structure segmentation, biometric landmark detection, and classification of standard fetal planes from raw images.
In this paper it was performed a systematic analysis of methods for the automated classification of fetal planes and the segmentation of related anatomical structures. For each type of analysis specialized architectures were evaluated, such as the SAMUS network for segmentation, HFSCCD for the identification of the standard cardiac plane, and LPC-Sononet for multi-plane classification and localization of areas of interest. Furthermore, it examines classical architecture, including U-Net, RNN, CNN, and Vision Transformer (ViT) models. The evaluation of these models highlights a range of advantages, including high precision and result reproducibility, underscoring their utility in contemporary clinical practice, while also identifying limitations such as the scarcity of annotated datasets. Furthermore, the study discusses optimization strategies for the presented models, potential solutions to overcome the identified constraints, and future research trajectories within the field.

Key words: Fetal ultrasonography, Deep Leaning, Convoluțional neural network, Visual transformers, Standard fetal planes, Segmentation of anatomical structures.

DISTRACTION MONITORING SYSTEM

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Abstract:

This paper proposes a new distraction monitoring system designed to improve workplace safety by reducing the risks associated with subject inattention. The purpose of this research is to advance the state of the art in the field and build a working system that can run on limited resource hardware. The model is designed to compute the distraction level using a Raspberry Pi 4 board and an external 1080p 30fps video camera. Thesis work studies various face landmarks and generates real time information regarding the current position of the subject. The proposed system utilizes a MediaPipe Face Mesh model, defined by a 468 mesh of facial landmarks designed to estimate a 3D geometry of the face using just the information extracted from one video input. The architecture of Face Mesh operates with a high-efficient machine learning pipeline, designed for mobile devices applications and built on a “tracking – over – detection” logic that uses previous frames to predict and adjust the landmarks for the next frame. The work explores a new implementation to detect the deviation from the normal position of the face. The first step integrates the initialization part where the algorithm uses the landmarks from the eyebrows, eyes, nose, mouth, chin and cheeks to generate the “face center”. This center is then adjusted in real time based on the new current position of the face to avoid errors introduced by changing the normal state, caused by work-related parameters. The second step is to calculate the real time position of the subject and compare it with the normal one. The system uses a binary segmentation model to estimate the threshold for the distraction. This method classifies the real time position into one of the two categories, attentive and inattentive and based on this information the algorithm analyzes if the subject is distracted or not. This research also highlights a generic formula for the attention level, based on parameters such as subjective awareness, subjective performance and background tasks performance.

Key words: Distraction, attention, segmentation, video processing, landmarks

THE EFFECT OF ROTATING CONTACTS ON COMMUTATION IN LOW VOLTAGE DC CIRCUITS

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Abstract:

The interest over renewable energy sources and the spread of electric vehicles are most likely among the main reasons why DC power grids have gained such an increased attention in the past few years. Since the energy conversion is a costly operation involving complex and expensive equipments, it is preferable to use the energy obtained from photovoltaic panels and the energy stored in batteries directly in DC power grids. This shows a need in the market for DC electrical devices capable of operating at high current values and it also surfaces the challenge of interrupting DC circuits due to the electric arc generated between the contacts of electrical devices. This paper studies an unconventional method for extinguishing the electrical arc for DC circuits and its purpose is to develop an efficient solution for connecting and disconnecting a DC contactor with the most advantageous operation there is. The paper briefly presents the use of a method for extinguishing the electrical arc using a pair of rotary contacts and the results obtained when tested in a situation when the circuit voltage is approximately 300V with different current values passing through the contacts. The study shows key values for the disconnecting time of the circuit, the evolution of the current, the evolution of the voltage and the evolution of the contact resistance in the circuit. Other interesting phenomena showed in the paper include the electrical arc image when disconnecting the circuit and the path it follows during this time.
This study falls within the field of electrical engineering and the development of electrical devices, aiming to present alternatives to conventional circuit disconnection techniques. The designed electrical device was tested for various current values at a voltage of approximately 300V and different disconnection speeds. The time periods for disconnection were on the order of milliseconds, and the lengths od the electric arcs were analyzed. The designed device successfully disconnected the circuit under the given conditions and can be tested in various future scenarios for comparison with devices operating in the same type of cicuits.

Key words: Rotary contacts, electrical arc, rotary actuation system, rotary actuator mechanism, contact arc, hybrid contactor

ARRYTHMIA CLASSIFICATION USING BAG-OF-WORDS MODEL

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Abstract:

Cardiovascular diseases (CVDs) affect the heart and blood vessels and include arrhythmia, coronary heart disease, cerebrovascular disease, rheumatic heart disease, and others. Over 80% of cardiovascular-related deaths are caused by heart attacks and strokes. Early identification of these conditions and appropriate treatment can help prevent premature deaths.
One of the most used tools for detecting and monitoring heart diseases is the electrocardiogram (ECG), due to its noninvasive nature. It captures the heart’s electrical activity, providing useful information regarding the myocardial function and overall cardiac health.
Among the various CVDs, arrhythmia is a common condition characterized by irregular heartbeats. While some arrythmias are harmless, others lead to serious complications such as heart failure and stroke, potentially resulting in a heart attack. Therefore, ECG analysis is crucial, as it can detect abnormal heart rhythms.
This paper aims to assess the performance of the well-known bag-of-words (BoW) classification model in discriminating between different types of arrhythmias and sinus rhythm, using a hybrid feature extraction approach. The BoW model was chosen because it demonstrated good capability in COVID-19 detection using cough signals and in ECG-based biometrics.
The proposed algorithm integrates morphological information extracted through beat-level FFT coefficients, encoded in a visual vocabulary, with temporal heart rate variability (HRV) metrics. Various experimental configurations, involving a vocabulary of 200 words and a Random Forest classifier were analyzed to capture both QRS complex shape anomalies and rhythm irregularities characteristic of pathologies such as atrial fibrillation or bradycardia.

Key words: Arrythmia detection, Bag-of-Words (BoW), ECG signal processing, Random Forest, Feature fusion.

UTILIZATION OF ARTIFICIAL INTELLIGENCE FOR ENHANCING ELECTRICAL PROPERTIES OF NANOCOMPOSITES

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Abstract:

Artificial intelligence is becoming an important support tool in the development of nanomaterials with improved electrical properties for applications such as electronics, energy storage, sensing, and insulation. In these systems, the electrical response is strongly influenced by filler type, concentration, morphology, interfaces, frequency, and processing conditions, which makes conventional trial-and-error optimization slow and resource-intensive. This contribution represents an initial stage of research focused on the use of AI for improving the evaluation of the electrical properties of nanomaterials.

The paper aims to provide a structured overview of how AI methods can assist the analysis, prediction, and interpretation of electrical-property-related behavior in nanomaterials and nanocomposites. The adopted methodology consisted of a targeted review and comparative analysis of recent literature relevant to this field of study, with emphasis on dielectric and conductivity-related studies. The reviewed works were organized according to the main properties of interest, the influencing factors considered as model inputs, the types of AI models employed, the data sources used for training, and the reported application areas.

The analysis shows that AI methods as artificial neural networks, support vector machines, random forest models, Gaussian process regression, convolutional neural networks, and graph-based models are already used for several relevant tasks. These include dielectric permittivity prediction, electrical conductivity estimation, interfacial-property characterization, and rapid screening of candidate material systems. The literature indicates that AI can significantly reduce development time by learning nonlinear structure-property relationships and by supporting data-driven discovery. At the same time, recurring limitations remain visible, especially the small size of available datasets, the frequent dependence on simulated data, and the limited generalization across materials and test conditions.

Overall, the reviewed studies support the idea that AI should be regarded not as a replacement for physical understanding, but as a complementary tool for faster and more informed evaluation of nanomaterial electrical behavior. The conclusions of this review define a clear future direction in this field: the development of AI-assisted frameworks supported by curated experimental data and physically meaningful descriptors.

Key words: artificial intelligence, machine learning, nanomaterials, electrical properties, property prediction.

TOWARD META-AFFECTIVE COMPUTING: A REAL-TIME EMOTIONAL CONGRUENCE INDEX BASED ON EEG–EDA–SELF-REPORT FUSION

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Abstract:

Recent advances in affective computing have enabled significant progress in the automatic recognition of human emotions using physiological signals. Most contemporary approaches rely on the valence–arousal dimensional model, which provides a continuous representation of affective states and is widely validated in experimental studies. Within this framework, electroencephalography (EEG) is extensively employed to estimate emotional valence due to its sensitivity to cortical activity patterns, while electrodermal activity (EDA) is recognized as a reliable indicator of autonomic arousal associated with sympathetic nervous system activation. The availability of benchmark datasets, such as DEAP, has further accelerated the development and validation of emotion recognition models.

State-of-the-art multimodal emotion recognition systems integrate EEG with peripheral physiological signals using advanced signal processing and machine learning techniques. Recent approaches employ deep learning architectures, including convolutional neural networks and recurrent models, achieving classification accuracies exceeding 85–90% under controlled experimental conditions. More recent developments incorporate attention mechanisms and transformer-based architectures to improve feature representation and cross-modal fusion. However, despite these advances, several limitations are consistently reported in the literature.

First, multimodal fusion strategies still face challenges related to cross-modal representation and generalization across subjects. Second, subjective self-reports are typically used only as offline ground truth labels, without being integrated into real-time computational frameworks. Third, and most importantly, existing systems do not explicitly model the relationship between objectively inferred physiological states and the subjectively perceived emotional experience.

The purpose of this research is to address this gap by extending affective computing toward the estimation of emotional awareness, defined as the degree of congruence between physiological affective markers and conscious emotional perception. The proposed methodology is based on a real-time multimodal architecture integrating EEG-derived valence estimation, EDA-based arousal quantification, and periodic self-report measurements obtained through standardized affective scales. Signal processing involves time–frequency feature extraction, followed by multimodal data fusion and the computation of a quantitative emotional congruence index.

In conclusion, this work builds upon existing multimodal emotion recognition systems while introducing a novel meta-affective perspective, with potential applications in clinical psychology, affective neuroscience, and adaptive brain–computer interface systems.

Key words: emotional congruence; EEG; electrodermal activity; multimodal fusion; real-time processing**;** affective computing; Kalman filter; dynamic time warping

EXPERIMENTAL STUDY OF HYBRID EDUCATIONAL ROBOTIC PLATFORMS FOR PROGRAMMING AND EDUCATIONAL ROBOTICS

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Abstract:

The integration of educational robotics into pre-university education represents an important direction for developing students’ digital and technical competencies, particularly in the fields of computer science and engineering. This study investigates the effectiveness of using hybrid educational robotic platforms within a unified learning environment for applied programming and educational robotics, including trajectory control and haptic interaction. The research is conducted in the context of Smart laboratories, funded through the National Recovery and Resilience Plan (PNRR), which provide the necessary infrastructure for modern experimental learning activities. The main objective of this study is to evaluate how the use of hybrid robotic platforms contributes to the development of programming skills, the improvement of motion control accuracy, and the increase of student engagement in pre-university education. The experimental study was carried out using LEGO, Fable, and NextLAB robotic kits, integrated into a common educational framework and supported by Smart laboratory resources. Students participated in hands-on activities involving the design, construction, and programming of robots to perform tasks such as writing letters and manipulating objects.The experimental methodology consisted of structured laboratory sessions in which students worked in teams to complete predefined tasks while interacting with robotic systems featuring trajectory control and haptic feedback. Data collection focused on task performance, programming efficiency, and qualitative indicators of engagement, collaboration, and motivation. The results demonstrate significant improvements in programming competencies, increased precision in robotic motion control, and a high level of student engagement in educational activities. The use of haptic interaction facilitated a more intuitive understanding of robotic system behavior. The discussion highlights the value of integrating multiple robotic platforms into a unified educational environment, emphasizing their flexibility and relevance for pre-university education.
In conclusion, the use of hybrid educational robotic platforms in Smart laboratories represents an effective approach for supporting the learning of programming and educational robotics, contributing to the development of students’ digital and engineering competencies.

Key words: educational robotics, programming education, haptic interaction, trajectory control**,** hybrid robotic platforms

A PRACTICAL LOW-COST WORKFLOW FOR NONLINEAR MAGNETIC MODELING IN LTSPICE BASED ON VARIABLE PERMEANCE

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Abstract:

This work presents a practical and low-cost workflow for nonlinear magnetic modeling of saturable inductors in LTspice based on a variable-permeance gyrator–capacitor (G–C) representation, complemented by an accessible experimental method for extracting inductance as a function of DC bias using standard laboratory equipment. In many power-electronic applications, fixed-inductance models become inaccurate under high DC premagnetization and near saturation, leading to errors in predicting current stress, waveform shape, and magnetic operating conditions. These limitations are particularly relevant in converters that operate most of the time around a nominal current level but must also withstand short-duration overloads or peak-current events significantly above nominal. To address this challenge, the proposed approach maps the magnetic element into a G–C network in which the inductor is represented through a virtual capacitor governed by the instantaneous permeance. This formulation preserves the physical relationships between magnetic flux, magnetomotive force, and current, while allowing nonlinear magnetic behavior to be directly introduced from either B–H data or inductance-versus-current characteristics. As a result, the model can capture the onset and progression of saturation, support more realistic current prediction, and provide additional internal variables such as magnetic flux density, which are highly relevant for magnetic design and margin evaluation. To support practical parameter extraction, the paper also introduces a simple and cost-effective setup for measuring the inductance-versus-DC-bias characteristic of a coil using widely available instruments, namely an LCR meter, a current-controlled DC source, and auxiliary passive components. This avoids the need for specialized bias-measurement systems and makes nonlinear magnetic characterization more accessible in typical laboratory environments.

The methodology is assessed on a wide-input Single Ended Primary Inductor Converter (SEPIC) designed around nominal operating conditions while allowing a controlled inductance roll-off under high-current peaks. The predictive capability of the LTspice implementation is validated against measurements from a hardware prototype by comparing inductor current waveforms, output-voltage ripple, and large-signal load-step behavior near the high-current operating region. The results show good agreement between simulation and experiment, demonstrating that the proposed workflow can support inductor sizing, core selection, and design-margin assessment while reducing prototyping effort, testing cost, and design uncertainty.

Key words: Nonlinear magnetic modeling, Gyrator–capacitor, Variable permeance, Ltspice, SEPIC Converter, Saturable inductors.

ANALYSIS AND COMPENSATION OF SENSOR DRIFT IN MODERN MONITORING SYSTEMS

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Abstract:

The performance of modern monitoring systems is dependent on the metrological stability of the sensors employed, given that drift phenomena represent the main source of long-term error. Both physical and chemical sensors exhibit time-dependent variations of the output signal, resulting from the complex interactions between environmental factors, material degradation processes, and stochastic error components, which lead to significant deviations from the true value and an increase in measurement uncertainty.
This paper presents a comprehensive analysis of drift phenomena, starting from the physical and chemical mechanisms (thermal effects, structural aging, mechanical stress, contamination, adsorption–desorption processes and changes in the properties of sensitive materials), continuing with mathematical and statistical models used to characterize them. Gauss–Markov processes, AR/ARMA models, logarithmic aging models, as well as modern approaches based on machine learning -LSTM, autoencoders, and hybrid CNN–LSTM networks are considered. The differences between static and dynamic drift are analysed, along with the specific manifestations in various sensor classes, including MEMS sensors (accelerometers, gyroscopes, pressure sensors), quartz resonant sensors, electrochemical sensors, and MOX sensors for gas detection. The metrological implications of drift on long-term stability, traceability, and measurement uncertainty are discussed, as well as the limitations of traditional calibration methods.
The paper synthesizes modern compensation strategies, ranging from hardware methods (isolation structures, internal references, self-calibration) to advanced software methods, including Kalman filtering and adaptive extensions (Sage–Husa), variational mode decomposition (VMD), time-varying coefficient regression, drift compensation models based on pseudo-calibration, domain adaptation, and recurrent neural networks (RNN). The literature analysis shows that integrating physical models with deep learning techniques can significantly reduce the drift, depending on the application, thereby extending the metrological lifetime of sensors.
Through this analysis, the paper highlights the need for an interdisciplinary approach in drift modelling and emphasizes the role of modern metrology in developing highly stable sensors intended for industrial, biomedical, and navigation applications.

Key words: sensor drift, measurement uncertainty, sensor calibration, metrological stability.

SPECTRAL ANALYSIS OF WINE USING UV-VIS TECHNIQUES FOR PHENOLIC CHARACTERIZATION AND COLOR METRICS

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Abstract:

Spectroscopic techniques have become essential tools in the analysis and characterization of wines, offering rapid, non-destructive and cost-effective alternatives to classical chemical methods. In particular, UV–VIS and FT-IR spectroscopy enable the investigation of phenolic compounds, which play a crucial role in determining wine color, taste, quality and authenticity. The spectral response of wines in the ultraviolet (190–400 nm) and visible (400–700 nm) regions provides valuable information regarding flavonoids, anthocyanins and phenolic acids, allowing both qualitative and quantitative assessment.
The purpose of this research is to make a literature review about spectrophotometric studies on wines their phenolic composition and color parameters, in order to evaluate their quality and potential classification. Experimental measurements were performed in laboratory conditions on multiple wine types (white, rosé and red wines), using UV–VIS spectrophotometry. The absorbance values were recorded over a wide wavelength range, with particular attention to characteristic bands such as 280 nm (total phenolics), 320 nm (hydroxycinnamic acids) and around 520 nm (anthocyanins). Additionally, color parameters such as color intensity (A420 + A520 + A620) and hue (A420/A520) were calculated.
The obtained results highlight clear spectral differences between wine types, reflecting variations in phenolic composition and concentration. Red wines exhibit higher absorbance in the visible region, particularly around 520 nm, confirming the presence of anthocyanins, while white wines show lower absorbance values and distinct UV signatures. The analysis also demonstrates that absorbance at 280 nm correlates with the total phenolic content, in agreement with literature findings. Furthermore, spectral patterns can be associated with sensory properties such as astringency and bitterness.
In conclusion, UV–VIS spectroscopy proves to be an efficient and reliable method for rapid wine characterization, offering valuable insights into composition, quality and classification. The approach can be further extended by integrating FT-IR analysis and multivariate methods for improved accuracy and real-time monitoring in winemaking processes.

Key words: UV–VIS spectroscopy, wine analysis, phenolic compounds, absorbance, color parameters, FT-IR

COMPARATIVE ANALYSIS OF THE MAIN PID ASSESSMENT METHODS FOR PV MODULES MANUFACTURED USING POLYCRYSTALLINE SILICON TECHNOLOGY

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Abstract:

Our paper presents a comparative analysis of the main methods used to assess Potential Induced Degradation (PID) in photovoltaic (PV) modules manufactured with polycrystalline silicon technology. PID is one of the most significant degradation mechanisms affecting the long-term reliability and energy performance of PV systems, especially under conditions of high system voltage, elevated temperature, high humidity, and unfavorable grounding configurations. Since PID can cause substantial power losses and irreversible damage if not detected in time, accurate assessment methods are essential for field diagnostics. Our study examines the most relevant techniques currently used for PID evaluation, highlighting their operating principles, advantages, limitations, and applicability. Among the analyzed methods are current-voltage (I–V) characterization, electroluminescence (EL) imaging, infrared thermography, insulation resistance measurement, leakage current monitoring, and accelerated stress testing under controlled environmental conditions. Each method is evaluated in terms of sensitivity, precision, testing time, cost, and ability to identify early-stage degradation or distinguish PID from other failure mechanisms. Special attention is given to the correlation between electrical performance losses and visual or thermal indicators obtained through non-destructive diagnostic techniques. The comparative approach allows the identification of the most efficient combinations of methods for reliable PID detection in polycrystalline silicon PV modules. While I–V analysis provides direct information on power reduction, EL imaging offers valuable insight into defect distribution at cell level, and thermal inspection supports the detection of abnormal operating patterns associated with degradation. Accelerated PID tests remain essential for reproducing stress conditions and validating module resistance to this phenomenon. The results emphasize that no single assessment method is sufficient for a complete PID diagnosis. The paper concludes that selecting an appropriate PID assessment methodology depends on the purpose of the investigation, available equipment, and the stage of module degradation. These findings contribute to improving diagnostic practices, supporting preventive maintenance, and enhancing the durability and operational efficiency of polycrystalline silicon PV systems.

Key words: Potential Induced Degradation, polycrystalline, electroluminescence, thermography

MAINTENANCE PLAN FOR A MEDIUM-SIZED GROUND-MOUNTED PHOTOVOLTAIC PLANT

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Abstract:

Our paper proposes a comprehensive maintenance plan for a medium-sized ground-mounted photovoltaic (PV) plant, with the aim of improving system reliability, energy yield, operational safety, and asset lifetime. As photovoltaic installations become increasingly important in modern power systems, effective maintenance strategies are essential to ensure stable performance and reduce long-term operational costs. Ground-mounted PV plants are exposed to a wide range of environmental and technical factors, including dust accumulation, vegetation growth, component aging, weather-related stress, and electrical faults, all of which can significantly affect efficiency if not properly managed.

Our paper outlines the main components of a structured maintenance program, including preventive, corrective, and predictive maintenance activities. Preventive maintenance focuses on regular inspections, cleaning of PV modules, checking mounting structures, tightening electrical connections, testing protection systems, and verifying inverter and monitoring system operation. Corrective maintenance addresses the identification and repair of faults such as damaged modules, cable degradation, inverter malfunctions, and hotspot formation. Predictive maintenance is based on continuous monitoring of performance indicators, thermal imaging, and data analysis to detect early signs of degradation and reduce unexpected downtime. Particular attention has been given to maintenance scheduling according to seasonal conditions, site accessibility, and plant operating characteristics. The paper also discusses the role of digital monitoring systems in detecting underperformance, comparing actual and expected energy production, and supporting timely intervention. In addition, safety procedures for maintenance personnel, documentation practices, and spare parts management are considered essential elements of the overall plan.

The proposed maintenance framework emphasizes the importance of balancing technical performance with economic efficiency. By integrating routine inspections, condition-based monitoring, and rapid corrective response, the maintenance plan contributes to minimizing energy losses and extending plant service life. The paper concludes that a well-designed maintenance strategy is a key factor in ensuring the sustainable and cost-effective operation of medium-sized ground-mounted PV plants, offering practical guidance for plant operators, maintenance teams, and energy managers involved in photovoltaic asset management.

Key words: Ground-mounted PV plant, preventive, predictive maintenance

STATISTICAL ROBUSTNESS ANALYSIS OF YOLO26S IN PCOM DETECTION

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Abstract:

Polycystic ovary morphology (PCOM) is an essential component of diagnosing Polycystic Ovary Syndrome (PCOS), the most common endocrine disorders affecting women of reproductive age. Because manual ultrasound interpretation is subjective and highly dependent on the operator's skill and experience, recent research has explored the use of deep learning to support more consistent and objective PCOM assessment. This study focuses on evaluating the statistical robustness of YOLO26s, the latest model in the YOLO family, when applied to PCOM detection on a custom, expert annotated ultrasound dataset.

The dataset used in this study contains 4071 clinically validated ultrasound images, consisting of 959 PCOS and 3112 non-PCOS cases. These were divided into 2848 training images (673 PCOS, 2175 non-PCOS), 815 validation images (185 PCOS, 630 non-PCOS), and 408 test images (101 PCOS, 307 non-PCOS). To assess how sensitive YOLO26s is to the natural randomness inherent in deep learning training, the model was trained five times under identical conditions, most notably using 416×416 input resolution, 30 epochs, and the same dataset split, while varying only the random seed. Because deep learning involves random initialization and non-deterministic GPU operations, slight differences between runs naturally occur even when all hyperparameters remain fixed.

Despite these sources of randomness, all five trained models showed remarkably consistent performance on the independent test set. Mean test accuracy was 0.9078 with a standard deviation of 0.0033, while the mean F1 score was 0.8402±0.0047. Sensitivity remained very high, averaging 0.9782±0.0040, and specificity also showed limited variation at 0.8847±0.0049. ROC–AUC values were similarly stable, with an average of 0.9793±0.0009 across runs. Confusion matrices differed by only one to three samples, indicating that the model consistently converged to nearly identical decision boundaries even when exposed to different random seeds.

Overall, these findings show that YOLO26s not only performs well on PCOM classification but does so with notable reproducibility, an essential requirement for deploying AI assisted tools in clinical environments. Future work will extend this analysis to larger, non augmented datasets and evaluate model behavior on ultrasound video sequences.

Key words: PCOS; PCOM; ultrasound imaging; YOLO26s; deep learning; statistical robustness

EQUIPMENT AND TECHNIQUES FOR PERFORMING IMAGING EXAMINATIONS IN DENTISTRY: FROM CONVENTIONAL RADIOGRAPHY TO MULTIMODAL FUSION GUIDED BY ARTIFICIAL INTELLIGENCE

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Abstract:

Dentomaxillofacial radiology (DMFR) has undergone a profound transformation over the past decade, transitioning from conventional two-dimensional (2D) methods to a complex range of digital, three-dimensional (3D), and artificial intelligence (AI)-assisted technologies. This synthesis examines the current state and directions of advancement of the principal imaging modalities in the field. Intraoral radiographs remain a foundational method owing to their high resolution, and comparative studies indicate that CMOS sensors are superior to PSP plates with respect to time efficiency and subjective image quality, without adversely affecting patient comfort. Panoramic radiography constitutes a valuable screening tool, providing an overview of the jaws at a low radiation dose; however, its limitations include geometric distortions and the superimposition of anatomical structures. Cone beam computed tomography (CBCT) has become established as the method of choice for the detailed assessment of hard tissues in implantology, endodontics, and maxillofacial surgery, while nonetheless necessitating rigorous individualisation of acquisition parameters in accordance with the ALADAIP principle. Non-ionising radiation technologies, such as ultrasonography and magnetic resonance imaging, offer valuable alternatives for soft tissue evaluation, and the emerging concept of dentistry-dedicated MRI (ddMRI) holds promise for bringing this modality into dental practices, although practical limitations continue to confine it to a complementary role. Artificial intelligence represents the most profound paradigm shift in DMFR, with applications ranging from the automated detection of carious lesions, periapical pathology, and fractures on panoramic and CBCT images, to the three-dimensional segmentation of anatomical structures, the creation of the "virtual patient," and 3D reconstruction from 2D images. The principal challenges that remain include the generalisability of models, algorithmic bias, the "black box" nature of AI-driven decisions, as well as ethical and regulatory considerations. In conclusion, the future of DMFR lies in the combination and integration of 2D and 3D methods, complemented by advanced AI techniques, with the ultimate goal of achieving a more accurate, personalised, and patient-centred diagnosis.

Key words: Dentomaxillofacial radiology, CBCT, AI-assisted technologies

EFFICIENCY EVALUATION OF ROMANIAN PUBLIC HOSPITALS USING DATA ENVELOPMENT ANALYSIS AND MACHINE LEARNING

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Abstract:

Healthcare facilities, particularly hospitals, play a crucial role in modern healthcare systems, offering a diverse and intricate range of services to address the medical needs of the population and generating a substantial volume of data for analysis. In the current context, characterized by rising healthcare costs, economic instability, and increasingly limited resources, evaluating hospital efficiency has become a strategic necessity for better healthcare management. Most hospitals operate based on reactive management, facing difficulties in supervising operations, budgeting, and allocating resources to areas that have the most significant impact on outcomes. This paper focuses on the analysis of the Romanian public hospital system, where significant inefficiencies in resource allocation and their alignment with strategic objectives have been previously identified. The primary objective of this paper is to assess the relative efficiency of a comprehensive sample of Romanian hospitals and to propose a framework for resource optimization by integrating statistical analysis with predictive techniques. A hybrid framework combining Data Envelopment Analysis with machine learning techniques was implemented to assess the efficiency of over 200 public hospitals. Variables were selected to describe the capacity to provide medical services, as well as the quality and complexity of the medical act. The main results show variations in efficiency scores across the hospitals included in the evaluation, highlighting areas where improvements can be made. The optimal resource allocation for an inefficient hospital can be identified by using machine learning techniques, supporting informed decision-making and operational optimization. The benchmarking can allow a hospital to learn from another with comparable resources but superior efficiency. By prioritizing resource allocation, hospitals can ensure a harmonized link between inputs and outcomes without compromising the quality of care. These results support the introduction of solutions that help hospital management transform activity indicators into actionable variables for operational optimization and the foundation for informed decisions and development strategies.

Key words: hospital efficiency, healthcare, management, resource optimization

INTERPRETING A DQN LUNARLANDER AGENT WITH SHAP: A CASE STUDY OF GLOBAL AND LOCAL EXPLANATIONS

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Abstract:

Deep Reinforcement Learning (DRL) algorithms can successfully solve complex decision-making tasks, but their limited interpretability and transparency make them difficult to understand and adopt in safety-critical domains such as autonomous systems. Analyzing how DRL agents select actions is essential for improving trust, debugging policies and ensuring reliable performance. The present work investigates the interpretability of DRL models using explainable artificial intelligence (XAI) methods, with a focus on interpreting agent behavior in discrete control tasks. In particular, it provides insights into the decision-making process of a Deep Q-Network (DQN) agent trained in the LunarLander environment from OpenAI Gym by applying SHapley Additive exPlanations (SHAP). A dataset of state-action pairs is collected from multiple successful episodes, capturing features such as position, velocity, orientation, and contact signals used by the agent to control a lander to achieve a safe landing. SHAP values are computed using a KernelSHAP approach to estimate feature contributions to the predicted Q-values of the selected actions, using a representative subset of observed states as background data. The analysis is performed at both global and local levels, including summary plots, temporal heatmaps and trajectory-based visualizations. Moreover, an unsupervised clustering technique (K-Means) is applied to SHAP values corresponding to the agent's chosen actions in order to identify distinct behavioral phases throughout each episode, with the number of clusters selected using the elbow method and validated through stability assessment. The results reveal that the agent follows a structured strategy composed of three main phases: stabilization, descent, and landing. Each phase is characterized by distinct dominant features, with state variables that describe vertical position and velocity influencing early and intermediate decisions, while attitude-related variables (angle and angular velocity) contribute to stabilization. During the final phase, contact signals and velocity features are critical for achieving a safe landing. While the neural network remains a black-box model, the SHAP-based analysis reveals consistent patterns in feature contributions associated with the agent's decisions. These findings indicate that post-hoc explanation methods can provide valuable insights into the factors influencing action selection, while also highlighting limitations in deriving explicit action-level rules and the fact that the study is limited to successful episodes only, thus contributing to improved transparency and interpretability in intelligent control systems.

Key words: Deep reinforcement learning, explainable AI, interpretability, post-hoc explanations, feature attribution

TESTS AND SOLUTIONS FOR IMPROVING EMC IMMUNITY OF ULTRA-LOW-FIELD MAGNETIC RESONANCE IMAGING (MRI) SYSTEMS

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Abstract:

Portable ultra-low-field magnetic resonance imaging (MRI) systems operating at approximately 64 mT represent a recent technological development intended to extend MRI access beyond conventional radiology suites. Current commercial systems are designed primarily for bedside brain imaging in situations where a full diagnostic MRI examination is impractical, especially in intensive care units, emergency departments, neonatal care, and other critical-care environments. Their portability, reduced siting burden, and lower fringe-field constraints make them attractive for patients whose transport is difficult or unsafe, as well as for resource-limited clinical settings. At the same time, the lower operating field implies weaker received MR signals and greater vulnerability to disturbances from the local electromagnetic environment.

Our paper proposes a practical perspective on immunity evaluation for such 64 mT MRI equipment through a set of simple, qualitative tests that are not intended to reproduce the full methodology of IEC 60601-1-2:2014, but rather to provide preliminary evidence of electromagnetic robustness in realistic use conditions. Our checks have included comparative image acquisition with nearby mobile phones and wireless devices alternately active and inactive; repeat scans with noncritical surrounding equipment such as monitors, infusion pumps, or laptop chargers placed at different distances; observation of image stability under intentional changes in cable routing and grounding arrangements; verification of behavior during mains-quality disturbances such as switching of nearby loads; and assessment of image degradation in the presence of typical power-frequency interference. Our qualitative criteria included visible artifacts, increased background noise, loss of contrast, repeatability of anatomical detail, and interruption of normal scanner workflow.

Based on the known sensitivity of portable low-field MRI to ambient electromagnetic noise, several practical actions are recommended to improve immunity in the place of use: establishment of a controlled scanning zone around the device, limitation of unnecessary RF emitters near the patient and scanner, careful cable management and grounding practice, verification of power quality, periodic baseline image-quality checks, and the integration of filtering, optimized receive-coil design, and software-based noise-correction methods. Such measures can significantly improve the reliability of portable 64 mT MRI in real clinical environments and support safer, more consistent bedside imaging.

Key words: Portable ultra-low-field MRI, electromagnetic (bedside) immunity

A COMPREHENSIVE ANALYSIS OF THE PROSUMERS' IMPACT ON THE OPERATION AND PLANNING OF THE ELECTRIC DISTRIBUTION NETWORKS

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Abstract:

In light of current global challenges, adopting renewable energy sources and decentralizing energy production are becoming essential for ensuring energy security and economic stability. The rise of prosumers, individuals who act as both consumers and producers of energy, plays a crucial role in the transition process of the energy sector. This transition improves resilience and sustainability but introduces operational challenges like voltage fluctuations, higher power losses, and supply-demand imbalances, all of which necessitate advanced management systems.

The paper offers a comprehensive analysis of how prosumers can impact the operation and planning of electric distribution networks, while also identifying best practices and effective policies to facilitate the energy transition. The first section covers the estimation process of energy production using a software tool linked to the PVGIS platform. The second section presents a mathematical model designed to assess how power injections from the prosumers affect the low-voltage distribution system. The active power generation profiles for photovoltaic systems were obtained from the prosumer database analyzed earlier.

The results from the PVGIS platform for 30 prosumers with connection notices showed a reduction in energy losses, ranging from 9% to 41% for small photovoltaic systems. However, voltage quality was adversely affected, as the upper voltage limit was exceeded during medium-energy production among prosumers with a penetration rate above 30%.

In the context of interoperability, security, and scalability, future development opportunities have been identified.

Key words: Electric distribution networks, prosumers, energy estimation, power generation profiles, impact, energy losses, voltage quality

UGR AS A STANDARDIZED METRIC: ROLE, LIMITATIONS AND APPLICABILITY IN INDOOR LIGHTING ENVIRONMENTS

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Abstract:

The Unified Glare Rating (UGR) is the CIE standard for evaluating visual discomfort caused by direct glare in interior spaces. Although the classical UGR formula provides a reproducible framework for quantifying luminance contrast relative to the observer's position and scene geometry, its applicability decreases in dynamic, user-centered architectural contexts. In practice, designers rely on different glare indices and varied mathematical dependencies, and the distinct implementations of the position index in simulation software lead to divergent glare values for the same lighting configuration.
This paper presents a critical analysis of the photometric foundations of the UGR model, discussing its tabulated simplifications, its sensitivity to source position, and its limitations in real-world scenarios. Ergonomic design strategies and simulation methodologies are examined in relation to tools such as DIALux, Relux, and AGi32. Although these platforms are highly effective for lighting design practice, their simplified glare algorithms and embedded assumptions make them less suitable for rigorous scientific research or comparative mathematical analysis. Furthermore, alternative metrics-such as DGI, VCP, and systems integrating biometric data-are analyzed for their potential to improve perceptual accuracy and contextual sensitivity. While the paper discusses only a few indices, the broader literature includes numerous glare models, each incorporating the light-source position factor either directly or indirectly. In indices such as **GR**, an examination of the mathematical dependencies reveals the implicit presence of a position function, even when it is not explicitly expressed.
By correlating technical metrics with user-centered design principles, the paper argues for a holistic approach to visual comfort, in which glare control becomes an essential component of wellbeing in contemporary lighting design. The analysis also highlights the lack ofrobust comparative studies on the influence oflight-source position on glare perception and the absence of a comprehensive mathematical treatment dedicated to this topic. These gaps justify the development of extended models and more rigorous standardization capable of reflecting the complexity of modern illuminated environments.
The contribution of this paper lies in clarifying the limitations ofUGR in user-centered environments, highlighting inconsistencies between software implementations, and emphasizing the critical yet often overlooked role of the light-source position index.

Key words: visual comfort; glare; adaptive lighting; interior lighting; photometric simulation

PERFORMANCE ANALYSIS OF DC-DC CONVERTERS: OUTPUT VOLTAGE RIPPLE AND EFFICIENCY

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Abstract:

DC-DC converters represent an essential class of conversion topologies used in modern switching power supplies, being widely employed in a broad range of low- and medium-power applications. They can be classified into isolated and non-isolated converters, depending on the presence or absence of galvanic isolation between the input and the load. In the context of increasing requirements for energy efficiency and power density, the study of these converters becomes essential. Control parameters, such as duty cycle and switching frequency, directly influence the performance of converters, particularly in terms of output voltage ripple and efficiency. DC-DC converters, whether isolated or non-isolated, can operate in continuous conduction mode (CCM) or discontinuous conduction mode (DCM), each mode having a significant impact on these parameters.

The aim of this paper is to analyze the performance of DC-DC converters from the perspective of output voltage ripple and efficiency, as well as to highlight the interdependence between the operating mode, duty cycle, switching frequency, and circuit parameters. In this context, the variations in output voltage ripple and efficiency in CCM and DCM operating modes are analyzed both theoretically, based on analytical models, and through numerical simulations, using representative models of the studied topologies implemented in the OrCAD PSpice simulation environment.

Output voltage ripple is an important parameter of DC-DC converters, as it determines the value of the capacitor connected in parallel with the load. Existing relations for its calculation are primarily derived under the assumption of operation in continuous conduction mode (CCM). However, switching power supplies where the output voltage and load current vary over wide ranges, converters operate in both CCM and DCM.

In addition to the classical analysis of converter behavior, this paper employs new analytical relations for determining the output voltage ripple even under discontinuous conduction mode operation (DCM), as well as an approach for efficiency evaluation based on real circuit parameters. The resulting equations provide an efficient and reproducible method for obtaining the results, eliminating the need for complex and costly experimental procedures and enabling rapid determination of key parameters.

The results obtained through simulations are used to validate the proposed model and to highlight the variation of efficiency as a function of the conduction mode, load level, and input voltage. The analysis shows that the conduction mode directly influences both the output voltage ripple and the distribution of power losses, leading to significant performance differences between CCM and DCM.

A direct correlation between the operating mode, output voltage ripple, and efficiency is highlighted, providing a solid basis for optimizing the design of DC-DC converters in practical applications.

Key words: DC-DC converter; galvanic isolation; output voltage ripple; efficiency, continuous conduction mode (CCM); discontinuous conduction mode (DCM)

DOMAIN RANDOMIZATION IN DEEP REINFORCEMENT LEARNING FOR PHYSICAL INVERTED PENDULUM CONTROL

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Abstract:

The simulation-to-reality (sim-to-real) transfer of deep reinforcement learning (DRL) control strategies consists of training models based on deep neural networks solely in simulated environments and later transferring them to real-world settings. Learning to balance a physical inverted pendulum remains a challenging task in DRL, especially due to factors such as low-cost hardware, mechanical wear, and unmodeled dynamics.
To address these issues, we incorporate entropy regularization to balance exploration and exploitation in pendulum control. In simulation, we evaluate several DRL algorithms, including Soft Q-Learning (SQN) and Soft Actor-Critic (SAC). The SAC variant, with an optimally tuned entropy coefficient, proves to be the best-performing baseline.
To counteract real-world perturbations, we train the prior controller using Robustly Informed Noise (RFI) and medium-amplitude perturbations. The real-world implementation involves a parallel real-time interface, where the SAC agent operates alongside low-level hardware control. This approach enables zero-shot transfer, achieving continuous and smooth control of the inverted pendulum despite unknown disturbances.
Furthermore, the proposed method is compared with a reference proportional–integral–derivative (PID) controller. The SAC algorithm trained with domain randomization exhibits anticipatory behavior and improved robustness. Additionally, we employ random noise injection (RNI), a technique from statistical modeling, to enhance sim-to-real transfer.
Experimental results demonstrate that SAC trained with domain randomization significantly improves real-world performance. The methodology proves effective for sim-to-real scenarios, where high-level decision-making combined with adaptive training enables robust control despite discrepancies between simulation and reality.

Key words: Reinforcement learning, deep learning, sim-to-real transfer, inverted pendulum, control system.

ATTENTION ASSESSMENT IN BCI SYSTEMS VIA DYNAMIC THRESHOLDS AND PHYSIOLOGICAL ARTEFACT RESILIENCE

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Abstract:

Focused attention assessment through Brain-Computer Interfaces (BCI) represents a major challenge due to the non-stationary nature of EEG signals and the omnipresent physiological interference in uncontrolled environments. Conventional monitoring systems often employ static thresholds, which fail to compensate for inter-individual variability or the noise inherent in high-impedance sensors.
This paper proposes an architecture for robust attention assessment, capable of ensuring high precision even in the presence of artifacts or hardware errors. The primary objective is the development of an adaptive model that enables automatic calibration and continuous monitoring of concentration states, serving as a valuable tool for testing BCI device performance under real-world operating conditions. The research methodology combines a critical review of literature regarding self-calibration algorithms with the implementation of a Python script designed for parametric testing. The process utilizes a 60-second automatic baseline module, followed by a machine learning algorithm that recalculates success thresholds at 30-second intervals. To ensure data accuracy, the script integrates adaptive filters for muscle and ocular artifact rejection, using on-the-fly statistics (such as moving average and standard deviation) to neutralize fluctuations caused by variable sensor contact quality.
Computational simulations and comparative analysis indicate that the use of dynamic thresholds increases assessment fidelity by over 25% compared to conventional models. In tests, the system demonstrates superior robustness in isolating relevant spectral activity, eliminating false-positive results induced by hardware noise or subject micro-movements. The analysis of the results emphasizes that the algorithm's adaptability allows for a fair assessment of attention, regardless of the user's fatigue level or the specific limitations of commercial BCI equipment.
In conclusion, this work substantiates the opportunity for intelligent assessment systems that treat sensor errors as software-controllable variables. The proposed theoretical framework and computational tool provide a solid foundation for future testing protocols, transforming BCI devices into high-precision cognitive diagnostic instruments.

Key words: Brain-Computer Interface (BCI), Focused attention, Adaptive algorithms, Signal processing, Self-calibration, Machine learning, Physiological artifacts, Dynamic thresholds

COMPARATIVE ANALYSIS OF PROFESSIONAL LITERATURE AND ALGORITHMIC SIMULATION VALIDATION OF TEMPORAL INTEGRITY IN CLOSED-LOOP BCI SYSTEMS

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Abstract:

Current research in the field of Brain-Computer Interfaces (BCI) has reached a stage where signal decoding complexity often overshadows the fundamental physical constraints of the communication loop. This work is placed within the general context of neuroadaptive systems, where the temporal alignment between neural activity and system response serves as the bedrock for effective interaction. Despite rapid hardware advancements, a critical gap remains in understanding how system delays influence the biological mechanisms of learning. The purpose of the research carried out is to provide a comprehensive theoretical perspective on how high latency, specifically exceeding the 100 ms threshold, fundamentally disrupts the information flow between the human brain and the machine. The description of experimentation methodology involves a two-pronged approach: a systematic critical evaluation of recent BCI literature (2016-2025) and the development of a specialized "BCI Data Flow Latency Simulator" implemented in Python. This simulator was designed to parametrically test system variables, such as chunk size and vectorized filtering efficiency, to measure end-to-end "scalp-to-screen" delays. The description of main results highlights a systemic omission in current literature, where temporal parameters are frequently categorized as "Not Reported," thereby compromising study replicability. Simulations demonstrate that a vectorized pipeline can maintain latency below 50 ms, a target supported by a solid statistical correlation ($r=0.58$, $p<0.01$) found in benchmark studies between system precision and the success of Hebbian associative learning. In a short discussion, the paper argues that ignoring latency transforms neurofeedback from a deterministic causal loop into a stochastic process, inducing user frustration and sensory dissonance. High latency essentially "decouples" the neural effort from the perceived reward, sabotaging synaptic plasticity. A short conclusion emphasizes that the true performance of a BCI interface cannot be validated without total transparency regarding technical infrastructure timing. This theoretical framework establishes that systemic stability must become a central pillar of design protocols, paving the way for high-fidelity neuroadaptive interactions that operate at the actual speed of thought.

Key words: Brain-Computer Interface (BCI), System Latency, Information Flow Fidelity, Hebbian Learning, Closed-loop Neurofeedback, Real-time Signal Processing.

3D ROUTING AND ITS IMPACT ON INTERCONNECT LENGTH

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Abstract:

One of the key advantages of 3D integration lies in its ability to significantly minimize the overall footprint required for placing a design, leading to a more efficient use of available space. In addition, this approach enables a considerable reduction in the length of interconnections between individual cells, as components can be stacked vertically rather than spread out across a single plane. As a direct consequence of these shorter interconnects, the signal propagation paths are reduced, which in turn leads to lower time delays and improved performance of the resulting connections. The placement of memory elements above standard cells within a design influences not only the overall area utilization, but also the lengths of interconnects associated with memory access as well as those of other routing wires. In this work, a three-dimensional (3D) implementation was realized by stacking memory blocks over standard cells, followed by full placement and routing. A comparative analysis was then conducted between the 3D implementation and an equivalent two-dimensional (2D) design, focusing on the resulting interconnect wire lengths. In both the two-dimensional (2D) and three-dimensional (3D) implementations, signal routing was carried out using six metal layers (M1–M6), with metal congestion carefully analyzed in each scenario. The 3D configuration, achieved by vertically stacking components, results in significantly shorter interconnect lengths compared to the conventional 2D approach. This reduction in wire length directly contributes to lower signal propagation delays, thereby enabling higher achievable operating frequencies. Furthermore, the decrease in interconnect length has a notable impact on the relationship between the number of contacts and the total number of wires. Shorter routing paths generally require fewer vias and contacts per connection, leading to a reduction in contact density relative to the number of routed wires. This improvement contributes to a more efficient and streamlined routing architecture in the 3D design, enhancing overall interconnect optimization compared to its 2D counterpart.

Key words: digital design, memories, 3D, congestion, routing

APPLYING A QUANTUM COMPARATOR TO IMAGE SEGMENTATION

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Abstract:

Quantum computing has emerged as a transformative paradigm in computer science, offering fundamentally new approaches to problems that are computationally intensive. In the field of image processing, quantum approaches have attracted growing interest due to their potential for massive parallelism, enabling pixel-level operations to be performed simultaneously across an entire image encoded in quantum superposition. Threshold-based image segmentation, one of the most widely used techniques in computer vision, is particularly well-suited for quantum implementation due to its inherent pixel-wise independence and conceptual simplicity, making it a natural candidate for exploration within quantum image processing frameworks.
The purpose of this work is to investigate the use of quantum comparator circuits as the core building block for threshold-based image segmentation within the Novel Enhanced Quantum Representation (NEQR) format. The quantum comparator evaluates the relative magnitude of quantum-encoded pixel intensities against predefined threshold values without collapsing the quantum image state, enabling conditional segmentation operations to be performed entirely within a quantum circuit. The proposed approach uses a quantum comparator and a single threshold value to classify pixels into two distinct intensity regions: below and above the threshold.
The segmentation pipeline was implemented and evaluated using the *Qiskit StatevectorSimulator*. The proposed circuit encodes pixel intensities using the NEQR representation, applies quantum comparators sequentially against the threshold value producing a segmented image. The entire circuit architecture was designed to preserve the integrity of the quantum image state throughout the segmentation process.
Experiments conducted on representative grayscale images confirm that the proposed design produces stable and reproducible segmentation results across multiple executions. The results demonstrate the correctness and scalability of the comparator-based segmentation approach.

Key words: quantum computing, quantum comparator, image segmentation, Qiskit, NEQR

DIELECTROPHORESIS – THEORY, PRINCIPLE AND APPLICATIONS

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Abstract:

Electric-field assisted manipulation of micro and nanoobjects represents an intensively studied field of research subject due to its inherent advantages and the innovative perspectives it offers. As a method for manipulating micro- and nano-structures, Dielectrophoresis (DEP) meets current requirements for the development of advanced analytical tools owing to its multiple advantages, including non-invasive and label-free operation, high accuracy, rapid detection, and low-cost instrumentation. Consequently, DEP became increasingly relevant in biomedical engineering, microfluidics, and lab-on-a-chip applications. Through DEP, the displacement of biological entities such as cells, bacteria, and biomolecules can be precisely controlled within non-uniform electric fields.
The herein paper is encompassing a comprehensive review of experimental set-ups reported in recent literature, ranging from the separation of microalgae and cancer cells to the manipulation of gold nanowires and DNA molecules. Specialized electrode configurations were examined across various studies to determine their effectiveness in generating the optimal electric field gradients. The results of these studies are influenced by physical and electrical parameters, particle properties (size, shape, dielectric characteristics), and the characteristics of the medium in which the micro/nano-structures are tested (conductivity, permittivity, viscosity, and pH).
The main results highlight that interdigitated electrodes are among the most effective patterns for cell separation due to their low voltage requirements and strong field gradients. Discussions indicate that successful manipulation is strictly dependent on the crossover frequency and the sign of the Clausius-Mossotti factor which dictates the type of DEP underdone by a particle, positive (pDEP) or negative (nDEP) dielectrophoresis. Overall, dielectrophoresis represents a versatile and promising tool for micro- and nanoscale manipulation, with significant potential for future development of biomedical diagnostic and microfluidic technologies. Further research is required to optimize device design and improve control over particle behavior in complex environments. Future studies should focus on scaling DEP systems for industrial applications and improving integration with existing technologies

Key words: Dielectrophoresis, Microfluidics, Lab-on-a-chip, Interdigitated electrodes, Cell separation

EYEPATCHVR: A NEW APPLICATION-INDEPENDENT STEAMVR OVERLAY FOR DICHOPTIC VISUAL PENALIZATION AMBLYOPIA THERAPY

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Abstract:

Adult anisometropic amblyopia is traditionally viewed as highly resistant to treatment due to diminished cortical neuroplasticity. However, modern psychophysical evidence demonstrates that active dichoptic training can effectively break interocular suppression and restore stereopsis. A major limitation of current virtual reality (VR) therapeutic systems is their strict reliance on purpose-built games or applications. These clinical applications frequently suffer from low patient compliance due to poor engagement and graphic fidelity when compared to commercial entertainment. To bridge this gap, we present EyePatchVR, a novel, opportunistic dichoptic training framework implemented as a real-time SteamVR overlay. This system introduces a universal, application-agnostic overlay architecture that penalizes the visual input to the dominant eye while allowing patients to interact seamlessly with any off-the-shelf commercial VR application. The developed prototype utilizes direct calls to the SteamVR pipeline to render a customizable transparent overlay exclusively over the dominant eye's display. Through a decoupled, real-time graphical user interface, users can configure the penalization parameters without modifications to the underlying game engine. The framework supports multiple clinically validated therapeutic paradigms: uniform settable transparency, spatially graded attenuation utilizing radial gradient masks (center-weighted and inverse-radial profiles) to selectively target foveal and peripheral suppression zones, and temporal modulation (adjustable frequency blinking or flicker). The temporal flicker mechanism specifically addresses the need for dynamic interocular suppression disruption, a proven catalyst for cortical rewiring. Technical validation was successfully conducted using an HTC Vive head-mounted display and headless VR emulation environments. The overlay effectively intercepted the stereoscopic rendering process, applying both static and dynamic visual constraints with negligible computational overhead. By decoupling the therapeutic visual intervention from the interactive content, EyePatchVR transforms highly engaging AAA commercial titles into viable amblyopia treatment environments. This open-architecture approach solves the need for purpose built applications in amblyopia therapy and provides researchers with a robust, accessible tool for advancing dichoptic amblyopia therapies within commercial VR environments.

Key words: Amblyopia, Virtual Reality, SteamVR, Dichoptic, Anisometropia

AN IN-DEPTH BIBLIOMETRIC ANALYSIS ON THE INTEGRATION OF INTERNET OF THINGS TECHNOLOGIES IN ENERGY CONSUMPTION MANAGEMENT SYSTEMS

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Abstract:

In the past decade, energy efficiency and sustainability have become major priorities globally. Pressure from rising consumption, climate change and high energy costs has driven the adoption of smart technologies in consumer infrastructure. All these advanced technologies are supported by the European Union's energy strategies, such as the European Green Deal and the Energy Efficiency Directive, which encourage the implementation of intelligent energy management systems in buildings and microgrids.

In this context, the paper provides an in-depth analysis of the current state of research on energy management systems integrated into buildings, which is particularly relevant to the integration of technologies based on the Internet of Things (IoT). The accelerated development of smart sensors, communication systems and data analysis platforms has led to the emergence of innovative solutions for monitoring, controlling and optimising energy consumption.

Thus, the authors conducted a statistical analysis, drawing on a synthesis of several relevant reports and studies, to identify the main research directions, emerging technologies, and existing limitations. In this sense, representative keywords, such as smart energy management, IoT, smart buildings, and energy consumption, were selected to identify the most relevant research studies from the papers indexed in the Scopus database using Bibliometric Analysis in RStudio. Thus, approximately 350 articles were identified on the practical integration of IoT in energy management. The performed analysis showed that IoT systems contribute to increased energy efficiency, reduced operational costs, and support the transition to smart grids. Additionally, the maturity level of existing solutions, the challenges related to interoperability, security, and scalability, and future development opportunities have been identified.

Key words: Energy Efficiency, Energy Consumption, Energy Managements, Monitoring, IoT, Bibliometric Analysis

APPROACH ON TUNING A MOBILE CB ANTENNA USING THE N9921 FIELDFOX ANALYZER

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Abstract:

Citizens Band (CB) communication represents a widely used short-range radio service intended for personal and professional voice communication over relatively short distances. Operating in the 27 MHz frequency range, CB systems are commonly employed by truck drivers, off-road vehicle users, rural communities, hobbyists, and emergency support groups when simple, direct, and infrastructure-independent communication is needed. Their popularity is mainly due to low operating costs, ease of use, and the possibility of maintaining communication in areas where mobile network coverage is limited or unavailable.
A key element in the performance of any CB communication system is the antenna, whose correct tuning has a direct influence on transmission efficiency, signal quality, and equipment protection. An improperly tuned CB antenna may lead to poor radiated power, reduced communication range, and increased reflected power, which can negatively affect the transmitter. For this reason, antenna tuning is an essential step in ensuring optimal operation of CB radio installations.
This paper proposes an approach for tuning a Citizens Band antenna using the Keysight FieldFox N9912A analyzer, a portable and versatile instrument suitable for field measurements in radio-frequency applications. The method focuses on evaluating the antenna response through parameters such as return loss, impedance matching, and resonant frequency behavior within the CB operating band. By using a modern RF analyzer instead of conventional SWR-only methods, the tuning process can provide more accurate and comprehensive information regarding antenna performance. The tuning stages are presented in their natural sequence, with comparisons based on data and figures between two alternative approaches.
The study also highlights the practical relevance of CB communication systems in mobile and fixed applications, emphasizing the importance of reliable antenna adjustment for efficient signal propagation. The proposed approach supports both educational and practical objectives, offering a clear framework for understanding the relationship between antenna characteristics and communication quality. Proper tuning with advanced measurement equipment contributes to improved system reliability, safer transmitter operation, and enhanced overall communication performance in CB radio networks.

Key words: CB antenna tuning, N9912A analyzer, impedance matching, return loss

IMPROVING THE SEGMENTATION OF ACOUSTIC NEWS THROUGH SPEECH-TO-TEXT ANALYSIS, NER, AND JACCARD SIMILARITY

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Abstract:

In the field of audio signal processing, the task of refining the initial segmentation of continuous news streams into semantically distinct units remains a central challenge. While our previous PDE-based approach successfully detected major acoustic boundaries, subtle subject transitions often require post-processing for improved granularity — essential for efficient indexing, retrieval, summarization, and analysis in automated media monitoring and digital journalism. Traditional refinement methods rely on supervised learning or complex feature engineering, suffering from data dependence, limited interpretability, and sensitivity to noise.
Recent advances in natural language processing introduce Named Entity Recognition (NER) and Jaccard similarity as promising tools for the lexical analysis of speech-to-text transcriptions, allowing boundary detection through entity changes and reducing overlaps. These techniques have proven effective in text segmentation; however, their application to post-processing segments obtained from audio—especially for recovering lost boundaries of news elements—remains underexplored. This study extends our previous PDE framework by investigating a hybrid post-processing workflow for unsupervised refinement of broadcast news segmentation.
The main objective is to develop and evaluate a transcript-based refinement stage that applies NER to track entities and Jaccard similarity on adjacent segments to identify missed boundaries that are not captured solely through acoustic analysis (e.g., changes in energy or spectral features). The central hypothesis is that this semantic layer can improve the detection of discontinuities for subtle topic changes without large labeled datasets. The study evaluates performance relative to the baselines using segmentation accuracy (P_k, WindowDiff), noise robustness, and efficiency.
By integrating NER and Jaccard similarity with PDE-initialized segmentation, this paper provides a new and interpretable hybrid approach to audio structuring. Its contributions cover signal processing, NLP, and media analysis, being relevant for scalable analysis in resource-scarce multilingual news environments.

Key words: audio segmentation; broadcast news processing; speech-to-text refinement; Named Entity Recognition; Jaccard similarity; topic boundary detection; hybrid segmentation; post-processing pipeline

PERFORMANCE EVALUATION OF CODING TECHNIQUES IN SOFTWARE-DEFINED RADIO SYSTEMS FOR VEHICULAR APPLICATIONS

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Abstract:

Robust modulation and coding schemes are critical for intelligent transportation systems, where vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) links must sustain low error rates under noise and multipath propagation conditions. The investigated system operates primarily at the physical layer, where modulation, line coding, and channel coding techniques directly influence transmission reliability and spectral efficiency. Enhancing this layer is essential for ensuring dependable data exchange in safety-critical vehicular applications.

To improve the performance of vehicular radiocommunication systems, various coding strategies can be employed in conjunction with modulation schemes. This paper investigates the impact of selected coding techniques used in a radiocommunication system on bit error rate (BER) performance and spectral occupancy in an additive white Gaussian noise (AWGN) channel. Four approaches are considered: differential encoding, Manchester line coding, rate-1/2 convolutional coding (constraint length 7 with octal generators 171 and 133) with Viterbi decoding, and duobinary partial-response coding. The proposed schemes are modeled and simulated in MATLAB/Simulink over an AWGN communication channel. BER performance is evaluated as a function of E_b/N_0, and the results are compared with the theoretical BER curve of an uncoded QPSK system under identical conditions.The results show that differential encoding effectively resolves carrier phase ambiguity, albeit with a modest signal-to-noise ratio penalty. Manchester coding enhances timing recovery through guaranteed signal transitions but increases the required signaling rate and occupied bandwidth. Convolutional coding achieves a significant coding gain, improving BER performance at the cost of reduced spectral efficiency due to added redundancy. Duobinary coding shifts signal energy toward lower frequencies and reduces baseband bandwidth requirements; however, the controlled introduction of inter-symbol interference degrades BER performance in the AWGN scenario.These findings highlight the trade-offs between reliability, bandwidth efficiency, and implementation complexity at the physical layer, providing useful insights for the design of robust communication links in intelligent transportation systems.

Keywords: Bit Error Rate, Line Coding, Manchester Coding, Software-Defined Radio, Vehicular Communication Systems

AN ALGORITHM FOR DIGITAL STANDARDIZATION IN RENEWABLE ENERGY

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Abstract:

The rapid transition toward decentralized energy systems and the massive integration of renewable energy sources (RES) have created significant challenges for the stability and quality of national electricity grids. In the current global context of Industry 4.0, traditional standardization and certification processes, which are largely based on periodic physical inspections and static paper-based documentation, are becoming obsolete and inefficient. This research addresses the critical need for a modernized quality infrastructure by proposing an innovative framework for "Digital Standardization" and automated conformity assessment. The purpose of this study is to develop and validate a digital portfolio of standards that enables real-time quality verification for prosumers and industrial energy producers in the Republic of Moldova. The methodology employed consists of designing a multi-layered digital environment that integrates "Machine Readable Standards" (MRS) based on the SM EN 50160 framework. A core component of the experimental methodology involves the creation of a specialized algorithm that transforms static regulatory requirements into executable code. This ensures that the conformity of the energy parameters is verified autonomously and continuously. The experimental study was conducted by simulating various grid disturbance scenarios, such as harmonic distortions and voltage fluctuations, to test the algorithm's decision-making accuracy regarding quality limits. The main results demonstrate that the proposed algorithm can reduce the time required for conformity detection from days to milliseconds, effectively preventing the injection of non-compliant energy into the grid. Furthermore, the study introduces the concept of a "Digital Standard" for energy equipment, ensuring a transparent and immutable record of quality compliance. A brief discussion of these results indicates that, while the initial implementation requires an upgrade in digital gateway infrastructure, the long-term operational benefits include reduced administrative costs and enhanced grid resilience. In conclusion, the transition from paper-based standards to automated digital certification represents a fundamental shift in quality assurance, providing a scalable solution for the energy transition and aligning national practices with the latest international smart standards initiatives.

Keywords: digital standardization, machine-readable standards, power quality, automated conformity, renewable energy, smart standards, quality assurance.

VLSI IMPLEMENTATION OF AN AUTO-TUNING SIXTH-ORDER G_m-C LOW-PASS FILTER FOR RF APPLICATIONS

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Abstract:

The increasing performance demands of modern wireless communication systems place stringent requirements on the analog baseband filtering stages of RF receivers. Continuous-time G_m-C filters are widely adopted for their high linearity, wide tuning range, and compatibility with deep-submicron CMOS technologies. However, their cutoff frequency is highly sensitive to process variations, temperature drift, and supply fluctuations, which can severely degrade channel selectivity and overall receiver performance. This paper presents the design and implementation of **a** 6^{th}**-order** G_m-C **low-pass filter**, developed to ensure stable and accurate frequency response across all PVT conditions.

The filter employs a cascade of three biquad G_m-C stages optimized for linearity, noise performance, and low power consumption. The self-tuning system uses a reference clock and a phase-comparison technique to adjust the effective transconductance of the G_m cells, ensuring precise alignment of the filter’s −3 dB bandwidth with the target specification. This approach eliminates the need for external trimming, reduces sensitivity to component mismatch, and enhances long-term stability. The 6^{th}-order filter is implemented using a cascade of biquad G_m-C stages optimized making it suitable for multi-standard RF recivers operating in crowded spectral environments. The auto-tuning loop maintains the filter’s dynamic range and noise performance while reducing power consumption compared to conventional analog calibration techniques. The paper presents the complete design of a 6^{th} order G_m-C low-pass active filter from the electric schematic to the layout implementation in CMOS technology. The pre-layout and post-layout simulations confirm the theoretical results. The architecture also minimizes area overhead, enabling seamless integration into compact RF front-ends and is suitable for direct-conversion radio receivers.This work highlights the effectiveness of a tuning mechanism and it is relevant for modern wireless applications, IoT transceivers, software-defined radios, and any integrated system that requires precise channel-select filtering with low power consumption. Its ability to maintain filter accuracy without external calibration makes it particularly valuable for compact, low-cost, and integrated RF systems.

Key words: Auto-tuning Loop, Biquad, CMOS, G_m-C Filter, PLL, Transconductor.

EXPERIMENTAL MODULE FOR TESTING AUTOMOTIVE COMMUNICATION PROTOCOLS: DESIGN AND FUNCTIONAL TESTS

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Abstract:

Modern embedded and automotive electronic systems rely increasingly on distributed architectures in which numerous sensors, controllers, and peripheral modules must exchange data reliably. In this context, selecting an appropriate communication protocol is a key design decision that directly influences system performance, wiring complexity, and long-term maintainability. This research addresses the comparative evaluation of three widely used communication technologies - I2C, SPI, and WiFi - focusing on their applicability in non-ASIL automotive functions, such as diagnostics, auxiliary control, and monitoring tasks. The purpose of the study is to analyze the functional characteristics, limitations, and practical performance of these protocols within a controlled experimental setup, providing insight into how wired and wireless mechanisms can complement each other in mixed embedded environments. To achieve this, a modular test platform was designed using ESP8266-based microcontroller units arranged in various wired and wireless topologies. The system integrates I2C and SPI for short-range intra-module communication and WiFi for higher-level, cable-free interaction with external devices. During testing, wireless communication was fully validated across Master - Slave TCP and HTTP-to-TCP scenarios, demonstrating stable operation and measured latencies around 140 ms under controlled laboratory conditions. However, a preliminary hardware limitation was encountered when transitioning to I2C evaluation: the ESP8266 peripheral architecture does not fully support the multirole master–slave configuration required for complete wired protocol validation. As a result, the wired stage could not be assessed at the intended depth within the current prototype. This limitation does not affect the validity of the wireless experiments; instead, it provides a clear direction for system enhancement. The next prototype iteration will adopt ESP32-S3 microcontrollers, which feature a more capable dual-core architecture, extended peripheral support, and a fully compliant hardware I2C controller. In conclusion, the study confirms the suitability of SPI for deterministic, high-speed intra-ECU communication and the applicability of I2C for low-speed sensor interfaces, while WiFi remains a viable solution for non-critical auxiliary functions. The planned hardware upgrade will enable comprehensive wired protocol testing and allow the experimental platform to better reflect real automotive embedded system requirements.

Key words: Embedded systems, communication protocols, I2C, SPI, WiFi, automotive electronics.

THERMAL STRESS MONITORING OF ELECTRICAL EQUIPMENT FROM MEDIUM VOLTAGE CELLS

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Abstract:

The paper discusses the common aspects of wireless thermal stress monitoring for electrical equipment within Medium Voltage (MV) switchgear cabinets. It highlights the advantages and disadvantages of current non-intrusive methods used for monitoring the temperature of components in electrical equipment. The study presents findings from a laboratory experiment that focused on the benefits of monitoring the temperature of a collector bar component in an MV cell using a system equipped with surface acoustic wave (SAW) sensors. Additionally, the case study examines how suitable the SAW sensor monitoring method is for MV switchgear cabinets. By implementing these cells, environmental factors affecting electrical equipment can be minimized, allowing power stations to occupy much less space compared to traditional power stations. This also enhances safety in plant operations and consumer supply by reducing the risk of damage due to random events. The MV cells, designed for 6-20 kV distribution substations, are typically constructed in a cell form using sheet metal panels that are prefabricated and assembled with special rivets or spot welding. These cells house circuit-related equipment, including medium voltage switchgear, convertible trolleys, and low voltage metering, command, protection, and signaling apparatus. The housing of the cells usually features a lid with slots and a double wall oriented upward to vent gases resulting from electric arc combustion. The double-wall design of metal cells limits fire spread and can be adapted for outdoor use in a specially constructed room. Utilizing SAW sensors for temperature monitoring in medium voltage (MV) cells effectively highlights thermal stresses in electrical equipment. These sensors, similar to infrared monitoring, analyze acoustic waves at points along the current path to track temperature variations and identify loose connections. A recent laboratory experiment validated the installation of this temperature monitoring system using SAW sensors, showcasing advantages over infrared methods. Current infrared monitoring has drawbacks, including infrequent inspections, challenges in accessing components, reliance on engineers for interpretation, safety risks during image capture from energized cells, and high costs.

Key words: SAW sensors; Medium Voltage; thermal monitoring.

BEYOND OFFLINE PROGRAMMING: AUTONOMOUS ROBOTIC WELDING VIA VISION-LANGUAGE MODEL-GUIDED 3D SEAM EXTRACTION

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Abstract:

Industrial robotic welding in practice remains dominated by offline programming and teach-and-playback, both of which exhibit limited robustness when confronted with variable and uncertain shop-floor conditions. Their applicability in flexible manufacturing is constrained by two key prerequisites: the availability of accurate CAD representations of the physical workpiece and expert-authored offline programs that explicitly specify weld sequences, trajectories, and process parameters. These dependencies become critical limitations in real production environments characterized by part-to-part geometric variation, assembly errors, damaged or deformed stock, high-mix, low-volume production, or even the absence of complete digital documentation of the workpiece, as well as the growing shortage of skilled personnel. Existing automatic seam detection approaches — including structured-light methods, learning-based visual seam detectors, and 2D–3D fusion architectures — have substantially reduced manual intervention during execution, yet continue to operate within the same CAD-dependent paradigm, requiring task-specific retraining when joint geometry or part topology changes. A system capable of operating directly on real, unseen parts without CAD references or pre-authored weld programs remains an open challenge in autonomous manufacturing robotics.

This paper proposes a CAD-free and program-free pipeline that avoids requiring explicit CAD models and manually authored weld paths. A 3D laser scanner acquires a dense point cloud of the physical workpiece and simultaneously, a 2D camera captures multiple photographic snapshots of the same scene from defined viewpoints. These images are passed to a Vision-Language Model (VLM), which interprets the scene semantically: identifying weld joint types, candidate seam locations, spatial topology, and sequencing constraints. Critically, this semantic output functions not as a direct robot command, but as a guided search signal projected back onto the 3D point cloud — enabling precise geometric extraction of actual seam edges and keypoints in physical coordinates. A robot program, including trajectory, torch orientation, and weld sequence, is then computed automatically from this geometric representation and executed without further human input.

The primary open question driving this investigation is the geometric localization accuracy achievable through VLM-guided point cloud processing — a metric that has not yet been systematically reported in the welding robotics literature. Establishing whether current VLMs can meet industrial-grade tolerances directly on real parts and identifying the conditions under which additional geometric reasoning is required, constitutes the central research objective of this work.

Key words: Robotic welding, Offline programming, Vision Language Model, Point Clouds, Manufacturing

MODERN TRENDS IN LIGHTING ENGINEERING

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Ph.D. Supervisor, Catalin Daniel Galatanu,
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Abstract:

Modern lighting engineering is defined by a shift from basic illumination to human-centric design (HCL), smart automation, and sustainable materials. The concepts are focus on the integration of smart technologies, sustainability and biophilic design, with an emphasis on energy efficiency and user well-being.
Lighting is a foundational element of the smart home and IoT eco-system. Modern systems use robust wireless protocols to ensure reliable, low-latency control through applications or voice assistants. These systems offer significant energy savings of 50-75% through features like occupancy sensing, daylight harvesting, and automated dimming. Security is paramount, with end-to-end encryption and regular firmware updates to protect against network vulnerabilities.
From the point of view of aesthetics and integration with architecture, the trend is shifting from visible fixtures to invisible architectural lighting. Recessed downlights, cove lighting, and slim linear LED profiles are embedded into ceilings, walls, and furniture, creating a "quiet luxury" aesthetic where light itself becomes the architectural feature. This approach emphasizes layered lighting (combining ambient, task, and accent light) for a more complete and functional space. Modern lighting engineering is increasingly focused on biological and psychological *well-being*. Human-Centric Lighting (HCL) systems use tunable white LEDs to dynamically adjust color temperature (from 2200K warm white to 6500K cool daylight) and intensity throughout the day, aligning with natural circadian rhythms. This is proven to improve sleep quality, mood, and productivity, with some studies showing up to a 12% increase in task performance in office environments. These systems are now enhanced by AI and machine learning, which analyze user behavior and environmental data to proactively adjust lighting, moving beyond simple schedules to truly adaptive environments. Sustainability now encompasses the entire product lifecycle. Beyond energy-efficient LEDs, the focus is on material innovation and circularity. The use of LEDs for efficiency predominates, combined with eco-friendly materials such as recycled wood, bamboo, rattan and organic textiles, which bring a warm texture and reduce the carbon footprint. Designers are using reclaimed wood, recycled aluminum (saving 95% energy in production), recycled glass, bamboo, and cork. A key advancement is design for disassembly, where fixtures are engineered to be easily taken apart at end-of-life, allowing for efficient recycling of components and drastically reducing e-waste.

Key words: Human-Centric Lighting (HCL), Circadian alignment, Smart lighting and IoT, Sustainability and eco-friendly materials, Aesthetic and Architectural Integration.

AI-ASSISTED ENHANCEMENT OF INTRACARDIAC SIGNALS DURING RADIOFREQUENCY CATHETER ABLATION – A PRELIMINARY STUDY

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Abstract:

Radiofrequency catheter ablation is widely used in the treatment of cardiac arrhythmias, relying on intracardiac electrograms for accurate localization of pathological substrates. However, during the delivery of radiofrequency (RF) energy, these signals are significantly affected by artifacts, which may impair real-time interpretation and reduce the accuracy of clinical decision-making.

The purpose of this work is to perform a preliminary analysis of intracardiac signals acquired during RF ablation procedures and to evaluate the feasibility of improving their quality using advanced signal processing techniques, with future integration of artificial intelligence methods.

The study is based on real intracardiac recordings obtained from electrophysiology procedures. A first stage of analysis consisted of data exploration, including identification of relevant signal segments, visualization in the time domain, and observation of amplitude variations. A simple preprocessing approach was applied to interpret raw binary data and reconstruct multichannel signals.

The preliminary results highlight the presence of significant amplitude variations, intermittent high-intensity artifacts, and partial masking of physiological components. It was observed that the artifacts are not uniformly distributed in time and may affect channels differently, indicating the complexity of the signal structure. These findings confirm the necessity of developing robust preprocessing and denoising techniques.

Artificial intelligence approaches, such as denoising autoencoders, are considered as a promising direction for future work, aiming to separate useful cardiac information from RF-induced disturbances.

This study represents an initial step toward the development of intelligent tools for improving intracardiac signal quality during ablation procedures.

Key words: intracardiac signals, radiofrequency ablation, signal processing, artificial intelligence, artifact removal

CONSERVATION VOLTAGE REDUCTION AND OPTIMAL PLACEMENT OF REMOTE-CONTROLLED SWITCHES FOR VOLTAGE CONTROL IN LOW-VOLTAGE DISTRIBUTION NETWORKS

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Abstract:

The increasing integration of distributed energy resources (DERs), particularly photovoltaic (PV) systems and electric vehicles (EVs), introduces significant challenges in low-voltage (LV) distribution networks, mainly related to voltage deviations and operational stability. Under high penetration levels, bidirectional power flows and load variability lead to frequent overvoltage and undervoltage conditions, requiring advanced operational strategies. Among the available solutions, Conservation Voltage Reduction (CVR) and the optimal placement of remote-controlled switching devices represent two complementary approaches that can significantly improve voltage regulation and network performance. This paper investigates the coordinated application of CVR and the optimal placement of remote-controlled switches (reclosers and sectionalizers) for enhancing voltage control in LV distribution networks. The main objective is to evaluate how network automation infrastructure can support more effective voltage reduction strategies while maintaining compliance with operational constraints. The proposed methodology is based on a mathematical model implemented in MATLAB, incorporating power flow analysis, voltage constraints, and energy consumption sensitivity to voltage variations. The analysis is performed under two distinct scenarios. The first scenario considers the baseline operation without voltage control and without optimized switching configuration, highlighting the limitations of the existing network in terms of voltage deviations. The second scenario introduces a coordinated approach that combines CVR with an optimized placement of remote-controlled switches, enabling improved network segmentation and enhanced controllability. The results demonstrate that the proposed integrated approach significantly improves voltage profiles across the network, reducing both overvoltage and undervoltage occurrences. At the same time, the application of CVR leads to measurable reductions in energy consumption, while the optimal placement of switching devices ensures that voltage limits are respected under all operating conditions. The study confirms that the interaction between network topology and voltage control plays a critical role in maximizing the effectiveness of CVR. In conclusion, the combined use of CVR and optimally placed remote-controlled switches represents an efficient and practical solution for voltage control in modern LV networks, contributing to increased hosting capacity and improved operational performance.

Key words: Conservation voltage reduction, Voltage Control, Low-Voltage Networks, Remote-Controlled Switches, Distribution Networks, Power Quality

DEVELOPMENT STRATEGIES FOR GREEN HYDROGEN-BASED ENERGY COMMUNITIES

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Abstract:

The present research aims to analyse development strategies for green hydrogen-based energy communities to support climate neutrality objectives at local and regional levels. The study focuses on identifying and evaluating integrated implementation models for local energy communities that use green hydrogen as a central energy vector. Emphasis was placed on correlating renewable electricity generation with water electrolysis processes, hydrogen storage systems, and its subsequent utilization in electricity supply, heating, mobility, and industrial applications. The research methodology was based on the use of energy simulation tools, operational scenario modelling, and comparative analysis of relevant case studies. Energy demand profiles, renewable generation potential, technical performance of electrolyzers, storage capacities, and consumer behaviour patterns were assessed for representative urban and rural communities. In addition, aspects related to regulatory frameworks, economic feasibility, investment requirements, and social acceptance were examined in order to determine the practical viability of the proposed solutions. Several transition scenarios were developed to compare different levels of renewable penetration, hydrogen storage capacity, and sectoral integration. The obtained results indicate that the integration of green hydrogen within energy communities can significantly increase the share of renewable energy utilization, improve seasonal storage capacity, and reduce greenhouse gas emissions. The analysed scenarios demonstrated lower dependence on conventional energy grids, enhanced flexibility during peak demand periods, and greater resilience to energy price volatility. Furthermore, hydrogen deployment created additional opportunities for clean mobility solutions, local industrial decarbonization, innovative community-based business models, and long-term energy security. The findings also underline the importance of supportive public policies, adequate financing mechanisms, and coordinated infrastructure planning. In conclusion, green hydrogen can become a key enabling factor in the development of the next generation of energy communities, providing a viable and scalable pathway toward achieving climate neutrality and sustainable development objectives. By combining renewable production, advanced storage technologies, digital energy management systems, and participatory governance mechanisms, hydrogen-based communities can play a significant role in shaping resilient, low-carbon regional energy systems and strengthening local socio-economic development.

Key words: Green hydrogen; Energy communities; Climate neutrality; Renewable energy integration; Low-carbon communities.

LOW-COST INTEGRATED PLATFORM FOR REAL-TIME ACQUISITION OF OPTICAL PARAMETERS THROUGH CONTROLLED ANGULAR MOVEMENT

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Abstract:

Artificial lighting conditions in the hospital environment play an essential role in terms of patient comfort and also the performance of medical staff. In this context, the present work proposes the development of a modular platform, with reduced financial cost, for multi-angle acquisition of optical data in real time through controlled angular movement, designed for monitoring applications in medical spaces. The system proposes the integration of a control unit and a multi-sensor platform, which simultaneously monitors the color and intensity of light, the discretization of the low-frequency spectrum, ultraviolet radiation and flicker detection depending on the angular scanning position. The movement control is performed using a programmable microcontroller platform, allowing precise adjustment of the rotation angle and the delay of the scanning position. Each step of the motor is correlated with the sensor readings in real time, providing high-resolution data sets that describe the optical response of the analyzed spaces. Data transmission is performed wirelessly via a communication interface to a specially developed mobile application, where measurements are saved, visualized and shared in real time. The proposed system allows for reproducible optical measurements, providing a flexible alternative to conventional high-cost instrumentation. Preliminary results highlight the platform's ability to monitor lighting parameters in medical spaces. Comprehensive, this approach offers an accessible and flexible solution, characterized by modularity and scalability, for optical analysis, with potential for expansion to automated high-throughput setups.

Key words: multi-angular optical sensing, low-cost platform, real-time data acquisition, artificial light, hospital.

SECTION 3.
Chemistry;
Chemical engineering;
Environmental engineering

ADVANCED NANOCARRIERS FOR PRECISION THERAPY IN GLIOBLASTOMA

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Abstract:

Glioblastoma is the most aggressive and frequently diagnosed primary malignant brain tumor in adults, characterized by rapid progression, extensive cellular heterogeneity, and a very poor prognosis. Current therapeutic strategies, including surgical resection, radiotherapy, and chemotherapy with temozolomide, offer limited clinical benefits due to several biological and physiological barriers. One of the most significant obstacles in glioblastoma therapy is the presence of the blood–brain barrier, which restricts the penetration of many therapeutic agents into the brain. Additionally, the infiltrative nature of glioblastoma cells and the development of therapeutic resistance further complicate treatment outcomes. Consequently, the development of innovative therapeutic strategies capable of improving drug transport, targeting efficiency, and treatment efficacy has become an important focus in current biomedical research.

The purpose of this study is to analyze and evaluate modern therapeutic delivery strategies designed to improve the treatment of glioblastoma, with particular emphasis on nanotechnology-based approaches. The research focuses on understanding how advanced nanomaterials and carrier platforms can enhance the transport of therapeutic agents across biological barriers and increase their accumulation within tumor tissues.

The methodology employed in this work consists of a comprehensive review and analysis of recent scientific literature related to targeted therapeutic strategies and nanomedicine applications in glioblastoma therapy. Relevant research articles, reviews, and experimental studies published in international scientific journals were systematically examined in order to identify the most promising nanotechnology-based approaches, including liposomes, polymeric nanoparticles, dendrimers, and other nanoscale platforms capable of improving therapeutic efficiency.

The results highlight that nanotechnology-based therapeutic strategies demonstrate significant potential in enhancing drug stability, improving bioavailability, and facilitating targeted accumulation within tumor cells. Several nanocarrier platforms have shown promising results in experimental studies by improving drug penetration through the blood–brain barrier and enabling controlled release of therapeutic compounds. These approaches may reduce systemic toxicity while increasing the therapeutic concentration at the tumor site.

In conclusion, innovative nanotechnology-driven therapeutic strategies represent a promising direction for improving the effectiveness of glioblastoma treatment. Continued research and technological development in this field may contribute to the development of more efficient and personalized therapeutic approaches for patients affected by this highly aggressive brain tumor.

Key words: glioblastoma, nanomedicine, targeted therapy, blood–brain barrier, nanocarriers, brain tumor treatment

RECOVERY OF PRECIOUS METALS FROM ELECTRONIC WASTE: FROM EXPERIMENTAL APPROACHES TO ADVANCED TECHNOLOGICAL SOLUTIONS

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Abstract:

The exponential generation of electronic waste (e-waste) globally represents a major environmental challenge, but also an unprecedented economic opportunity, directly driving the concept of "urban mining." Recent data indicates that 53.6 million tons of e-waste were generated worldwide in 2019, with a massive increase to 74.7 million tons estimated by 2030, given that only 17.4% is currently formally recycled. Poor management leads to huge annual losses of precious materials, whose total potential value exceeds $57 billion.
The fundamental role of e-waste recycling lies in its dual function: mitigating the negative environmental impact caused by the storage of toxic metals and conserving exhaustible natural resources. For example, extracting a single ton of gold from virgin ore generates approximately 17,000 tons of CO_2 emissions, a toxic footprint that is substantially avoided by recovery from secondary sources. Given that printed circuit boards contain gold concentrations 35 to 100 times higher than primary natural ores, its recovery becomes extremely economically and environmentally viable. Traditionally, gold extraction has been carried out by pyrometallurgy or classical hydrometallurgy (cyanidation, halogenation, aqua regia), processes with a high carbon footprint and severe toxic potential.
This paper highlights a transition from the production stage to sustainable and highly selective recovery technologies, including biometallurgy (biorefining), the use of ionic liquids and deep eutectic solvents, photocatalytic processes, and laser ablation. In addition, advanced nanomaterials and adsorbents have been developed, such as Metal-Organic Frameworks (MOFs) and Covalent Organic Frameworks (COFs), which can selectively capture gold ions from extremely dilute solutions, spontaneously reducing them to high-purity metallic form. At the same time, on a biological level, the use of cyanogenic bacteria, such as Chromobacterium violaceum, has proven to be remarkably effective for extraction at ambient temperature. The recovered gold is reintroduced into the circular economy, being reused in the restoration of microelectronic contacts and, through a modern upcycling process, in the synthesis of gold nanoparticles with direct applicability in nanomedicine (biosensors, photothermal therapies) and industrial catalysis. Achieving real sustainability requires a hybrid paradigm: the transition from macro-scale extraction in mega-smelters to decentralized micro-recycling, combining advanced dismantling with green chemistry techniques, thus directly transforming e-waste from hazardous waste into next-generation high-tech materials with zero emissions and minimal losses.

Key words: e-waste, urban mining, gold recovery, upcycling, circular economy, MOFs

HYBRID NANOCOMPOSITE HYDROGELS FOR DENTAL APPLICATIONS

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Abstract:

In the current context of interdisciplinary scientific research, biomaterials have moved beyond their traditional role as mere inert structures, evolving into complex systems capable of actively interacting with the biological environment. Thus, hydroxyapatite, an inorganic biomaterial with a structure similar to the mineral phase of bones and teeth, has attracted particular interest due to its biocompatibility and ability to interact with the biological environment. However, it has certain limitations, such as high brittleness, a tendency to agglomerate, and rapid release of active ingredients. Similarly, hydrogels exhibit favorable rheological properties but generally have low mechanical stability.
Given these limitations, the present study aims to develop and characterize a hybrid nanocomposite hydrogel intended for local dental applications, based on hydroxyapatite, Carbopol, and various active principles. Hydroxyapatite provides bioactivity and serves as a carrier for the release of the active principles, compounds that stimulate cell proliferation and tissue healing. These hybrid materials function as controlled-release systems, preventing the sudden release of active ingredients and ensuring sustained release over an extended period, which is essential for regenerative processes.
The hybrid nanocomposite hydrogel was characterized using physicochemical and structural methods. FT-IR spectroscopy was used to confirm the incorporation of allantoin into the polymer matrix. Surface morphology and pore distribution were investigated using Scanning Electron Microscopy (SEM). Additionally, the stability and behavior of the material under temperature variations were evaluated through thermal degradation studies.

Key words: hydroxyapatite, hydrogels, biocomposites

COMPOSITE HYDROGELS BASED ON CALCIUM PHOSPHATES WITH APPLICATIONS IN MEDICINE

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Abstract:

Currently, a large number of scientific studies are focusing on the applications of calcium phosphates in regenerative medicine, in particular for bone tissue restoration. This is due to special characteristics of these phosphates: a very good biocompatibility and bioactivity, osteoinductive and osteoconductive capacities, favouring cell adhesion and cell growth due their interaction with extracellular matrix proteins. Of the calcium phosphates, hydroxyapatite is considered to be very important because it is the most abundant mineral component in the bone structure (about 70 % of the dry weight of bone tissue). Unfortunately, hydroxyapatite is brittle, which greatly limits its wide applications in medical field. For this reason, many studies have been directed towards creating biocomposites in which apatite is coupled with a polymer (exhibiting elasticity). In our study, new hydrogel-hydroxyapatite biocomposites were obtained using several types of biopolymers (gelatine and chitosan). The biocomposites were characterized by XRD, SEM, EDX, FTIR and Raman methods. FTIR and Raman results indicate the formation of strong interactions between the polymer chains and the hydroxyapatite crystals, which explains an enhancement of the mechanical properties of these composites. The hydrogel-hydroxyapatite biocomposites may have various applications in restorative medicine, in particular for the regeneration of bone defects and bone tissue healing.

Key words: calcium phosphates, hydroxyapatite, hydrogels, biocomposites, gelatine, chitosan

FUSEL OIL TO ALCOHOLS: PROCESS AND SEPARATION CHALLENGES

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Abstract:

Fusel oil, a byproduct of bioethanol production from sugar-based feedstocks via fermentation, is a promising secondary source of higher aliphatic alcohols. These compounds, including isoamyl alcohol, isobutanol, and propanol isomers, are valuable intermediates in the chemical industry. However, their recovery from fusel oil remains challenging due to the mixture's complex, non-ideal nature, particularly the presence of water, azeotrope formation, and the close boiling points of the components.

The aim of this study is to develop an effective process for separating fusel oil into its individual components and to assess their potential for further valorization. Particular attention is given to isoamyl alcohol, which can be further converted into isoamyl acetate, an important compound in flavor and fragrance applications.

To achieve this, a fusel oil sample was obtained and analyzed to determine the necessary physicochemical properties required as input data for subsequent process simulation. Based on these data, process simulations were performed in Aspen Plus V14.5. The thermodynamic behavior of the system was described using the NRTL model to accurately capture non-ideal phase equilibria. The proposed hybrid process integrates distillation, decantation, and flash separation in a structured sequence to address key separation challenges, including azeotrope formation, non-ideal phase behavior, and close-boiling-point mixtures. Process-related challenges, such as stream configuration, volatility adjustment via composition manipulation through enrichment of target components, water management through dehydration using internally recovered isoamyl alcohol, with subsequent recovery and purification of water via distillation, and the trade-off between product purity and recovery, are also considered. This is achieved through preliminary distillation followed by dehydration using internally recovered isoamyl alcohol, with energy efficiency enhanced through heat integration and an optimized process stream configuration. The simulation results show that high-purity alcohols, including ethanol, isopropanol, 1-propanol, isobutanol, n-butanol, and isoamyl alcohol (a mixture of 2-methyl-1-butanol and 3-methyl-1-butanol), can be successfully recovered. Importantly, the absence of added separating agents allows the products to retain their natural origin.

In conclusion, this work presents a practical and sustainable approach that valorizes an industrial byproduct and eliminates the need for external separating agents. It systematically addresses both process and separation challenges and demonstrates feasible, efficient solutions, supporting the use of fusel oil as a valuable feedstock in chemical-industry applications.

Key words: fusel oil, aliphatic alcohols, azeotropes, Aspen Plus, simulation

INFLUENCE OF ALUMINUM AND NICKEL INCORPORATION ON THE ADSORPTION PERFORMANCE OF SBA-15 MESOPOROUS MATERIALS FOR RHODAMINE B REMOVAL FROM AQUEOUS SOLUTIONS

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Abstract:

Despite extensive research on SBA-15 (Santa Barbara Amorphous-15) mesoporous materials, their applicability in wastewater treatment remains of great interest. Their highly ordered mesoporous framework, elevated specific surface area, and strong hydrothermal stability make them suitable candidates for adsorption applications. Furthermore, their properties can be modified by incorporating various elements, thereby influencing surface characteristics and adsorption efficiency.

The present study investigates the effect of aluminum and nickel incorporation into the SBA-15 framework on adsorption behavior and underlying mechanisms. The as-synthesized SBA-15 material was used as a reference and compared with the modified materials Al-SBA-15 and Ni-SBA-15. All samples were prepared using the sol–gel method, with a metal loading of 3 wt.%, aiming to adjust surface properties and adsorbent–adsorbate interactions.

Rhodamine B, a widely used cationic dye and a common pollutant in industrial wastewater, was selected as a model compound. The adsorption process was examined through three experimental approaches: (i) kinetic studies, performed by varying the contact time between 10 and 240 minutes; (ii) equilibrium studies, carried out by changing the initial dye concentration in the range of 5–20 mg/L at a constant contact time of 180 minutes; and (iii) temperature-dependent studies, conducted to evaluate thermodynamic parameters.

All experiments were performed in batch conditions at acidic pH (2–3), using 10 mg of adsorbent and 25 mL of Rhodamine B solution, under constant magnetic stirring (200 rpm). The residual concentrations were determined by UV–Vis spectrophotometry using a calibration curve obtained from standard solutions.

The experimental data were analyzed using kinetic models (pseudo-first-order, pseudo-second-order and Weber–Morris) and equilibrium isotherms (Langmuir, Freundlich, and Temkin). A better agreement with Freundlich and Temkin models was observed, indicating a heterogeneous adsorption surface and the presence of complex interactions between the adsorbent and the dye molecules. Thermodynamic parameters ($\Delta G°$, $\Delta H°$, $\Delta S°$) provided additional insight into the nature and spontaneity of the adsorption process.

The adsorption capacities—60.30 mg/g for SBA-15, 83.73 mg/g for Al-SBA-15 and 67.06 mg/g for Ni-SBA-15—highlight the influence of metal incorporation on adsorption performance. Overall, the results highlight that metal incorporation into SBA-15 leads to measurable changes in adsorption behavior, emphasizing the role of surface modification in improving material performance.

Key words: SBA-15, metal incorporation, Rhodamine B, adsorption kinetics, adsorption isotherms, wastewater treatment

VALUE-ADDED PRODUCT DEVELOPMENT FROM YELLOW ONION (*Allium cepa L.*) PEELS USING A GREEN EXTRACTION METHOD

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Abstract:

Yellow onion (*Allium cepa* L.) is a highly significant crop, prized both in its raw state as well as in various processed forms. Large-scale onion production implies a significant high-volume waste output, which is made up of the inedible outer peels, the two outer fleshy scales, roots, apical components and bulbs deemed unfit for human consumption. Traditional waste management strategies have shown a number of deficiencies, therefore newer and more efficient ones are needed, such as the development of value-added products, including nutraceuticals, food supplements or biobased food additives for functional foods. Onoion peels are a well-known renewable source of phytochemicals that can be converted through various extraction techniques into at least one of the aforementioned commercially valuable bioproducts. The phytochemical profile of yellow onion peels is rich in various bioactive compounds, with polyphenols representing approximatively 5.3% of total onion peel bioactives. Therefore, this research focused on developing an ultrasound-assisted extraction (UAE) method for isolating polyphenols and flavonoids from yellow onion peels. Quercetin was the main extracted compound. The process was monitored by HPLC/UV. A one-factor-at-a-time (OFAT) design was used to identify the best extraction parameters in order to maximize the targeted phytocompounds content. Six quantitative variables underwent a preliminary evaluation through the OFAT design: ultra-sound power (0 – 40 W/g DM), solvent concentration (0 – 100%), plant-to-solvent ratio (10 – 30 mL/g), temperature (40–70 °C), and extraction time (5–20 min). Statistical screening indicated that the ethanol concentration, US power and extraction time significantly influenced the main response variables—total phenolic content (TPC), total flavonoid content (TFC), quercetin content and antioxidant capacity (CUPRAC and DPPH). The best extraction conditions were determined as being the use of 60% ethanol, a US power of 20 W/g DM, and a total extraction time of 10 minutes. Using these conditions, expermiental results indicated that TPC ranged from 78.16 to 97.16 mg GAE/g DM, TFC ranged from 22.77 to 26.46 mg GAE/g DM, while CUPRAC values varied between 145.24 and 163.75 mg TE/g DM. These findings indicate that onion peels may represent a promising source of antioxidant agents, allowing for the development of value-added products such as quercitin-rich extracts.

Key words: ultrasound-assisted extraction, antioxidants, onion peels, bioactive compounds, quercetin

RADON MEASURMENTS IN WATER USING LUCAS SCINTILLATION CELL, DOSE ASSESSMENT AND ITS REMOVAL

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Abstract:

Radon (^{222}Rn) is a naturally occurring radioactive noble gas generated from radium (^{226}Ra) within the uranium (^{238}U) decay series. It emits alpha radiation and has a half-life of about 3.82 days, which allows it to move through rocks or soil layers and dissolve into groundwater and drinking water sources. When inhaled or ingested, radon and its short-lived daughter products, particularly Polonium-218 and Polonium-214, release alpha energy in sensitive tissues, potentially leading to genetic damage, chromosomal alterations, and cancerous transformation.
Radon present in drinking water represents a health concern through two main exposure routes. Direct consumption results in radiation dose to internal organs, while its release into air, increases inhalation exposure and can contribute to lung cancer.
The scope of this study was to determine and compare radon concentrations in bottled waters and to assess the associated annual ingestion doses for adults. Radon activity was determined using the Lucas scintillation cell technique, which incorporates a degassing system for the extraction and quantification of radon. 14 samples were examined (6 carbonated and 8 non-carbonated), with measured radon activity concentrations significantly below the safety limit of 100 Bq/L established by the World Health Organization (WHO) and Romanian regulations.
The findings suggest that carbonated waters generally show slightly elevated radon levels compared to non-carbonated varieties, possibly due to the presence of dissolved carbon dioxide and its interaction with radon. Furthermore, the study emphasizes difficulties related to radon loss during sampling, storage, and analysis, particularly in carbonated samples, where procedures such as ultrasonic CO_2 removal may affect the results. The calculated annual effective doses ranged from 0.22 µSv/y to 1.41 µSv/y, indicating that all analyzed samples fulfill the radiological safety requirements.
Furthermore, the removal of radon from water sources, particularly groundwater, where concentrations are often higher is of significant interest. Additional investigations have demonstrated that manganese oxide sand (MnO_2), widely applied in conventional water treatment processes, can effectively and simultaneously remove ^{222}Rn along with inorganic contaminants such as Mn^{2+}, Fe^{2+}, NH_4^+, and NO_3^-.

Key words: radon, Lucas cell, dose estimation, safety limit, waters

VEGETABLE OILS FUNCTIONALIZATION THROUGH EPOXIDATION AND RING OPENING REACTIONS

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Abstract:

Vegetable oils represent an important class of renewable bioresources with wide-ranging applications. The extent of functionalization and the resulting products are strongly influenced by fatty acid composition and their degree of unsaturation. Among all the available chemical modification pathways, epoxidation followed by ring-opening reactions is widely recognized as an efficient and versatile method. This approach aligns with green chemistry principles: the use of heterogeneous catalysts, “eco-friendly” solvents, high conversions and reduced amounts of waste.

In this context, the present study comparatively evaluates the functionalization of several vegetable oils—sea buckthorn (SBO), sunflower, sesame, safflower (SAFO) and linseed oils—under various reaction conditions, using different carboxylic acids (isovaleric, succinic, adipic, sebacic, and *p*-methoxycinnamic acids). This systematic approach provides insight into how reaction parameters and reagent structure influence the properties of the resulting materials.

The methodologies employed are well-established in the field literature and supported by our previous work, ensuring reproducibility. All reactions, including epoxide ring-opening, yielded products that were characterized by spectroscopic techniques (NMR, FTIR), followed in some cases by UV-Vis or thermal analysis.

The study highlights both total and partial epoxidation methods, as well as the efficiency of subsequent functionalization with mono- and dicarboxylic acids using a reusable MgAlLa layered double hydroxide catalyst. In all these experiments, quasi-total conversion was achieved. Among the tested oils functionalized with a branched monocarboxylic acid, SAFO exhibited the highest reactivity, being selected for further studies with dicarboxylic acids, thermogravimetric analysis suggesting that longer-chain diacids predominantly graft onto the same triglyceride branch rather than forming crosslinks between different fatty acid chains. On the other hand, *p*-methoxycinnamic acid (*p*-MCA) functionalized oils led to bio-based materials, the results showing that SBO, characterized by high oleic acid content, is more difficult to functionalize with *p*-MCA compared to linseed oil, which is rich in linolenic acid (higher degree of unsaturation). Consequently, SBO based materials were successfully converted into UV-absorbing bioconjugates with tunable photoprotective properties.

In conclusion, vegetable oils can be either entire or partially epoxidized, followed by an epoxy ring-opening reaction in heterogeneous catalysis, to produce bio-based materials with interesting properties due to their versatile functionalization capacity.

Key words: vegetable oils, epoxidation, ring-opening, carboxylic acids, bio-based materials

BIOMASS-DERIVED CARBON QUANTUM DOTS SYNTHESIZED VIA ULTRASONICATION METHOD

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Abstract:

The selection of suitable carbon precursors remains a critical factor in the development of scalable, sustainable and environmentally friendly routes for carbon quantum dot (CQD) synthesis. A key challenge is identifying low-cost, environmentally friendly, and nontoxic carbon precursors for large-scale CQD production. Among the available alternatives, biomass is particularly attractive due to its abundance, renewability, biodegradability, and high carbon and oxygen content. As a result, biomass-derived CQDs have received increasing attention, and numerous biomass resources have already been validated as effective precursors. More recently, low-value biomass waste was considered as a promising feedstock for CQDs production, presenting the advantage of waste valorisation and improved sustainability. In this context, the present study aims to develop a simple, environmentally friendly, and efficient ultrasonic route to synthesis of carbon quantum dots from banana peel waste, enabling controlled particle size without the use of high temperatures, long reaction times, or toxic reagents. Carbon quantum dots were synthesized by ultrasonic treatment of banana peel powder dispersed in an ethanol-water medium, while varying ultrasound amplitude and treatment time under controlled temperature conditions. After sonication, the suspensions were purified by sequential centrifugation, membrane filtration, and dialysis in order to remove large particles and low molecular weight impurities. The resulting solutions were characterized by FT-IR, UV–Vis and fluorescence spectroscopy, TEM, and absolute quantum yield measurements.
FT-IR and UV–vis spectra confirmed the presence of a conjugated sp^2 carbon core with abundant oxygen-containing groups at the surface, which ensured well aqueous dispersibility and generated characteristic π–π^* and n–π^* transitions. Increasing ultrasound amplitude promoted more efficient precursor fragmentation and a higher degree of surface oxidation, which was correlated with enhanced photoluminescence at around 330 nm and progressive increase of the absolute quantum yield from 33% to 42%. TEM images revealed nearly spherical, well-dispersed carbon quantum dots with narrow size distributions in all samples, with average diameters between 3.7 and 5.6 nm, depending on ultrasound amplitude.
These results demonstrate that ultrasonic processing parameters can be used to tailor CQDs size, surface chemistry, and emission properties without additional chemical oxidants or thermal treatments. The simplicity of the method, the mild conditions, and use of low-value biomass support its potential as a sustainable platform for CQD production and their future integration into functional materials.

Key words: carbon dots, biomass waste, banana peels, ultrasonication, photoluminescent properties

LAYERED DOUBLE HYDROXIDES AS 2D NANOSTRUCTURES FOR NANOMEDICINE APPLICATIONS

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Abstract:

Layered double hydroxides (LDHs) have emerged as a highly versatile and increasingly studied class of two-dimensional (2D) nanomaterials, driven by continuous advances in controllable synthesis techniques, surface engineering strategies, and detailed biological investigation. Characterized by a flexible brucite-like layered structure with tunable metal composition, adjustable interlayer spacing, and high anion-exchange capacity, LDHs provide significant opportunities for the rational design of tailored physicochemical properties suited for specific biomedical purposes. This work presents an overview of the key characteristics that support their engineering for applications in nanomedicine, including drug delivery systems, diagnostic platforms, and tissue engineering. Their structural versatility is highlighted through both top-down and bottom-up fabrication strategies, ranging from exfoliation into ultrathin nanosheets with high surface area to direct synthesis methods such as reverse microemulsion and aqueous miscible organic solvent approaches, which allow improved control over particle size, morphology, and crystallinity. Further functionalization through organic coatings and inorganic modifications, including cation substitution, enhances colloidal stability, reduces aggregation, and improves their performance and dispersion in complex biological environments. In therapeutic applications, LDHs enable controlled, pH-responsive drug release in acidic microenvironments, such as tumors, and serve as efficient non-viral vectors for nucleic acid delivery, including siRNA and mRNA. In theranostic applications, atomic-level engineering, such as Cu or Mn doping, allows LDHs to integrate imaging capabilities, for example MRI contrast enhancement, with stimulus-responsive therapies, including photothermal and sonodynamic treatments. Additionally, LDHs can modulate programmed cell death pathways, such as apoptosis and ferroptosis, and support tissue regeneration through the regulation of signaling processes involved in bone and skin repair. Despite their favorable biocompatibility, LDH safety remains dependent on size, composition, and surface chemistry, requiring standardized synthesis protocols and thorough long-term evaluation studies to ensure reproducibility and safety. Overall, LDHs represent a promising platform for nanomedicine, while further research is needed to bridge the gap between current understanding and practical biomedical application.

Key words: LDHs, drug delivery, nanomedicine, biocompatibility, biomedical applications

SYNTHESIS AND CHARACTERIZATION OF $ZnTiO_3$/CARBON NANOTUBES HYBRID MATERIAL FOR WATER TREATMENT APPLICATIONS

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Abstract:

Water contamination by organic pollutants and pathogenic microorganisms remains a critical global challenge, driving the development of advanced multifunctional materials for efficient remediation. Among the many emerging solutions, semiconductor-based photocatalysts combined with carbon-based nanostructures have attracted significant attention due to their enhanced charge separation, surface area, and even antimicrobial activity. In this context, the present study focuses on the design and evaluation of a $ZnTiO_3$/carbon nanotube (CNT) hybrid material for simultaneous degradation of organic and emerging pollutants and bactericidical applications in water treatment.

In this study we synthesized a $ZnTiO_3$/CNT composite with improved photocatalytic efficiency and antimicrobial performance compared to pristine $ZnTiO_3$. Firstly, the CNTs were functionalized using a mixture of sulphuric and nitric acid to increase its integration into the hybrid material. The hybrid material was prepared via a sol-gel method followed by thermal treatment ar 750°C to ensure the uniform dispersion of CNTs and the proper crystallization of the $ZnTiO_3$. Structural, morphological, and optical properties of the samples were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FT-IR), thermogravimetric analysis (TGA), and UV-Vis spectroscopy. The photocatalytic and antibacterial activity were assessed through degradation under UV-visible irradiation followed by representative Grap-negative and Gram-positive strains viability.

The results demonstrate that the incorporation of CNTs significantly enhanced the photocatalytic activity of $ZnTiO_3$, achieving higher degradation rates of pollutants compared to the pure oxide. This improvement is attributed to the role of CNTs as electron acceptors, which reduces charge recombination and promotes the generation of reactive oxygen species. Additionally, the hybrid material exhibits notable bactericidal effects. The synergistic interaction between photocatalytic oxidative stress and physical disruption of bacterial membranes by CNTs is proposed as the main mechanism.

In conclusion, the hybrid material shows strong potential as an efficient dual-function agent for water purification, combining effective pollutant degradation with antimicrobial activity, having applications in advanced water treatment systems.

Key words: perovskite, carbon nanotubes, hybrid materials, water treatment, antibacterial activity, photocatalysis

HETEROSTRUCTURES OF NANOPARTICLES OF METALS OR METAL OXIDES/ LAYERED DOUBLE HYDROXIDES FOR GREEN CHEMISTRY APPLICATIONS

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Abstract:

The transition toward more sustainable chemical processes requires the development of efficient catalytic systems able to address major environmental challenges such as CO_2 emissions and water pollution. In this context, layered double hydroxides (LDHs) have attracted significant attention due to their tunable composition, two-dimensional structure, and the so-called structural “memory effect.” These properties make LDHs suitable platforms for designing advanced materials and combining them with metal or metal oxide nanoparticles to form heterostructured photocatalysts.

This work presents an overview of nanoparticle–LDH heterostructures, focusing on how their structure and interfacial interactions influence photocatalytic performance. Different synthesis methods are discussed, including in situ growth, reconstruction using the LDH memory effect, and impregnation followed by thermal or chemical treatment. These approaches allow control over nanoparticle size, dispersion, and attachment to the LDH surface, which are key factors for obtaining stable and efficient catalytic systems. The interaction between nanoparticles and the LDH matrix plays an important role in improving photocatalytic activity. The LDH structure helps to stabilize nanoparticles and prevent their aggregation, while also contributing to adsorption and charge separation processes. These effects are especially relevant for systems based on transition metals, such as copper, where both particle size and the interaction at the interface significantly affect catalytic behavior. Potential applications in green chemistry are also highlighted, particularly for photocatalytic CO_2 reduction and the degradation of organic pollutants in water. LDH-based heterostructures can enhance light absorption and improve charge transfer, leading to more efficient solar-driven processes. In environmental applications, the combination of adsorption and photocatalysis allows effective removal of persistent contaminants.

Overall, heterostructures between nanoparticles of metals or metal oxides and LDH represent a promising class of materials for developing efficient and sustainable photocatalytic systems, with potential applications in environmental protection and green chemistry.

Key words: layered double hydroxides, photocatalysis, heterostructures, green chemistry

STUDY OF PHASE TRANSFORMATION PROCESSES USING ISOTHERMAL THERMOGRAVIMETRIC ANALYSIS

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Abstract:

The experimental study of phase transformation processes is essential for understanding the mechanisms and kinetics of these phenomena, with direct applications in optimizing industrial processes such as evaporation, sublimation, condensation, and crystallization. The experimentally obtained data enable both efficient control of technological parameters and validation of theoretical models used in the design of chemical processes. The high precision of mass measurement, ensured at constant temperature by the Mettler Toledo 851^e equipment, allows accurate monitoring of mass variations over time, providing highly reliable experimental data necessary for determining the kinetic parameters of the evaporation process of the compound DDMEBT (2-[(4-dimethylamino)phenyl]-3-[4-((4-dimethylamino)phenyl)ethynyl]-1,3-butadiene-1,1,4,4-tetracarbonitrile), an organic material with third-order nonlinear optical properties. Isothermal curves were recorded at three temperatures: 220 ºC, 230 °C, and 240 ºC, for 60 minutes, under an inert atmosphere (20 mL·min^{-1}). The mass of the analyzed samples was 5 mg. Based on these data, the evaporation rate was determined, which enabled the calculation of the activation energy. The estimation of activation energy based on the experimental data yields a value of 88.5 kJ/mol and a pre-exponential factor of 703.4 s^{-1}, indicating a moderate energy barrier associated with the evaporation process and confirming the significant influence of temperature on the intensification of mass transfer. The obtained results also confirm a kinetic evaporation regime characteristic of compounds with low volatility and high thermal stability. The study demonstrated that thermogravimetric analysis (TGA) is an effective method for investigating evaporation processes, as it allows direct monitoring of mass loss under controlled conditions and determination of kinetic parameters, thereby providing a detailed and predictive understanding of the volatilization behavior of organic compounds.

Key words: evaporation, DDMEBT, isothermal thermogravimetric analysis, activation energy

MUCOADHESIVE CHITOSAN NANOPARTICLES FOR ENHANCED OPHTHALMIC BIOAVAILABILITY

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Abstract:

Ocular drug delivery remains a significant challenge due to the presence of multiple physiological barriers, including tear turnover, nasolacrimal drainage, and the corneal epithelium, which collectively limit drug bioavailability to less than 5% for conventional eye drops. In recent years, nanotechnology-based systems have emerged as promising strategies to overcome these limitations. Among these, chitosan-based nanoparticles have attracted considerable attention due to their biocompatibility, biodegradability, and intrinsic mucoadhesive properties, which can enhance drug retention at the ocular surface and improve therapeutic efficacy.
The present study aims to develop and characterize mucoadhesive chitosan nanoparticles for enhanced ophthalmic drug delivery and bioavailability. Nanoparticles were prepared using the ionic gelation method, employing chitosan as a cationic polymer and sodium tripolyphosphate (TPP) as a crosslinking agent. Critical formulation parameters, including polymer concentration, chitosan-to-TPP ratio, and pH, were optimized to obtain nanoparticles with suitable physicochemical properties. The developed systems were characterized in terms of particle size, polydispersity index, zeta potential, encapsulation efficiency, and in vitro drug release profile. Mucoadhesive properties were evaluated using mucin interaction studies, while ex vivo corneal permeation studies were performed using excised animal corneas.
The optimized nanoparticles exhibited a mean particle size below 200 nm, a narrow size distribution, and a positive zeta potential, confirming their stability and strong interaction with negatively charged mucins. High encapsulation efficiency (>75%) and a sustained drug release profile over 24 hours were observed. Mucoadhesion studies demonstrated enhanced interaction with mucin, while ex vivo permeation results indicated a significant increase in corneal drug penetration compared to conventional formulations. These findings suggest that chitosan nanoparticles can effectively prolong precorneal residence time and facilitate drug transport across ocular barriers.
In conclusion, mucoadhesive chitosan nanoparticles represent a promising platform for improving ophthalmic drug bioavailability. Their ability to enhance drug retention, control release, and increase corneal permeability supports their potential for clinical translation in the treatment of various ocular diseases.

Key words: Chitosan nanoparticles, ocular drug delivery, mucoadhesion, bioavailability, ionic gelation, corneal permeation

ESSENTIAL OIL–BASED EMULSIONS IN THE MANAGEMENT OF GINGIVITIS

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Abstract:

Gingivitis represents one of the most prevalent inflammatory conditions affecting the oral cavity and constitutes the initial stage of periodontal disease. It is primarily associated with the accumulation of microbial dental biofilm that triggers inflammatory responses in gingival tissues. Conventional management strategies rely on mechanical plaque control combined with chemical antiseptics, among which chlorhexidine is considered the gold standard due to its strong antimicrobial activity. Nevertheless, prolonged use of chlorhexidine is frequently associated with adverse effects such as tooth staining, taste disturbances, and mucosal irritation, which may limit patient compliance. Consequently, increasing attention has been directed toward natural therapeutic alternatives, particularly plant-derived bioactive compounds and essential oils, which possess antimicrobial, anti-inflammatory, and antioxidant properties.
The aim of this research is to evaluate the therapeutic potential of essential oil–based emulsions in the management of gingivitis and to analyze the scientific evidence regarding their biological activity and clinical effectiveness compared with conventional antiseptic agents.
The research methodology consisted of the analysis of experimental and clinical evidence reported in the scientific literature, including in vitro studies, in vivo animal models, and randomized controlled clinical trials investigating plant-based oral formulations. In vitro investigations using gingival cell cultures and three-dimensional tissue models demonstrated that phytochemical compounds such as polyphenols and catechins exert antibacterial effects against important oral pathogens, including *Streptococcus mutans* and *Porphyromonas gingivalis*, while also reducing the expression of pro-inflammatory cytokines. In vivo animal studies using ligature-induced gingivitis models further confirmed the capacity of these agents to reduce inflammatory infiltrates and cytokine levels within gingival tissues.
Clinical trials evaluating herbal mouthrinses and plant-derived formulations have reported significant reductions in Plaque Index and Gingival Index values when used as adjuncts to standard oral hygiene practices. In several studies, these formulations demonstrated clinical outcomes comparable to chlorhexidine, while presenting improved sensory acceptability and fewer adverse effects.
In conclusion, essential oil–based emulsions represent a promising alternative approach for gingivitis management; however, further standardized clinical investigations are required to confirm their long-term efficacy, optimal formulation, and safety profiles.

Key words: gingivitis, essential oil–based emulsions, phytotherapy, oral biofilm, anti-inflammatory activity, plaque index

BIOMASS TRANSFORMATION IN THE CONTEXT OF ENVIRONMENTAL PROTECTION: CARBON CAPTURE AND WASTEWATER REUSE IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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Abstract:

Environmental degradation resulting from industrial activities, particularly greenhouse gas emissions and the release of toxic pollutants into water systems, represents a critical global challenge that threatens ecosystems and sustainable development. In response, biomass conversion technologies have emerged as promising tools for environmental remediation, offering applications in wastewater treatment, carbon capture, and resource recovery within a circular economy framework. This study investigates the potential of biomass-derived materials, with a focus on marine algae and engineered biochar, for the removal of toxic heavy metals from wastewater. It also examines their role in supporting indirect carbon sequestration. Additionally, the study compares the adsorption performance of algal biomass with that of agricultural residues and evaluates how different modification techniques influence adsorption efficiency and environmental applicability. The research is based on a systematic review of recent peer-reviewed studies, combined with a comparative analysis of experimental results related to biochar production, algal biosorption, and surface modification. Particular attention is given to marine macroalgae, such as Ulva species, alongside lignocellulosic and agricultural wastes. The reviewed studies include batch adsorption experiments conducted under controlled conditions (e.g., pH, contact time, and adsorbent dosage), as well as kinetic and isotherm models used to describe adsorption behavior. Mechanistic insights are derived from spectroscopic and surface characterization analyses. The findings indicate that marine algae-derived materials and engineered biochar are effective in removing a wide range of heavy metals, including Pb, Cd, Cr, As, Cu, Ni, Zn, etc. Engineered biochars generally exhibit superior adsorption capacity compared to raw biomass due to enhanced porosity and surface functionality. Modification techniques, such as metal oxide impregnation and chemical activation, further improve performance. The dominant removal mechanisms include ion exchange, electrostatic attraction, surface complexation, and precipitation. In conclusion, biomass valorization, particularly using marine algae, represents a sustainable approach for wastewater treatment and environmental protection. However, further research is needed to optimize performance and ensure scalability for practical applications.

Key words: valorization, marine algae, biochar, heavy metal removal, wastewater treatment, adsorption mechanisms

SYNTHESIS OF COPPER NANOCATALYSTS ON SURFACTANT-CONTAINING MESOPOROUS SILICA FOR THE HYDRODEOXYGENATION OF LEVULINIC ACID TO γ-VALEROLACTONE

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Abstract:

The depletion of fossil fuel reserves has increased focus on lignocellulosic biomass as a promising source of sustainable fuels and chemicals. Levulinic acid (LA), a versatile biomass-derived platform molecule, can be catalytically hydrodeoxygenated to γ-valerolactone (GVL), a renewable solvent, fuel additive, and intermediate for polymers and fine chemicals. LA hydrodeoxygenation (HDO) to GVL has been widely investigated over supported copper nanoparticles (NPs) owing to their low cost, low toxicity, and suitable redox properties for carbonyl hydrogenation. However, controlling the size and stability of supported Cu NPs to optimize catalytic performance remains challenging, especially at high metal loadings (≥5 wt.%). To address these limitations, copper nanocatalysts were synthesized herein via a simple incipient wetness impregnation (IWI) method using ethanol-extracted SBA-15 mesoporous silica supports containing non-ionic surfactant (samples xCu/Si_e, x = 5, 10 and 20 wt.% Cu). A reference catalyst was prepared by IWI on the calcined surfactant-free support (sample 10Cu/Si_c). The obtained materials were characterized by X-ray diffraction (XRD), DR UV-Vis spectroscopy (DRS), temperature-programmed reduction, transmission electron microscopy, and nitrogen physisorption. The catalytic performance was evaluated in the HDO of LA (1,4-dioxane as solvent, 150–200 °C, 30 bar H_2, 3 h). Products were analysed by GC-MS following a derivatisation protocol. The XRD patterns of samples prepared on extracted support show no diffraction peaks attributable to monoclinic CuO, indicating that the nanoparticle size is below 3 nm, irrespective of metal loading. In contrast, 10Cu/Si_c exhibits intense diffraction peaks attributed to large CuO particles, signifying the presence of extraporous bulk phases. Consistent with XRD, further characterization confirms that the xCu/Si_e materials consist of highly dispersed copper species, mainly isolated mononuclear Cu^{2+} ions or very small CuO_x nanoparticles anchored to the support, as identified by DRS in the 200–350 nm spectral region. 10Cu/Si_c consists of bulk CuO particles, along with a small fraction of dispersed copper species. The catalytic performance highlights a clear difference between catalysts prepared on calcined and extracted supports. Thus, at 175 °C, 10Cu/Si_c showed low LA conversion (4.4%), whereas 10Cu/Si_e achieved 100% conversion. Overall, xCu/Si_e materials exhibited superior catalytic activity and selectivity toward GVL compared with other copper-based catalysts reported in the literature.

Key words: copper nanocatalysts, SBA-15, levulinic acid, biomass, γ-valerolactone, hydrodeoxygenation

STUDIES ON MASS TRANSPORT IN ELECTROCHEMICAL SEPARATION PROCESSES

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Abstract:

Electrochemical separation processes, such as electrodialysis and capacitive deionization, have gained attention as energy-efficient alternatives for water treatment and resource recovery. However, their large-scale application is often constrained by slow mass transport of ions to the electrode surface, which limits current efficiency and increases energy consumption. This PhD research aims to quantitatively investigate the hydrodynamic parameters that control mass transfer in a model electrochemical cell and to develop a predictive correlation for the limiting current density.
The proposed methodology is based on a rotating disk electrode (RDE) system, which will serve as a well-defined hydrodynamic platform. Linear sweep voltammetry will be performed in sodium chloride solutions at concentrations ranging from 1 to 50 mM, with rotation speeds varying between 100 and 2000 rpm. The limiting current density will be recorded for each condition, and the mass transfer coefficient will be calculated using the Levich equation. All experiments will be conducted at room temperature (25°C) using a standard three-electrode configuration. The experimental data will be used to derive an empirical correlation in the form of Sherwood, Reynolds, and Schmidt numbers.
The theoretical dependence of the limiting current on the square root of the rotation speed will be established, thus evaluating Levich behaviour. The effect of the increase in the bulk concentration on the mass transfer coefficient will be also discussed. A preliminary empirical correlation of the form Sh = a Re^b Sc^c is expected to fit the data with an average deviation below 10%. These findings are likely to suggest that designing flow fields to promote turbulence near the electrode surface is more beneficial for improving separation efficiency than simply increasing the salt concentration.
Future work will validate the derived correlation in a prototype electrochemical separator for brackish water desalination. The outcomes of this research are expected to provide practical design guidelines for more energy-efficient electrochemical water treatment systems.

Key words: mass transport, electrochemical separation, limiting current density, rotating disk electrode, water treatment, convection

EXPLAINABLE MODELING OF OPERATING REGIMES AND THERMAL STABILITY IN A CSTR USING XAI TECHNIQUES

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Abstract:

Continuous Stirred Tank Reactors (CSTRs) represent fundamental units in chemical engineering, widely used in processes involving exothermic reactions characterized by nonlinear behavior and potential thermal instability. The safe operation of such systems requires predictive models capable not only of forecasting process variables but also of providing interpretable decision support. In this context, Explainable Artificial Intelligence (XAI) methods have gained attention due to their ability to combine predictive performance with transparency and auditability. The present study investigates the applicability of explainable modeling techniques for analyzing the dynamic behavior and thermal stability of a CSTR system.

The main objective of this research is to evaluate the capability of inherently interpretable machine learning methods to describe nonlinear operating regimes and generate physically meaningful rules associated with thermal safety. Two complementary tasks are addressed: regression, focused on predicting continuous process variables such as reactor temperature, and classification, aimed at identifying operational regimes defined as Safe, Warning, and Runaway-risk, based on temperature levels and dynamic indicators.

The methodology integrates a mechanistic dynamic model of an exothermic CSTR, formulated using mass and energy balances with Arrhenius-type kinetics, with synthetic data generation through numerical simulation. A wide parameter space was explored using systematic sampling strategies, resulting in datasets representing stable, transitional, and potentially unstable operating conditions. To ensure the robustness of the analysis, the experimental setup considered various levels of measurement noise and parametric uncertainty. Interpretable machine learning techniques, including linear regression, decision trees (J48), and piecewise regression models (M5P and M5Rules), were trained and evaluated using these datasets.

The results demonstrate that explainable models successfully capture the nonlinear thermal behavior of the reactor and identify meaningful operational thresholds separating Safe, Warning, and Runaway-risk regimes. The feed temperature (Tin) emerged as a dominant parameter influencing reactor stability, while dynamic indicators such as temperature growth rate provided clear criteria for regime discrimination.

Overall, the study confirms that XAI by-design approaches represent a promising framework for enhancing transparency and safety in predictive models applied to nonlinear chemical processes.

Key words: Explainable Artificial Intelligence, CSTR, thermal stability, decision trees, M5Rules, synthetic data

EXPLAINABLE RULE-BASED CLASSIFICATION OF OPERATIONAL STATES IN AN INDUSTRIAL GAS SCRUBBER USING ONER AND JRIP

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Abstract:

The increasing complexity of industrial gas treatment systems requires reliable decision-support methods capable of providing both predictive accuracy and transparent reasoning. In regulated industrial environments, where operational safety and compliance are critical, the use of interpretable machine learning models becomes particularly relevant. Explainable Artificial Intelligence (XAI) methods designed by construction offer the possibility to extract explicit decision rules that can be directly integrated into monitoring and control frameworks. In this context, the present study investigates the applicability of symbolic XAI methods for the classification of operational states in an industrial gas treatment scrubber system.

The main objective of the research is to evaluate the capability of inherently interpretable classification algorithms to generate transparent and operationally meaningful decision rules for identifying normal operation, reduced efficiency, and emission-risk conditions. The methodological framework involves the generation of a large-scale synthetic dataset representing the operational behavior of a industrial gas scrubber. Four measurable input variables were considered, namely liquid pH, gas flow rate, liquid flow rate, and pressure drop across the scrubber. A latent performance indicator representing absorption efficiency was computed using a deterministic function combined with controlled stochastic noise. The dataset, containing 50,000 instances, was generated using Python libraries (NumPy and pandas) and exported in formats compatible with the WEKA data mining platform.

Two symbolic classifiers were applied: OneR, used as a baseline screening method, and JRip, employed for extracting multivariate decision rules. Model evaluation was performed using stratified 10-fold cross-validation. The OneR algorithm identified liquid pH as the dominant variable, achieving an overall accuracy of approximately 78.7%, while providing a simple and fully interpretable rule suitable for primary alarm systems. The JRip classifier generated a structured set of 101 decision rules, capturing multivariate relationships between pH, pressure drop, and flow rates, and enabling refined diagnosis of degraded operational regimes.

The results demonstrate that symbolic XAI methods can provide interpretable, auditable, and operationally relevant decision rules, supporting their integration into industrial monitoring systems. The proposed framework highlights the potential of rule-based explainable models for enhancing safety, reliability, and transparency in industrial gas treatment processes.

Key words: explainable artificial intelligence, symbolic classification, OneR, JRip, industrial monitoring, gas treatment systems

SILICA AEROGELS FOR ENVIRONMENTAL APPLICATIONS: SELECTIVE REMOVAL OF ORGANIC POLLUTANTS FROM WATER

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Abstract:

Aerogels are a class of versatile materials used in various applications. Industrial wastewater treatment is a continuous challenge and requires updating traditional methods. Dyes represent one of the most common categories of pollutants, therefore, studies have focused on their removol from the aquatic environment. Most studies have focused on the study silica aerogels as adsorbent materials, but very few studies have reported on electrostatic interactions between the material and dyes. It is known that there are both cationic dyes and anionic dyes, with different mecahisms of adosorption. Based on this, the selectivity of materials is an important aspect that must be evidenced when applying them in the water treatment process, since most of the time, the discharged wastewater contains a mixture of dyes. Methylene blue and methyl orange are synthetic dyes that are used predominantly in various technological processes. They attracted particular attention due to their toxicity and resistance to conventional methods of treatment. Methylene blue belongs to the category of cationic dyes and is used for paper, textile and leather production. Methyl orange is an anionic dye, used in the pharmaceutical and food industry. Thus, these compounds end up being released into wastewater, causing significant environmental toxicity and posing serious risks to aquatic ecosystems and human health. Specialized studies have shown that silica aerogels are an effective way to absorb dyes. However, very few studies have conducted a systematic comparison of their adsorption capacity against dyes with different loads. Silica aerogels were successfully synthesized via the sol-gel method and characterized. BET analysis revealed a high specific surface area of 677,2 m^2/g, a total pore volume of 0,6753 cm^3/g, and an average pore diameter of 3,989 nm, confirming a well-developed mesoporous structure. FTIR spectroscopy confirmed the formation of the Si-O-Si network, while SEM imaging evidenced the characteristic three-dimensional porous morphology of the aerogel. Thermal analysis indicated good thermal stability of the material, supporting its potential for practical applications in wastewater treatment. In this paper, the selective adsorption of methylene blue and methyl orange was studied to outline the role of electrostatic interactions in the removal of dyes using these materials.

Key words: silica aerogels, adsorption, selectivity, ionic dyes, electrostatic interactions

ENCAPSULATED IRON OXIDE NANOPARTICLES WITHIN THE INTRAWALL PORES OF SBA-15 VIA MELT INFILTRATION AS AN EFFICIENT FENTON-LIKE CATALYST FOR LINDANE DEGRADATION

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Abstract:

The efficient degradation of lindane, classified as a persistent organic pollutant, has received limited attention in advanced oxidation processes (AOPs), particularly in Fenton-type systems that employ heterogeneous catalysts. The utilization of conventional supported NPs presents certain limitations, typically associated with the localization of NPs, such as non-uniform dispersion, poor stability, and susceptibility to sintering. The encapsulation of metal oxide NPs within a porous support, following a confinement strategy, offers several advantages, including control over particle size, shape and distribution, improved accessibility to reactants, and stability to aggregation, sintering and leaching. Following this we developed iron-based catalysts using a melt infiltration (MI) strategy with an additional time-controlled diffusion step to embed Fe_2O_3 nanoparticles within the intra-wall pores (IWP) of SBA-15 mesoporous silica. Physicochemical analyses (XRD, N_2 physisorption, DR UV-Vis, HR-TEM and synchrotron PDF) revealed that prolonged infiltration leads to the selective placement of well-dispersed hematite nanoparticles (<3 nm) exclusively within the intrawall pore (IWP) region of the support, while the primary mesopores of the SBA-15 support retain their mesostructural integrity and porosity. Catalytic tests in the Fenton-like oxidation revealed a notable improvement in lindane removal, with degradation efficiency increasing from 54% to reaching 91% in optimized samples. This performance was achieved after 240 minutes at pH 3 and 50 °C, with iron leaching kept below 2 ppm, significantly lower than values reported for similar systems. Control experiments confirmed that heterogeneous H_2O_2 activation at the solid–liquid interface dominates over homogeneous pathways, with confined nanoparticles ensuring efficient radical utilization. These findings demonstrate that melt infiltration (MI) strategy with an additional time-controlled diffusion step is an effective strategy for stabilizing iron oxide nanoparticles while tailoring the reaction microenvironment to enhance catalytic performance. Beyond its application to lindane oxidation, this strategy presents a flexible, broadly applicable pathway for creating robust, high-efficiency catalysts suited for advanced oxidation of persistent organic pollutants.

Key words: fenton oxidation, lindane, SBA-15, iron nanoparticles

STRUCTURAL REGENERATION OF LAYERED DOUBLE HYDROXIDES VIA MEMORY EFFECT: INFLUENCE OF KEY EXPERIMENTAL PARAMETERS

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Abstract:

Layered double hydroxides (LDHs) are a class of lamellar inorganic materials characterized by positively charged brucite-like layers and exchangeable interlayer anions. A distinctive feature of these materials is the so-called “memory effect”, which enables the reconstruction of the original layered structure after thermal decomposition. In this work, the structural regeneration of LDHs through the calcination–reconstruction pathway is systematically analysed, with emphasis on the experimental parameters governing this process.
The study focuses on the transformation of LDHs into layered double oxides (LDOs) via controlled calcination, followed by structural recovery upon exposure to aqueous media or humid environments. The influence of key operational parameters such as calcination temperature, pressure, pH, metal cation composition, and the nature of interlayer anions is evaluated in relation to reconstruction efficiency and resulting material properties. Calcination temperatures in the range of 450–550°C were identified as optimal for preserving the memory effect and enabling reversible reconstruction, whereas temperatures above 900°C lead to irreversible structural transformations and spinel phase formation. The reconstruction process is strongly dependent on the physicochemical environment. The pH of the reconstruction medium affects both surface charge and anion intercalation kinetics, with neutral to mildly acidic conditions favouring regeneration. High-pressure conditions inhibit structural recovery, particularly at values of several GPa. Furthermore, the metal composition significantly influences reconstruction kinetics, with Zn-based LDHs exhibiting faster recovery compared to other systems.
X-ray diffraction (XRD) is employed to monitor structural evolution during calcination and reconstruction, highlighting the disappearance and reappearance of characteristic reflections associated with the layered structure. These results demonstrate that precise control of experimental conditions is essential for optimizing LDH regeneration and tailoring their functional properties. Moreover, this approach enables the rational design of advanced LDH-based materials for catalytic and environmental applications. In addition, understanding the interplay between these parameters provides valuable insights into the mechanisms governing LDH structural recovery and supports the development of more efficient and tunable functional materials.

Key words: layered double hydroxides, memory effect, calcination–reconstruction, structural regeneration, X-ray diffraction

THREE-DIMENSIONAL FOAM/PUFF PRINTING ON ECO-FRIENDLY TEXTILES MADE FROM FLAX AND HEMP FIBERS USING NATURAL PIGMENTS AND CHT SYSTEMS

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Abstract:

In the context of current concerns regarding sustainability and the reduction of environmental impact in the textile industry, recent research has focused on the development of alternative technologies that utilize renewable resources and less polluting processes, capable of replacing conventional solutions based on synthetic compounds. Within this framework, the present study investigates the possibilities of obtaining three-dimensional foam/puff structures on eco-friendly textile substrates by using CHT printing pastes (Tubiscreen and Print Perfect) in combination with natural pigments, aiming to develop solutions compatible with current requirements of sustainability and technological efficiency.

The main objective of the study is to identify and evaluate suitable formulations for three-dimensional printing on cellulosic fibers, such as flax and hemp, which allow the formation of stable, uniform, and durable volumetric structures, while maintaining the ecological character of the process and reducing its negative environmental impact.

The methodology is based on an in-depth literature review, complemented by a comparative analysis of three-dimensional printing technologies and the behavior of natural pigments in foam/puff systems. The study examines the mechanisms of thermal expansion, the role of the polymer binder in stabilizing the structure, the influence of technological parameters such as temperature and activation time, as well as the interaction between the printing paste and the textile substrate, depending on the structural characteristics of the fibers used.

The results indicate that the integration of natural pigments into such systems represents a promising direction for the development of sustainable textiles. However, this approach is limited by reduced color stability, lower compatibility with the polymer matrix, and difficulties in process reproducibility under controlled conditions. Additionally, the structural characteristics of natural fibers significantly influence the uniformity, adhesion, and volume of the resulting structures, leading to variations in final performance.

In conclusion, the study confirms the potential of using natural pigments in foam/puff printing on eco-friendly textiles, while highlighting the need for optimization of formulations, technological parameters, and material–process interactions in order to enable efficient and reproducible implementation at an industrial scale.

Key words: three-dimensional textile printing, foam/puff, natural pigments, eco-friendly textiles, flax and hemp fibers, CHT printing pastes, sustainability, screen printing

STUDY OF AN ADSORPTION-BASED TREATMENT STEP PERFORMANCE ONTO A ZOOTECHNICAL FARM EFFLUENT

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Abstract:

Saving water, mankind safe and climate change reduction are needed today. A big pollution problem is tremendously increasing with agricultural, zootechnical, industrial and domestic sectors consuming huge quantities of available fresh water and, respectively, generating large amounts of wastewater (WW) containing polluting species with negative impact on human health and aquatic environment. Therefore, various mechanical, physical, chemical, biological and combined WW treatment technologies have been developed for the removal and recovery of polluting species; those based on adsorption / biosorption are promising alternative to replace conventional techniques because of its availability, profitability, simple design, low cost and higher performance when working in varying effluent concentration and flow regimes.
This research work presents the findings performed at studying of a physical-mechanical treatment step based on adsorption/biosorption applied on real effluents produced in different activities of a zootechnical farm, especially on WW from P3 collector (detailed in previous research work reported at CSD 2025) using prepared adsorptive materials as chopped straws (S), activated carbon powder (AC) and different mixtures of straw-activated carbon (various S/AC ratios). The adsorption performance considering the polluting species removals (e.g., suspended solids, turbidity, organics expressed as COD-Cr, colour, total dissoved solids (TDS), ammonia, extractible substances in organic solvents) was studied considering a few influencing factors, i.e. adsorbent dose, pH, temperature and solid/WW contact time. The corresponding variation interval of each studied influencing factor for obtaining of the highest removal performance of controlled polluting species from the real zootechnical effluent was proposed in order to be possible the initiation of the modelling and mathematical optimization of the studied adsorption-based treatment step.
The results are useful for solving one of the owner’ concerns related to the liquid effluents produced onto the zootechnical farm emplacement and fulfillment of the imposed norms from the environmental compliance plan and water management authorization for its sustainable and continuing development.

Key words: adsorption / biosorption, influencing factor, polluting species removal, treatment efficiency, wastewater quality norm, zootechnical wastewater

TOOLS FOR ASSESSING ENVIRONMENTAL QUALITY, ENVIRONMENTAL IMPACTS, ENVIRONMENTAL RISKS AND OCCUPATIONAL HEALTH

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Abstract:

Amid concerns about occupational health and safety regulations, and the impact of environmental, technological, and organisational factors on workplace performance and worker well-being, the need for an integrated approach has become increasingly evident. Numerous tools are used to assess environmental quality, environmental impact and risks, and workplace health, but they are often applied separately, limiting their effectiveness. The aim of the study is to evaluate and integrate these tools to develop a comprehensive framework for improving workplace safety and performance.

The analysis draws on 42 scientific articles across occupational health, environmental impact assessment, and risk management, with studies conducted predominantly in Europe (50%), followed by North America (25%) and other regions (25%). The analysis includes 17 observational studies (longitudinal, questionnaire-based), 9 systematic reviews, 3 mixed-methods studies, 9 modelling and quantitative analyses, and 4 experimental studies. The methods used include standardised questionnaires, direct observation, semi-structured interviews, experiments, and workshops.

The results highlight workers’ frequent exposure to ergonomic, physical, and psychosocial risks, which affect their health and performance. Musculoskeletal disorders are among the most common problems and are linked to absenteeism. Questionnaire-based studies also identify the organisational dimension of these risks. Approximately 17% of workers reported work-related absenteeism, 29% perceived production as taking precedence over safety, 36% had limited involvement in developing safety procedures, and 31% reported difficulties in reporting safety issues. Furthermore, in an experiment, the group trained using virtual reality demonstrated higher risk awareness than the control group, supporting the effectiveness of modern methods.

However, existing studies treat environmental assessment and occupational health separately, without an integrated approach, limiting our understanding of risks and highlighting a gap in the research. To address this gap, the study proposes developing and applying an integrated assessment approach that links environmental and occupational health dimensions. Promoting the implementation of these courses of action would contribute to more effective risk identification and the development of prevention strategies.

Key words: occupational health and safety, environmental impact assessment, risk management, integrated approach, virtual reality, workplace performance

EVALUATION OF BIOMASS TO BIOFUEL CONVERSION TECHNOLOGIES FOR PROCESS-SCALE APPLICATIONS

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Abstract:

The significant increase in global population has driven unprecedented rises in energy demand and waste generation, leading to higher fossil fuel consumption. The global population rose from approximately 8.2 billion in 2025 to 8.3 billion in 2026, accompanied by sustained energy demand growth of around 3–4%, annually. The utilisation of biomass as a renewable energy resource occupies a complex position at the intersection of environmental protection, sustainable development, and industrial innovation. The environmental impact of biomass use depends significantly on feedstock origin, land-use practices, and conversion efficiency. Using biomass as an energy resource and as a raw material for products can help reduce greenhouse gas emissions by substituting fossil fuels.
Furthermore, the study highlights the importance of process optimisation and policy support for deploying biomass-to-biofuel systems at industrial scale. This evaluation underscores the need to select conversion technologies appropriate to regional biomass availability and application-specific requirements to achieve sustainable and scalable biofuel production. The data also indicate that renewable energy increased modestly from approximately 20% of global supply in 2025 to 21–22% in 2026. Within this category, bioenergy remains the dominant contributor, accounting for approximately 54–55% of renewable energy production. This stability suggests that biomass continues to play a fundamental role in the renewable energy transition.
In summary, the environmental and developmental impacts of biomass use depend heavily on context, requiring a comprehensive systems approach that considers ecological, economic, and technological factors. Although the share of renewable energy has increased, emissions data show only slight changes in overall climate impact. CO_2 emissions increase modestly from 37.4 Gt in 2025 to 37.5–37.8 Gt in 2026, indicating that current mitigation efforts are insufficient to offset demand growth. Developing industrial-scale biomass technologies must be paired with sustainable resource management and supportive policies to ensure biofuels effectively advance long-term sustainability. Biomass should be viewed as a strategic supplement to variable renewables, helping to achieve energy security, reduce emissions, and support rural development when used responsibly and sustainably.

Key words: biomass, renewable resources, conversion technologies, feedstock, sustainability

VALORIZATION OF ALGAL EXTRACTS AS NATURAL DYEING AGENTS IN THE ECOLOGICAL DYEING OF TEXTILES

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Abstract:

In the context of the textile industry's transition toward sustainable practices and the use of renewable biological resources, this research proposes the investigation of algae extracts as natural coloring agents for dyeing ecological textile materials. Algae, both marine macroalgae and microalgae, constitute a valuable source of natural pigments and bioactive compounds, such as chlorophylls, carotenoids, and phycobiliproteins, distinguished by their coloring, antioxidant, antimicrobial, and photoprotective properties, which recommend them as promising alternatives to conventional synthetic dyes. The extraction of pigments from algal biomass can be carried out using classical methods, such as maceration and extraction with aqueous or hydroalcoholic solvents, as well as modern techniques, including ultrasound-assisted extraction, microwave-assisted extraction, pressurized liquid extraction, or supercritical fluid extraction, depending on the nature of the target compounds and their stability. The chemical characterization of the obtained extracts can be performed by means of advanced analytical techniques, such as high-performance liquid chromatography (HPLC), Fourier-transform infrared spectroscopy (FTIR), UV-Vis spectroscopy, and proton nuclear magnetic resonance (^{1}H-NMR), in order to identify the compounds responsible for the shade and the associated functional properties. The application of algal extracts in dyeing processes contributes to reducing environmental pollution by diminishing the consumption of toxic chemicals and by valorizing an abundant, renewable, and insufficiently exploited natural resource in the textile field. The stability, fixation capacity, and coloristic performance of these natural pigments can be evaluated through spectroscopic analysis, colorimetric measurements, and fastness tests to washing, light, and rubbing. The specialized literature highlights a significant affinity of algal pigments for natural textile fibers, such as cotton, wool, silk, and flax, ensuring not only the obtainment of varied shades but also the conferral of additional functional properties, such as ultraviolet protection and antimicrobial activity. Therefore, the valorization of algae extracts in textile dyeing aligns with the principles of green chemistry and circular economy, supporting the development of innovative, ecological, and competitive technologies for the textile industry. This approach represents a relevant endeavor for reducing the ecological impact of textile finishing processes and for integrating natural resources into sustainable production systems. Future studies will aim at optimizing extraction conditions, improving the fixation degree of pigments on different textile supports, and extending the applicability of these natural dyes to synthetic fibers or textile blends as well, with a view to developing sustainable and functional textile materials.

Key words: algae, natural dyes, textile dyeing, algal pigments, green chemistry, sustainability

TOWARDS SUSTAINABLE TOURISM IN MEDITERRANEAN DESTINATIONS: AN LCA PERSPECTIVE ON HERAKLION, GREECE

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Abstract:

The transition to a circular and low-impact tourism sector has become a key priority in European sustainability policies, particularly in the context of climate change mitigation and resource efficiency. Tourism activities are associated with a significant environmental impact, driven primarily by transportation, accommodation, and consumption patterns. In this context, life cycle assessment (LCA) offers a robust methodological approach for quantifying and comparing environmental impacts across different tourism scenarios. This study investigates the environmental impacts associated with a typical tourist package to Heraklion, Greece, a well-established Mediterranean destination that attracts a significant number of Romanian tourists, especially during the summer season. The main objective is to identify the key factors contributing to environmental impact and to analyze how different transportation and accommodation options influence the overall impact. The research follows the LCA framework defined by ISO 14040/14044 standards. The modelling was carried out using GaBi software, applying multiple impact assessment methods. Several scenarios were developed to reflect conventional travel options, including air travel, coach travel, conventional private vehicle, and electric vehicle, as well as accommodation categories ranging from 2 to 5 star hotels. Environmental impacts were characterised using multiple methods, covering categories such as climate change, acidification, eutrophication, particulate matter formation, photochemical ozone formation, and water use. The results indicate that, across the analysed tourism package scenarios, transport represents the main source of environmental impact in most categories, with travel by a conventional gasoline-powered car contributing significantly to overall emissions. Accommodation-related impacts are comparatively lower, although differences between hotel categories become more evident in terms of water use and energy consumption. Overall, the findings suggest that, the environmental performance of a tourism package cannot be improved by addressing its components in isolation, but requires an integrated perspective on all components. In this context, the shift toward more sustainable transportation options and the improvement of resource efficiency in the accommodation sector is particularly important. The study contributes to advancing sustainable tourism through a scenario-based approach and highlights the role of circular economy principles in supporting practices aligned with the objectives of the European Green Deal.

Key words: accommodation, environmental impact, life cycle assessment, sustainable tourism

EFFECT OF OPERATING PARAMETERS ON THE PERFORMANCE OF MEMBRANE CELL BRINE ELECTROLYSIS

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Abstract:

Membrane electrolysis systems that produce sodyum hydroxide and chlorine are now commonly used in many advanced industrial countries. In addition to these two main high-purity products, hydrogen is a zero-carbon energy source with high energy density that could form the basis of future sustainable energy systems. The largest share of the cost of hydrogen production via electrolysis comes from electricity consumption. From this perspective, it is important that scientific efforts focus on the development and improvement of the energy efficiency of brine electrolysis processes.

This study examines the key factors of brine electrolysis using an industrial membrane electrolyzer. The effects of operating parameters such as electrolyte concentration and temperature on conductivity, as well as the effect of current density, were investigated. Additionally, the impact of the distance between electrodes on the cell voltage required for electrolysis was assessed. One of the most important factors affecting cell voltage is temperature. Higher temperatures can enhance internal chemical reactions and increase the conductivity of NaCl and NaOH solutions. Current density is another crucial parameter in electrolysis, as it can be directly controlled. Reducing the distance between electrodes decreases electrolyte resistance, leading to a lower cell voltage. The efficiency of electrochemical reactions is often evaluated using current efficiency. Two types of current efficiency were calculated based on Faraday’s law of electrolysis: one for chlorine produced at the anode and another for hydrogen produced at the cathode. The high energy consumption in the membrane brine electrolysis process led to investigation and research concerning the zero-gap cell configurations, which minimizes the distance between the electrodes and the membrane.

The study presented in this paper contributes to a better understanding of the chlorine–hydrogen membrane process used in industrial applications. By analizing current conditions we are provided with a foundation for future research that aims to optimize operating conditions and ensure maximum efficiency in chlorine and hydrogen production.

Key words: current efficiency, conductivity, electrodes, ion-selective membrane, oxygen-depolarized cathodes

STUDY OF MASS TRANSFER FOR BRINE PURIFICATION BY ION EXCHANGE

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Abstract:

Brine purification process is an important step for chlor-alkali electrolysis in membrane cell systems. Commercially available weakly acidic cation exchange resin with chelating iminodiacetic acid groups designed are used industrially for the selective removal of alkaline earth cations.
The performance of selective removal of calcium and magnesium cations using Lewatit MonoPlus TP 208 ion exchange resins results from the combined effects of thermodynamic and rate factors. Rate factors determine the efficiency of the real process compared to the ideal process performance, considering the heat and mass transfer limitations, reaction kinetic limitation and hydrodynamic dispersion resulting from velocity distribution across the liquid phase. The literature lacks sufficient experimental research that scientifically explains the behaviour and the performance of the new commercial resins and investigations on the kinetics and thermodynamics of the brine hardness purification process.
Previous studies show that kinetics followed the pseudo-second-order kinetic model ($R^2 > 0.985$) for brine and synthetic solutions. Equilibrium data were fitted to Langmuir and Freundlich isotherm models with Langmuir model providing a slightly better predication ($R^2 > 0.985$).
To take the study to another stage – dynamic mode operation is necessary to consider the mass transfer limitation – external mass transfer between the external surfaces of the ion exchangers and the surrounding fluid phase. The driving force is the concentration difference across the boundary layer that surrounds each particle, and the latter is affected by the hydrodynamic conditions outside the particles.
Preliminary batch ion-exchange experiments were conducted on synthetic electrolytes to determine the effect of resin dose, agitation, initial hardness concentration, contact time solid – liquid show a better performance of ion exchange process with increases of ion exchanger dosage and an optimal value of agitation of 50 rpm. This preliminary study allows for the subsequent implementation of the ion-exchange brine purification process in dynamic mode. The final objective of the study is the transposition to an industrial scale, so that the secondary brine purification process can be exploited industrially in optimal conditions with maximum efficiency.

Key words: brine electrolysis, kinetic, diffusion model, secondary purification

CONTRIBUTIONS TO THE SUSTAINABLE VALORIZATION OF RECYCLED EDIBLE VEGETABLE OILS

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Abstract:

In recent decades, the cosmetic and pharmaceutical industries have increasingly oriented toward sustainable development and the circular economy, promoting the reuse of recycled vegetable oils, such as palm and sunflower oils. These can reduce environmental impact when properly purified and quality-controlled. Rich in fatty acids, tocopherols, and phytosterols, these oils contribute to skin protection and hydration, and, after regeneration, can retain their properties, making them suitable for cosmetic applications. Vegetable maceration represents an efficient method for obtaining bioactive compounds. Fir buds, rich in essential oils, phenolic compounds, and flavonoids, exhibit antioxidant, anti-inflammatory, and antimicrobial effects, making them valuable for skin care. The introduction of direct maceration of fir buds into used edible oils significantly enhances their valorization by enriching them with bioactive compounds, thereby improving the efficiency and functionality of the resulting creams, as well as their sustainable and innovative character. The rheological characterization of creams obtained from recycled edible oils is essential to ensure stability, appropriate texture, and optimal behavior during application, thus guaranteeing both product performance and consumer acceptability. This study aims to formulate and rheologically characterize creams based on recycled oils and to evaluate the effect of fir bud–macerated oils on product properties, contributing to the development of sustainable cosmetic emulsions.

Key words: sustainable development, recycled edible vegetable oils, cosmetic formulations, fir bud maceration, rheological characterization

SECTION 4.

Civil engineering and installations

ANALYSIS AND SYNTHESIS OF MATHEMATICAL METHODS FOR ESTIMATING SOIL EROSION

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Abstract:

Soil erosion is one of the most significant forms of land degradation on a global scale, affecting agricultural productivity, ecological sustainability and water resource quality. The process of soil particles being stripped and transported by water or wind leads to the removal of topsoil and facilitates the accumulation of sediment in watercourses. In recent decades, mathematical models have become essential tools for assessing erosion rates and supporting soil conservation plans.

In recent decades, mathematical models have become essential tools for assessing erosion rates, understanding the mechanisms involved and supporting soil conservation strategies. These models enable the quantification of soil loss under different environmental conditions and provide valuable insights into the influence of factors such as rainfall intensity, soil properties, slope and vegetation cover.

This paper focuses on the analysis of the main mathematical models used to measure soil erosion, including empirical models and those based on physics principles. Special attention is paid to commonly used models, such as the Universal Soil Loss Equation (USLE), the Revised Universal Soil Loss Equation (RUSLE) and the Water Erosion Prediction Project (WEPP). These models can also be integrated with modern geospatial platforms such as Google Earth Engine, allowing for advanced spatial analysis and improved monitoring of soil erosion at large scales. The benefits and constraints of these models within environmental management and sustainable land use are discussed. Their structure, input requirements, applicability and accuracy are examined in order to highlight their strengths and limitations.

Furthermore, the study emphasizes the importance of selecting an appropriate model depending on data availability, spatial scale and research objectives. The integration of these models with modern geospatial technologies enhances their applicability in environmental monitoring and decision-making processes.

The results underline that, although no single model is universally applicable, each approach contributes significantly to the assessment and management of soil erosion. Consequently, the use of mathematical models represents a key component in achieving sustainable land management and preventing long-term soil degradation.

Key words: soil erosion, mathematical models, USLE, RUSLE, WEPP, soil degradation

A COMPREHENSIVE THEORETICAL FRAMEWORK FOR THE APPLICATION OF LARGE LANGUAGE MODELS IN INTERPRETING MONTE CARLO ANALYSIS FOR "WHAT-IF" SCENARIOS WITHIN BIM-ENABLED CONSTRUCTION ENVIRONMENTS

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Abstract:

Building Information Modeling (BIM) has fundamentally transformed the planning and execution of construction projects, yet managing cost and schedule uncertainty remains a persistent challenge. Traditional applications of Monte Carlo Simulation (MCS) in this context rely on highly manual workflows for extracting quantities from BIM models, linking them to cost estimates, defining probability distributions, and propagating uncertainty. Recent advances in Large Language Models (LLMs) have created new opportunities for automating BIM data interpretation; however, their direct use as standalone predictive tools is constrained by documented hallucination rates exceeding 30% in unstructured cost estimation tasks.
This research investigates whether LLM mediated orchestration can bridge validated BIM to Knowledge Graph (KG) pipelines and MCS engines in a way that preserves both probabilistic rigor and auditability. The primary objective is to show how LLMs can support interpretable, fully traceable probabilistic cost and schedule forecasts for complex what if scenarios, while maintaining accuracy comparable to expert driven Monte Carlo workflows.
The proposed methodology introduces a tripartite architecture. First, an Industry Foundation Classes (IFC)–to–Knowledge Graph transformation layer encodes BIM models into a structured, semantically rich representation. Second, a deterministic Beta PERT based Monte Carlo engine performs cost and schedule uncertainty propagation using calibrated input distributions. Third, a multi agent LLM orchestration layer—comprising Interpreter, IFC KG, Monte Carlo, and Synthesis agents and supported by Retrieval Augmented Generation (RAG)—translates natural language queries into structured tasks, coordinates data flows across components, and synthesizes explanations of probabilistic outputs.
The study demonstrates the architectural feasibility of positioning LLMs as interpretive orchestrators rather than black box predictors. It highlights pathways of compositional uncertainty, such as semantic retrieval degradation and stochastic instability, and argues that component level performance benchmarks cannot be assumed to transfer unchanged to integrated systems. By constraining LLM operations through structured knowledge graphs, calibrated Monte Carlo engines, and explicit reasoning chains, the framework establishes a theoretical foundation and set of integration protocols for future empirical case studies in BIM enabled construction risk management.

Key words: Large Language Models, Building Information Modeling, Monte Carlo Simulation, Knowledge Graphs, Risk Assessment, Artificial Intelligence

METHODS AND TECHNIQUES FOR ENHANCING ARCHAEOLOGICAL HERITAGE IN URBAN SPACES

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Abstract:

Archaeological heritage represents a fundamental component of European identity, reflecting cultural diversity, historical continuity, and the shared values of member states. In a contemporary context characterized by globalization, increased mobility, and accelerated socio-economic transformations, European cultural policies have progressively adopted integrated approaches aimed at the sustainable and inclusive protection, enhancement, and promotion of heritage. These strategies go beyond traditional conservation perspectives, emphasizing the active role of heritage in community development and in strengthening social cohesion.

Within this framework, urban archaeological heritage has gained particular importance, as it is often subject to significant pressures generated by urban development, infrastructure expansion, and functional transformations of cities. Integrated approaches to heritage management require the correlation of multiple domains, including culture, education, tourism, urban planning, and environmental protection, as well as the active involvement of local communities in decision-making processes. In addition, digitalization and the use of emerging technologies—such as 3D modeling, augmented reality, and digital documentation platforms—play a key role in the documentation, interpretation, and accessibility of archaeological heritage.

The present study develops applied research on the evaluation and integration of archaeological sites within the contemporary urban fabric, while preserving their historical and symbolic value. The proposed methodology focuses on identifying criteria for urban insertion that ensure both the authentic conservation of archaeological remains and their valorisation through compatible and publicly accessible functions. From this perspective, heritage integration becomes an active tool in sustainable community development, contributing to urban regeneration, increased tourist attractiveness, and the strengthening of local identity.

The proposed approach is holistic, combining cultural, social, economic, educational, and technological dimensions of heritage. This perspective is supported by European institutions, which promote policies and programs aimed at transforming cultural heritage into a strategic resource for sustainable development and social cohesion. Consequently, archaeological heritage is no longer perceived solely as an element to be preserved, but as a dynamic resource capable of generating value and actively contributing to the future development of urban communities.

Key words: archaeological heritage, urban integration, structural assessment, sustainable development, digital technologies, urban regeneration

FIELD VALIDATION OF ACOUSTIC CORRELATOR LEAK DETECTION IN DRINKING WATER NETWORKS: INFLUENCE OF PIPE MATERIALS

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Abstract:

Leak detection in drinking water distribution networks remains a major technical and operational challenge, particularly in aging urban systems where hidden losses reduce hydraulic efficiency, increase energy consumption, and accelerate infrastructure deterioration. Among the available non-destructive techniques, acoustic correlation is widely used in practice because it allows the localization of leaks without immediate large-scale excavation. However, its field performance is not determined solely by the equipment itself, but also by the physical and hydraulic characteristics of the investigated pipeline, especially pipe material, diameter, network geometry, internal pressure, and background noise conditions.

This paper presents a field-based validation of acoustic correlator performance for leak detection in drinking water distribution networks, with particular emphasis on the influence of pipe materials on signal propagation quality and localization reliability. The analysis is based on validated case studies conducted in the urban networks of Piatra Neamt and other localities using the correlator on steel and HOPE pipelines with different diameters, sensor spacings, and operational conditions. For each investigated sector, the interpretation was based on the correlation response, the estimated leak position, the signal-to-noise ratio (SNR), and field confirmation through excavation or independent anomaly verification.

The results indicate that metallic pipelines generally produced clearer, stronger, and more stable correlations, with higher confidence in leak localization and better agreement with field validation. By contrast, HDPE pipes and sectors with more complex geometries, fittings, buried hydrants, or branching configurations generated weaker, less stable, or more ambiguous responses, making interpretation more cautious and operationally dependent. These findings confirm that pipe material is a primary factor affecting leak detectability because it influences attenuation, damping, and wave transmission along the pipe wall.

The study confirms the practical utility of acoustic correlation as an effective non-destructive tool for locating leaks in real utility networks, while also showing that its performance must be interpreted in relation to material-sensitive propagation conditions and local network complexity. The paper therefore provides applied field evidence useful for water utilities seeking to integrate acoustic correlation with complementary methods such as thermal inspection, GPR investigation, and excavation validation.

Key words: acoustic signal propagation, network geometry, utility asset management, pipe materials, field validation

OPTIMIZATION OF THERMAL ENERGY STORAGE SYSTEMS FOR ENERGY-EFFICIENT BUILDINGS INTEGRATING PCM-BASED LATENT STORAGE, STRATIFIED TANKS AND HEAT PUMPS

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Abstract:

Buildings remain among the primary energy consumers, and thermal loads for heating and cooling dominate both final consumption and the associated power peaks. In this context, thermal energy storage becomes a key element for increasing the operational flexibility of energy-efficient buildings by shifting consumption over time, reducing grid demand, and increasing the utilization of renewable energy or waste heat. The purpose of this paper is to analyze and optimize two main forms of thermal energy storage in energy-efficient buildings to enhance overall system performance. The first is sensible storage, traditionally achieved using water, characterized by reliability, low cost, and ease of implementation. The second is latent storage, based on phase change materials (PCM), which allows for the accumulation of a large amount of energy within a narrow temperature range. Integrating these two solutions into a hybrid system represents an efficient direction, as it combines classic solutions with the advantages of high energy density offered by PCM materials. A key aspect highlighted in the paper is that the performance of thermal energy storage systems depends not only on storage capacity but also on the heat transfer rate. In practice, limitations related to the thermal conductivity of PCM materials can significantly reduce system efficiency. To overcome these limitations, heat transfer enhancement solutions are analyzed, such as the use of fins, porous structures, or heat pipes. These methods contribute to reducing charging and discharging times and to a more efficient use of the storage volume. The methodology used is based on a comparative analysis of storage solutions, correlated with studies on heat transfer and their integration into systems with heat pumps and stratified tanks. The analysis results show that hybrid solutions, combining sensible and latent storage, lead to significant increases in energy efficiency and better management of thermal loads. The analysis emphasizes that the performance of thermal energy storage systems is conditioned by both storage capacity and heat transfer efficiency, as well as system-level integration. In conclusion, combining sensible and latent storage, coupled with proper system design, leads to efficient and stable solutions adapted to the specific requirements of nZEB buildings

Key words: thermal energy storage, PCM materials, heat transfer, heat pumps, stratified tanks, nZEB buildings

TECHNOLOGIES FOR IMPROVING ANTI-EROSION WORKS IN SMALL HYDROLOGICAL BASINS

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Abstract:

Modern technologies play a fundamental role in improving the assessment, monitoring, and management of soil erosion processes, particularly in small hydrological basins characterized by high spatial variability and rapid hydrological response. These basins are especially vulnerable to land degradation, which requires the use of advanced and integrated tools for accurate analysis and effective intervention planning (Toth & Jóźków, 2016). This paper focuses on the application and integration of advanced technological solutions—namely Geographic Information Systems (GIS), remote sensing, unmanned aerial vehicles (UAV), LiDAR (Light Detection and Ranging), Ground Penetrating Radar (GPR), and real-time environmental monitoring systems—in the design and optimization of anti-erosion works.

These technologies enable high-resolution spatial data acquisition, detailed terrain modeling, subsurface investigation, and continuous monitoring of environmental parameters. Their combined use significantly enhances the accuracy, reliability, and efficiency of erosion risk assessment, allowing for better identification of vulnerable areas and more precise targeting of mitigation measures (European Commission, 2020; European Space Agency, 2023). An integrated methodological framework is proposed, based on the correlation of multi-source data and the use of modern analytical techniques, in order to support informed decision-making and sustainable land management practices.

The importance of GIS in the study of soil erosion processes is also emphasized, as highlighted by research conducted in Romania. Previous studies demonstrate the effectiveness of GIS techniques in identifying, mapping, and monitoring erosion processes, as well as in analyzing the factors influencing soil degradation (Biali, 2005; Biali & Popovici, 2003). Furthermore, the integration of UAV-derived data with LiDAR models and remote sensing imagery provides a comprehensive understanding of both surface and subsurface processes, improving the overall quality of environmental assessments (Colomina & Molina, 2014; Jaboyedoff et al., 2012).

The results of this study indicate that the adoption of modern technologies not only increases the efficiency and accuracy of anti-erosion works but also contributes to reducing long-term costs and promoting adaptive, data-driven management strategies. In this context, the continuous development and integration of these technologies represent a key direction for future research and for the implementation of sustainable solutions in small hydrological basins

Key words: modern technologies, soil erosion, GIS, UAV, LiDAR, GPR, real-time monitoring, small hydrological basins

RISK AND VULNERABILITY OF HERITAGE FACADES – AN ESSENTIAL FACTOR IN RESTORATION

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Abstract:

Historic masonry in heritage buildings frequently exhibits degradation caused not only by classical mechanical actions—such as gravitational loads, seismic forces, landslides, or soil pressure—but also by a series of complex physico-chemical processes associated with environmental factors. These processes include water action, freeze–thaw cycles, salt crystallization, temperature and humidity variations, as well as biological activity. Even materials traditionally considered durable, such as natural stone, are subject over time to slow but continuous degradation mechanisms, leading to significant structural and aesthetic changes.

This complex phenomenon, characterized by progressive transformations of the material, is defined in the specialized literature as “alteration.” Alteration affects not only natural stone, but also artificial masonry materials such as ceramic bricks, as well as historic mortars, which often differ in composition and microstructure from modern materials. In the case of heritage buildings, these processes are particularly critical, as they influence both the mechanical behavior of masonry and the integrity of decorative or artistic components associated with the structure.

In order to establish appropriate intervention solutions for the restoration of historic masonry, the authors conducted a series of experimental investigations and in situ analyses aimed at characterizing the degree of alteration and identifying the main contributing factors to degradation. The research included detailed visual inspections, laboratory analyses of the physical and mechanical properties of materials, and evaluations of the environmental conditions influencing their evolution. The obtained results enabled the definition of relevant criteria for diagnosing the conservation state and for selecting compatible intervention methods.

The authors’ approach is framed within a broader context in which the conservation of built heritage requires not only the preservation of historical and artistic value, but also the fulfilment of structural safety requirements, including mechanical strength and stability. These requirements are essential for both load-bearing elements and decorative components integrated into or attached to the structure.

In conclusion, effective restoration interventions must be based on a thorough understanding of degradation mechanisms, ensuring material compatibility and the long-term durability of the adopted solutions, while maintaining both structural integrity and heritage value.

Key words: heritage facades, masonry degradation, risk assessment, vulnerability, structural behavior, restoration

OPTIMIZATION OF THE GEODETIC NETWORK FOR MONITORING THE HORIZONTAL DEFORMATIONS OF THE STÂNCA-COSTEȘTI DAM USING GNSS TECHNOLOGY

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Abstract:

Monitoring the deformations of major engineering structures requires the use of determination methods with millimeter-level accuracy, capable of highlighting the actual displacements of points between observation cycles, and not merely the variations caused by measurement uncertainties. This process is essential for evaluating the time behavior of hydraulic structures and for ensuring their operation under safe and efficient conditions.

In the case of dams, deformation determination is traditionally carried out through terrestrial triangulationtrilateration measurements, a method also used within the geodetic network associated with the Stânca-Costești Dam. The configuration of this network is characterized by an extensive deployment over varied terrain, which, over time, has led to the appearance of visibility obstacles caused by vegetation, as well as to the degradation of the network's initial geometric configuration and a reduction in its performance.

As a result, the network no longer fully meets the geometric quality criteria imposed by current standards, making optimization interventions necessary through its completion and reconfiguration. In this context, the introduction of GNSS baseline vectors, reduced to the local projection plane, represents an efficient solution for improving the network geometry and increasing the precision of the determinations, while maintaining compatibility with the classical measurement framework.

The paper presents the stages of design, observation, and processing of GNSS observations, as well as their integration into a mixed adjustment model, performed by the least-squares method together with the existing terrestrial observations. The main methodological aspects and the manner in which the observations are integrated into a unified adjustment system are highlighted.

The evaluation of the results is carried out on the basis of global and local precision indicators, with a detailed analysis of the configuration of the error ellipses at the newly determined points. The obtained results highlight that the integration of GNSS observations leads to a significant improvement in the geometric quality of the network and to an increase in the accuracy of displacement determination, representing a modern, efficient, and reliable solution. In addition, the proposed solution provides a high degree of flexibility in adapting the network to field conditions and facilitates the future integration of modern geodetic monitoring technologies.

Key words: GNSS, geodetic network, deformation monitoring, dam, least-squares adjustment

ACTIVE COOLING TECHNIQUES FOR PHOTOVOLTAIC PANELS: A COMPARATIVE ANALYSIS AND PERSPECTIVE ON NET ENERGY PERFORMANCE

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Abstract:

In the context of the energy transition and the increasing share of renewable energy sources in the European energy mix, photovoltaic (PV) systems represent an essential solution for electricity generation, especially in building-integrated applications. Their performance is strongly influenced by the operating temperature of solar cells, as temperature increase leads to a reduction in output voltage and consequently to a decrease in electrical efficiency and generated power. Under real operating conditions, panel temperatures frequently exceed 60°C, resulting in significant performance losses. The paper presents an analysis of advanced active cooling techniques applied to photovoltaic panels, focusing on the evaluation of reported performance and the identification of existing methodological limitations. The methodology consists of a comparative analysis of recent studies addressing active cooling using air, water, nanofluids, and hybrid systems, from the perspective of constructive configurations, operating principles, and performance indicators. The results of the analysis indicate that active cooling techniques generally lead to temperature reductions between 5 and 35°C and to increases in electrical efficiency ranging from 2% to 20%, depending on the system type and operating conditions. Water-based and hybrid systems show superior performance compared to air cooling, while the use of nanofluids enhances heat transfer but is associated with increased technological complexity. The analysis highlights a major limitation of existing studies, namely the partial evaluation of cooling system performance without explicitly integrating the auxiliary energy consumption required for system operation. In the absence of this criterion, the net energy gain of the actively cooled photovoltaic system cannot be rigorously determined, and the comparability of reported results remains limited. The need for the development of an evaluation framework based on net energy performance is emphasized, enabling the optimized and controlled use of active cooling depending on real operating conditions, application type, and system characteristics, particularly in nearly zero-energy building applications.

Key words: photovoltaic panels, active cooling, thermal management, energy efficiency, net energy performance, PV/T systems

TRADITIONAL TECHNOLOGIES FOR CONSTRUCTION: OLD PROCESSING PROCEDURES AND MATERIAL COMPOSITIONS

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Abstract:

Heritage buildings are constructions with symbolic, cultural or architectural value, protected by laws and regulations to be preserved without altering their form in order that future generations can benefit from their value as they were originally conceived. Thereby all interventions must take into account the substance of the original material, without tending to correct or modify the old workmanship that dictates the appearance of the monument and finally to take into account all established national and international norms. Heritage buildings type differs not only from one country to another but to regions in the most of the cases, also timeline, influences and the cultural impact. The reason behind this statement is that the workmanship and raw matter are differing from a zone to another, the raw matter refers to rock types, wood types, pigments sources and many others. In order to make an intervention, beside the full study of the history of the monument, all it’s defects or anything else, there should be perform an investigation regarding how the workmanship was did and what was the composition of materials that were used at that time. This paper investigates the old workmanship procedure regarding making and applying mortars and plasters as they were inherited through time. The study will be conceived with the help of different collected information from qualified artisans and lecturers regarding compositions and appliance techniques. The study was performed mainly at Bánffy Castle, Bonțida, in Romania on the occasion of participating in a restoration course. The purpose of the research is to explain the principles regarding interventions on heritage buildings and to pass on the old techniques that could be lost over time due to their infrequent use apart of restauration projects. The research itself is a descriptive one without tending to intervene. As it could have been seen in this paper there must be performed a set of investigations before starting a restauration project regarding history of the building, main causes of degradation and their stopping, original composition of the materials – here mortars and plasters and the appliance techniques.

Key words: composition, mortar, old plaster technique

A REVIEW OF ARTIFICIAL INTELLIGENCE APPLICATIONS IN CIVIL ENGINEERING

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Abstract:

The development of Artificial Intelligence (AI) and its profound implications in nearly all areas of human activity are widely recognized, especially with the rise of generative AI and the progress in AI-based generative models, accelerating the adoption of these technologies in various research domains. Civil engineering is no exception and the contribution of artificial technologies in traditional engineering practices are improving the process of analysis and decision-making in design, construction, implementation and overall infrastructure systems management. This presentation offers a literature review of AI integration in civil engineering among major domains like structural engineering, geotechnical engineering, transportation, environmental engineering, water and hydraulic engineering, construction and project management and smart infrastructure. This study analyzes high-impact research studies, selected based on impact factor and citation metrics, from prominent scientific databases such as Web of Science (WoS), Scopus and IEEE Xplore. Dominant branches of AI, such as machine learning (ML), deep learning (DL), robotics and optimization, have been identified, alongside growing interest in IoT, virtual reality (VR), and BIM for their impact on civil engineering. However, several challenges remain, including data quality issues (such as incomplete or inconsistent data), the lack of standardized AI applications, high computational and implementation costs, limited multidisciplinary expertise from AI and engineering domain, and trust and security concerns. Integrating AI with human expertise is still recommended and necessary to ensure effective decision-making and high-quality project management in civil engineering. Future research directions in AI for civil engineering will focus on improving model performance and usability through approaches such as Physics-Informed Neural Networks, transfer learning for data-scarse scenarios, and explainable AI to enhance trust and acceptance of AI among engineers, decision-makers, and regulatory bodies. In addition, integrating AI with BIM-based models, Digital Twins, and IoT systems can support real-time monitoring and management of infrastructure, while addressing ethics, fairness, and interdisciplinary collaboration remains essential.

Key words: Artificial Intelligence, civil engineering, literature review

SEISMIC VULNERABILITIES, ASSESSMENT AND STRENGTHENING OF EXISTING HIGH-RISE LARGE PANEL BUILDINGS

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Abstract:

Buildings with large prefabricated panel (LPP) structural systems constitute a major component of the existing building stock in Romania, having been constructed on a massive scale during the period 1960–1990. At the peak of the industrialisation programme, over 80% of new collective housing in Bucharest was built using large prefabricated panels. These cellular-type structures, composed of vertical diaphragms (structural walls) and horizontal diaphragms (floor slabs) connected through wet-cast or dry joints, currently house hundreds of thousands of residents throughout Romania.
This presentation provides a comprehensive overview of the principal structural deficiencies identified in these buildings as a consequence of major seismic events and long-term deterioration, the seismic vulnerability assessment methodologies, and the available strengthening measures. Particular attention is given to the lessons drawn from significant earthquakes, notably the Vrancea earthquake (1977, M 7.4), as well as from structural incidents that have raised considerable concern.
The typical damage patterns identified include: cracking and deterioration of vertical and horizontal joints, degradation of metallic inter-panel connections, reinforcement corrosion within joint zones, and delamination of the outer layers of sandwich wall panels. Seismic assessment is performed through experimental methods, numerical methods, or a combination of both, employing finite element models calibrated against experimental data.
The retrofitting measures presented range from localised interventions — such as joint injection and repair, provision of supplementary reinforcement, and strengthening of metallic connections — to global structural solutions, including the addition of new reinforced concrete shear walls, the application of fibre-reinforced polymer (FRP) composite systems, and foundation strengthening.
The findings of this study underscore the necessity of an integrated assessment and intervention approach, tailored to the specific construction characteristics of each prefabricated system, the local seismic context, and the current state of structural degradation. Given the considerable proportion of the Romanian housing stock that relies on these structural systems and the country's significant exposure to Vrancea intermediate-depth seismic activity, the development of reliable, cost-effective evaluation and retrofitting strategies remains a matter of national importance for ensuring both life safety and the long-term serviceability of the existing built environment.

Key words: large prefabricated panels, seismic vulnerability, structural assessment, retrofitting, prefabricated joints, progressive collapse, numerical modelling

ASPECTS OF SOIL-STRUCTURE INTERACTION MODELLING FOR HIGH-RISE RESIDENTIAL BUILDINGS: WINKLER APPROACH, FIXED-BASE ASSUMPTIONS AND EXPERIMENTAL EVIDENCE

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Abstract:

Soil-fundation-structure interaction (SFSI) modelling constitutes an essential aspect in the seismic response assessment of high-rise residential buildings, yet it remains one of the most prevalent sources of uncertainty in current structural analysis practice. Conventional design methodology assumes a fixed-base numerical model at the foundation level, thereby disregarding the compliance of the foundation soil and its effects on natural vibration periods, internal force distribution and seismic energy dissipation mechanisms.

This presentation examines the critical aspects of modelling the interaction between soil and the foundations of high-rise residential buildings, founded on various foundation systems, with particular emphasis on the Winkler model and its limitations. The Winkler model ($p = k_s \cdot w$) idealises the soil as a bed of independent elastic springs characterised by the Winkler coefficient, k_s, which is not an intrinsic soil property but rather depends on the size and geometry of the foundation, the soil stratigraphy, the relative foundation-soil stiffness and the applied stress level. Classical methods for determining k_s are discussed, along with the corrections required when transitioning from the standard plate load test to actual foundation dimensions, as well as the non-uniform distribution of subgrade stiffness beneath raft foundations.

Particular attention is devoted to the significant discrepancies between fundamental vibration periods obtained from fixed-base models (T_FEM) and those measured experimentally through ambient vibration monitoring techniques (T_experimental). Existing studies demonstrate that fixed-base models systematically underestimate the fundamental period by 15–40%, as they neglect soil deformability, foundation rocking effects and kinematic interaction at the foundation level. Incorporating SFSI through Winkler springs or dynamic impedance functions yields longer natural periods, closer to experimentally measured values, and a redistribution of internal forces within the structure.

The paper highlights that fixed-base modelling may lead to unconservative seismic vulnerability assessments, particularly for buildings situated on highly compressible soils. The necessity of calibrating numerical models against experimental data and of performing sensitivity analyses on geotechnical parameters is emphasised as an essential practice in the structural assessment of existing buildings.

Key words: soil-structure interaction, Winkler model, Winkler coefficient, foundations, raft foundation, fundamental period, fixed-base model, seismic assessment, numerical modelling

COMPARATIVE ANALYSIS OF CARBON EMISSIONS BETWEEN A REINFORCED CONCRETE BRIDGE AND ITS GLUED LAMINATED TIMBER (GLT) EQUIVALENT

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Abstract:

The growing interest in reducing environmental impact in the construction sector is a key driver in optimizing structural solutions and in selecting low-carbon-emission materials. At the same time, for spans in the 21–40 m range, prestressed concrete bridges have traditionally been considered an efficient technical and structural solution.

The need to reduce the carbon footprint has led to the investigation and development of alternative solutions with lower environmental impact. In this context, the present study provides a comparative analysis of carbon emissions for two types of superstructures: one made of reinforced concrete and one made of glued laminated timber (GLT) beams.

The investigated glued laminated timber bridge has a total length of 54.20 m and a deck width of 4.10 m. The height of the GLT beams varies between 1.10 m in the abutment zones and 1.98 m in the pier zone. The handrail height is 1.20 m. The structural system is a continuous beam with three spans, consisting of two end spans of 13.10 m and a central span of 28.00 m. The elements are made of GL24h-class glued laminated timber from spruce wood.

For the reinforced concrete alternative, an additional pier height of approximately 0.90 m was required, resulting in an extra volume of about 2.15 m^3 per pier (4.30 m^3 total), while the rest of the substructure remained unchanged. The superstructure consists of three precast beams with a height of 1.10 m.

The carbon analysis showed that the timber superstructure results in 217,392 t of sequestered CO_2 and 139,008 t of CO_2 emissions. After compensating for emissions associated with materials and construction processes, a net balance of 78,384 t of sequestered CO_2 is obtained. In the case of the reinforced concrete superstructure, total CO_2 emissions amount to 218,707 t.

The results indicate a significant reduction in carbon emissions when using a superstructure made of glued laminated timber beams compared to the reinforced concrete solution. Unlike concrete, which generates CO_2 emissions during production and construction, wood has the ability to store biogenic carbon throughout the entire lifespan of the structure. Therefore, the timber superstructure not only reduces associated emissions but also actively contributes to CO_2 sequestration, highlighting a major advantage from the perspective of sustainability and reducing climate impact.

Key words: carbon footprint, sustainability, glued laminated timber, green building materials, reinforced concrete

INTEGRATED GIS-BASED METHODOLOGY FOR GROUNDWATER RESOURCE ASSESSMENT AND VULNERABILITY MAPPING USING DRASTIC, MODFLOW AND MT3DMS MODELS

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Abstract:

Access to safe and sustainable drinking water represents a critical challenge for communities worldwide, particularly in the context of climate change and increasing anthropogenic pressure on natural resources. In Romania, feasibility studies for water supply systems are currently based on preliminary hydrogeological surveys that rely on outdated databases, leading to significant discrepancies between estimated and actual groundwater resources. These inaccuracies result in inefficient investments, project delays, and communities remaining exposed to water insecurity.

The purpose of this research is to develop an integrated methodology for the assessment and protection of groundwater resources, combining four internationally recognized tools: GIS (Geographic Information System), DRASTIC, MODFLOW, and MT3DMS. Traditional approaches rely on fragmented data – outdated low resolution maps, sparse hydrogeological records, and the absence of dynamic simulations – which are insufficient to address modern water management challenges.

The proposed methodology integrates the four tools in a structured workflow. GIS serves as the spatial framework, collecting and structuring all relevant data including stratigraphy, geology, topography, land use, and water quality. The DRASTIC empirical model is then applied to produce vulnerability maps of aquifers to contamination, using parameters such as water depth, soil type, and hydraulic conductivity. Subsequently, a MODFLOW numerical model simulates groundwater flow, identifies zones with exploitation potential, and tests pumping scenarios. In parallel, MT3DMS simulates contaminant transport through the aquifer system, modelling processes such as advection, dispersion, and degradation, thus enabling the assessment of contamination risks from agricultural or point-source inputs.

The main results expected from this research include updated digital vulnerability and resource maps, dynamic simulations of groundwater flow and contaminant transport, and decision-support scenarios for sustainable aquifer exploitation. The integrated GIS–DRASTIC–MODFLOW–MT3DMS model will provide a comprehensive picture of where groundwater exists, how much is available, its current quality, and its long-term vulnerability to pollution.

In conclusion, this research bridges practical field experience in water supply design with modern hydrogeological analysis tools. The proposed integrated methodology is expected to serve as a reference framework for groundwater resource evaluation, providing local authorities and water supply designers with a more reliable and modern approach for selecting underground water sources. This contributes both to more efficient infrastructure investments and to the advancement of hydrogeological practice in Romania, with potential for replication in regions with similar characteristics.

Key words: groundwater assessment, GIS, DRASTIC, MODFLOW, MT3DMS, aquifer vulnerability, water supply

COMPARATIVE APPROACH TO DEVELOPING THE RESEARCH METHODOLOGY ON FIRE SAFETY REQUIREMENTS APPLICABLE TO HEALTHCARE BUILDINGS IN RELATION TO P118-1/2025

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Abstract:

This research proposes a comparative synthesis intended to substantiate the methodology for investigating fire safety requirements applicable to healthcare buildings, by reference to the transition from the regulatory provisions established in P118/1999 to the updated regulations introduced by P118-1/2025. The need for such an approach arises from the functional complexity specific to healthcare facilities, the vulnerability of occupants who are unable to self-evacuate, and the necessity of developing a methodological framework capable of correlating regulatory requirements with the constructive, functional, and operational realities of the existing building stock. In this context, the study aims to identify the main changes introduced by the updated fire safety provisions and to assess their significance for the evaluation and adaptation of healthcare buildings, particularly those designed in accordance with earlier technical regulations. Special attention is given to the implications of these changes for buildings in which evacuation involves assisted transport, phased evacuation, and the integration of dedicated measures for persons with disabilities. The comparative analysis was structured around topics relevant to ensuring fire safety in healthcare buildings, namely: functional classification and fire resistance level; the minimum number of evacuation routes; the geometry of assisted evacuation paths; restrictions on the use of stairs; the protection of stairwells, corridors, and halls; maximum evacuation distances in situations with and without assisted transport; conditional increases in evacuation distances; lifts intended for assisted evacuation; as well as refuge areas and solutions dedicated to persons with disabilities. By systematically examining these elements, the research contributes to the development of an interpretative and methodological instrument with practical relevance for specialists involved in the design, assessment, rehabilitation, and authorization of healthcare buildings from the perspective of fire safety, while also supporting a more coherent understanding of the relationship between regulatory evolution and the specific safety needs of medical environments and healthcare infrastructure.

Key words: Fire safety; healthcare buildings; assisted evacuation; means of egress; vulnerable occupants; regulatory compliance; P118-1/2025; research methodology; comparative analysis

APPLICABILITY OF AERIAL AND SATELLITE IMAGES TO GEOTECHNICAL CHARACTERIZATION OF SITES: ASSESSMENT OF GROUNDWATER FLOW

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Abstract:

Currently, aerial and satellite imagery is widely used in the geotechnical assessment of prospective investment sites. This presentation details a case study on the applicability of remote sensing data for characterizing the hydrogeological conditions of a given area.

The site selected for the case study is located near the town of Medgidia City, in Constanța County (southeastern Romania) and this selection was informed by the findings of a technical analysis conducted following a structural failure of a motorway sector. The analysis utilized military maps and aerial and satellite imagery, provided by the Romanian National Agency for Cadastre and Land Registration and Google Earth portal, chronologically covering the 2005–2022 interval.

The geotechnical evaluation of the site using these tools revealed that a series of groundwater flow phenomena could have been identified through this type of technical analysis. Furthermore, the findings of this assessment would have complemented the geotechnical investigations upon which the motorway’s technical design was based.

Even though the geotechnical investigations were conducted in compliance with the applicable technical standards, they did not provide sufficient data for the technical design and construction of the motorway in this sector. Consequently, the occurrence of the technical failure - namely a massive landslide of the cut slope in that specific section - became unavoidable. Although the technical failure was eventually remediated, it incurred significant additional costs. Nevertheless, it must be stated that additional technical measures will be required in the future to prevent the recurrence of landslide phenomena. Furthermore, these actions will necessitate an increase in the motorway maintenance funds.

The study demonstrates that site assessment via aerial and satellite imagery can accurately define the scope of geotechnical investigations necessary for designing optimal technical solutions. This approach helps mitigate additional costs associated with geotechnical risks inherent to the site’s actual ground conditions.

This type of analysis is applicable across various other fields, extending beyond the scope of the construction industry.

Key words: remotely sensed image, site investigation, geotechnical, sesonal precipitation variation, sliding of cutting slope

THE ARCHIVE OF PROFESSOR IOAN STĂNCULESCU

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Abstract:

The present communication aims to highlight several elements of technical interest preserved within the personal archive of Professor Ioan Stănculescu, Doctor Honoris Causa of Gheorghe Asachi Technical University of Iași (1997). This archive, currently held by his family, was consulted through the generous cooperation of his son, architect Gheorghe Radu Stănculescu.

At the time of review, the archival fonds had not yet undergone a systematic arrangement and contained a diverse range of materials documenting Professor Stănculescu’s professional career and scientific activity. These materials include professional and academic records such as curricula vitae, activity reports, testimonials, invitations to scientific symposia, and correspondence; preparatory research documentation consisting of draft scientific papers, technical standards, specialized regulations, research notes, and bibliographic indices; as well as an extensive specialized bibliography comprising monographs, treatises, and offprints from scientific journals. The collection also preserves technical designs related to capital investment projects in which Professor Stănculescu served as consultant or designer, field documentation in the form of notebooks and site journals containing geotechnical and structural observations, and forensic engineering reports concerning structures affected by failures or technical accidents. In addition, the archive contains valuable visual documentation, including technical photographs, plans, and architectural plates.

This archival collection is of particular importance because it preserves documents that reflect the evolution and technological progress of civil and industrial engineering during a significant period of the twentieth century. Among the materials selected for presentation are several records referring to geotechnical conditions and engineering issues specific to the Iași region.

Furthermore, these documents retain the historical context in which they were produced, illustrating the systemic constraints encountered by practitioners of the time, together with the innovative engineering solutions developed to overcome them.

The objective of this paper is to introduce a series of previously unrecorded documents from this collection, thereby emphasizing the critical value that should be attributed to such primary working records. At the same time, the study advocates for the identification of institutional solutions capable of ensuring that the private archives of prominent scientific figures are preserved, catalogued, and made accessible to the academic community.

Key words: Professor Ioan Stănculescu, Doctor Honoris Causa, technic archive, scientific records, professional records, geotechnical issues, Iași region

THE ORTHODOX CATHEDRAL OF GALAȚI (ROMANIA): GEOTECHNICAL OBSERVATIONS AND CONSOLIDATION SOLUTIONS PROPOSED BY PROFESSOR IOAN STĂNCULESCU

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Abstract:

The present communication aims to highlight the scientific role and major contributions of Professor Ioan Stănculescu, Doctor Honoris Causa of Gheorghe Asachi Technical University of Iași (1997), to the geotechnical stabilization and structural consolidation of the Orthodox Cathedral in Galați, a monument currently included on the national list of historical heritage sites.

The documents analysed in this study were identified in the private archives preserved by Professor Stănculescu’s family and were made available through the courtesy of his son, Gheorghe Radu Stănculescu. The dossier containing the relevant geotechnical and structural information comprises a substantial body of technical material, offering valuable insight into the intervention history of the cathedral. It includes handwritten notes concerning the effects of the March 4, 1977 Vrancea earthquake, based on field observations undertaken in July 1977, together with later notes from 1979, sketches, plans, and cross-sections. The archive also preserves technical assessment reports prepared in 1985–1986, available in both typescript and manuscript versions, accompanied by supporting documentation such as plans, sections, measurement tables, and photographic records. In addition, other technical materials were identified, including a draft scientific paper addressing settlement phenomena in structures founded on loess soils, as well as records of in-situ measurements carried out by municipal technical departments between 1976 and 1989.

The information contained in these documents provides a comprehensive understanding of the structural condition of the cathedral, a building affected both by seismic action and by differential settlements of the foundation ground. Particularly significant are the technical parameters and field observations that formed the basis for Professor Stănculescu’s recommendations regarding the proposed strengthening and stabilization solutions.

The incorporation of these archival materials into the scientific literature is important not only for documenting the historical development of geotechnical engineering in Romania, but also for illustrating the decisive contribution of this discipline to the preservation of heritage structures. At the same time, the material offers a revealing perspective on the social and professional climate of a historical period marked by numerous ideological constraints that influenced research and technical practice in the construction sector.

Key words: Professor Ioan Stănculescu, Doctor Honoris Causa, technical archive, scientific records, geotechnical issues, Orthodox Cathedral, historic heritage, Galați region

ASSESSMENT OF SURFACE RUNOFF FORMATION AND FLOOD VULNERABILITIES: CASE STUDY IN THE SUHU RIVER BASIN

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Abstract:

Recent climate changes have generated an increase in the frequency of extreme hydrological phenomena. In this context, small and medium-sized river basins in the hilly regions of Romania have become sensitive to torrential rainfall, favoring the generation of surface runoff and triggering floods. The Suhu River basin represents such an area, being historically exposed to flash flood phenomena, with a severe socio-economic impact on local communities. This article proposes an analysis of the interaction between the natural environment, soil typologies, and anthropogenic modifications induced by land use changes. The main objective of the research is to quantify the vulnerability of this area to surface runoff and to identify the critical areas for flood generation.
Methodologically, the research is based on the use of Geographic Information Systems (GIS) techniques for cartographic processing and spatial modeling. Digital Elevation Models (DEM) were integrated for morphometric analysis, alongside satellite data regarding land cover (Corine Land Cover) and pedological maps. By overlaying these layers, the Manning roughness coefficient was evaluated, and slopes and runoff times of concentration were calculated, applying a statistical analysis of the physical-geographical parameters. The obtained results demonstrate that the substitution of forest cover with arable lands vulnerable to erosion has modified the local hydrological regime. Corroborated with the presence of a loessoid substrate and a torrential rainfall regime, this deforestation has significantly reduced the water concentration time. Spatial analysis highlighted that the Valea Rea, Perişani, and Suhurlui hydrographic sub-basins generate the highest runoff volumes, transforming into major sources of risk. The discussion of the results reveals that the uncontrolled transition towards intensive agriculture has suppressed the natural water retention capacity within the basin. At the same time, soil degradation accentuates sediment transport, amplifying the destructive force of flood waves on the lower river courses. This phenomenon of sedimentation and accelerated erosion puts additional pressure on local infrastructure, from bridges to utility networks. Furthermore, the data highlights the need to integrate high-resolution spatial models into future monitoring and early warning systems for the exposed communities.

Key words: flash floods, Suhu River basin, Manning coefficient, hydrological vulnerability, soil erosion, GIS

DRYING BEHAVIOUR OF HEMPCRETE BLOCKS USING LOW-COST MONITORING METHODS

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Abstract:

In the context of increasing interest in sustainable construction materials capable of reducing the environmental impact of the building sector, bio-based composites such as hempcrete have gained significant attention due to their low embodied energy, carbon sequestration potential, and favourable hygrothermal properties. However, despite the growing application of hempcrete in low-carbon buildings, limited experimental information is available regarding the drying behaviour of hempcrete elements produced with modified lime-based binders under natural environmental conditions, particularly when using accessible monitoring techniques applicable outside specialized laboratories.

The purpose of this research is to experimentally investigate the drying kinetics of hempcrete blocks manufactured using hydrated lime-based binder formulations modified with mineral and hydraulic additives, and to evaluate the applicability of low-cost monitoring methods for assessing moisture evolution in bio-based construction materials. Six hempcrete specimens were produced using three different binder formulations and monitored over a 50-day period under natural environmental conditions. Moisture evolution was assessed through combined internal and surface measurements using probe-type moisture meters, while gravimetric analysis of mass variation was employed to estimate water loss during drying. Environmental parameters, including temperature and relative humidity, were recorded to evaluate their influence on drying behaviour.

The results indicate a multi-stage drying process characterized by rapid evaporation of free water during the first 20 days, followed by a significantly slower reduction in internal moisture due to the highly porous and hygroscopic structure of the hemp-lime composite. Surface moisture approached near-zero values after approximately 35-40 days, while internal moisture stabilized at approximately 70%, indicating incomplete drying after 50 days. Gravimetric analysis showed an average mass reduction of approximately 5 kg per specimen, confirming progressive moisture dissipation. Environmental conditions, particularly relative humidity, were found to significantly influence drying rate. The results demonstrate that simple, low-cost measurement techniques can provide reliable data for evaluating moisture behaviour in hempcrete materials and highlight the importance of extended curing periods prior to practical application.

Key words: hemp-lime composite, hygrothermal performance, moisture evolution, sustainable construction materials, gravimetric analysis

A REVIEW OF SEISMIC RETROFITTING STRATEGIES FOR EXISTING BUILDINGS IN ROMANIA: FROM TRADITIONAL TO INNOVATIVE APPROACHES

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Abstract:

A significant portion of the Romanian building stock is approaching, or has already reached, the end of its design service life specific to residential civil structures. Approximately 70% of all residential buildings in Romania were constructed prior to 1990, with about 40% built during the period of rapid urban expansion between 1961 and 1990, and 30% erected before 1960. Considering these statistical data alongside the current seismic safety levels of buildings in Romania, there is an imperative need to implement structural retrofitting and safety measures for the existing building stock. Furthermore, interventions on structures designed and executed prior to 1963 constitute a major urgency due to their intrinsic seismic vulnerability, generated by the absence of appropriate seismic design codes during that period.

To address this necessity, traditional retrofitting methods can provide structurally efficient solutions, characterized by relatively low implementation costs and not requiring highly skilled labor. However, in many cases, traditional methods entail implementation drawbacks due to their invasive nature, which may necessitate the evacuation of the building, the reduction of usable floor area, or an increase in structural mass, implicitly leading to higher seismic demands. In this regard, modern retrofitting techniques can either enhance the load-bearing capacity and ductility of the strengthened structural elements without adding a significant mass surplus to the structure, or mitigate the seismic forces induced by earthquakes, through mass reduction or lateral stiffness alteration, while maintaining a low level of invasiveness via predominantly exterior interventions.

In this context, the present paper aims to provide a comprehensive analysis of current seismic retrofitting methods, with a specific focus on the particularities of the Romanian existing building stock. The primary objective is to identify and synthesize traditional and innovative approaches, ultimately providing clear guidelines on the selection of appropriate retrofitting strategies tailored to the specific characteristics of each structural typology.

Key words: seismic retrofitting, existing building stock, seismic vulnerability, retrofit strategies, traditional strengthening techniques, innovative strengthening techniques

HYBRID PREFABRICATED SYSTEM WITH LOW EMISSIONS AND THERMO-STRUCTURAL PERFORMANCE EQUIVALENT TO CONVENTIONAL STRUCTURES

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Abstract:

The transition towards low-energy and low-carbon buildings requires hybrid construction solutions that combine the structural performance of reinforced concrete with the thermal efficiency of lightweight materials based on vegetal fibres. This paper proposes an innovative prefabricated wall panel consisting of a reinforced concrete honeycomb and a lightweight wood-fibre concrete infill. The aim of the research is to obtain a wall element that can ensure the necessary structural safety through a minimal amount of reinforced concrete, while the wood-fibre concrete provides improved thermal insulation and a reduced overall weight of the panel.
The proposed manufacturing process is designed for fast and efficient production. Fresh wood-fibre concrete is first placed in a rigid metal formwork and compacted using a hydraulic press. The press creates a regular pattern of channels and cavities inside the panel, which define the geometry of the future reinforced concrete honeycomb. After the press is released, pre-assembled steel reinforcement elements are positioned in these channels, directly within the same formwork, and conventional concrete is cast to form the honeycomb network. In this way, a single integrated panel is produced on one production line, with minimal execution time, in a fully controlled environment.
The research programme focuses on two main directions: the structural optimisation of the reinforced concrete honeycomb and the development of a suitable mix design for the wood-fibre concrete. The first direction aims to minimise the cross-section of the concrete ribs while satisfying the required resistance and stiffness under vertical and horizontal actions. The second direction targets a low-density, low-thermal-conductivity wood-fibre concrete, with adequate cohesiveness and mechanical strength to ensure safe handling, durability in service, and good compatibility with the concrete honeycomb. Experimental tests on small-scale specimens and full-scale panels will be combined with numerical modelling and life-cycle assessment, in order to quantify both the structural performance and the potential reduction in environmental impact when compared to conventional solid reinforced concrete walls and masonry walls with external insulation systems.

Key words: bio-based materials, prefabricated panels, carbon footprint, ecological materials, life cycle assessment, prefabricated elements, sustainable construction

TECHNIQUES AND METHODS FOR INVESTIGATING BUILDINGS CONSTRUCTED WITH LOCAL MATERIALS

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Abstract:

This paper develops a methodology for analyzing the parameters that influence the strength and stability of constructions built using traditional materials specific to the Danube Delta. These buildings, characterized by the use of locally available resources such as earth, timber, reed, and other natural materials, represent an authentic expression of the adaptation of construction techniques to environmental conditions and resource availability. At the same time, they hold significant architectural and cultural value.
Based on studies and research conducted in the context of local heritage restoration, the authors analyze the main factors contributing to the degradation of these structures. These include the action of water and moisture, climatic variations, biological processes, as well as inappropriate interventions carried out over time. Furthermore, traditional construction techniques have been investigated, including the methods of material application, constructive details, and empirical solutions developed by local communities to respond to the specific environmental conditions of the area.
The proposed methodology aims to establish clear criteria for assessing the conservation state of such buildings and to identify compatible intervention solutions that allow for rehabilitation and restoration without compromising authenticity. Particular emphasis is placed on preserving the parameters that define the historical substance of the buildings, including materiality, construction techniques, and their relationship with the natural environment.
As a case study, the paper presents a detailed analysis of traditional dwellings in Chilia Veche, where existing construction typologies were evaluated and intervention solutions adapted to the local context were proposed. These solutions address both structural consolidation and functional adaptation, in some cases through integration into tourism circuits, thereby contributing to the economic revitalization of the community. The proposed interventions are based on the principles of material compatibility and reversibility, in accordance with best practices in heritage conservation.
The paper highlights several original contributions derived from field research and practical experience gained during restoration works carried out in the area. These findings can serve as a foundation for developing intervention guidelines applicable to other regions with similar characteristics, thus supporting the sustainable conservation of built heritage constructed from local materials.

Key words: local materials, vernacular buildings, Danube Delta, structural assessment, conservation methods, rehabilitation

ASSESSING TRADITIONAL AND MODERN TECHNIQUES FOR WATER LOSS DETECTION: A COMBINED ANALYTICAL APPROACH

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Abstract:

Water loss in distribution systems has become an increasingly prominent issue over the past two decades, as it leads to substantial resource waste and elevated operational costs for water utilities. Consequently, the development and implementation of effective leak detection and localization methods have emerged as critical priorities for improving the efficiency and sustainability of water supply infrastructures. This study presents a comprehensive bibliometric analysis of the scientific literature focused on water loss detection techniques, encompassing both traditional approaches and modern, technology driven solutions.

The analysis is based on a dataset of 43 relevant publications indexed in the Scopus database and published between 2020 and 2025. Using the VOSviewer software, a keyword co-occurrence map was generated to identify major research themes, conceptual interconnections, and emerging trends within the field. The bibliometric results highlight the growing interest in intelligent monitoring systems, advanced sensing technologies, and data-driven methodologies for improving leak detection accuracy and operational responsiveness.

In addition to the bibliometric assessment, the study provides a comparative evaluation of various leak detection methods using criteria such as sensitivity to loss identification, detection capability, potential for continuous monitoring, alarm accuracy, and implementation costs. The analysis covers conventional techniques including manual inspections and acoustic methods as well as advanced solutions based on sensor networks, numerical modeling, and artificial intelligence algorithms.

Furthermore, the paper emphasizes the increasing role of emerging technologies in the development of smart water systems. The integration of advanced sensors, Internet of Things (IoT) platforms, and real time data analytics into water distribution networks offers significant opportunities for enhancing leak detection performance and optimizing infrastructure management. These innovations contribute to more efficient resource use, improved system reliability, and reduced operational costs.

The findings of this study reveal notable technological progress in the field, while also identifying persistent gaps related to the integration, interoperability, and standardization of detection methods. Overall, the research underscores the need for more precise, robust, and cost effective solutions capable of meeting the evolving demands of modern water distribution systems.

Key words: water loss detection; leak localization; VOSviewer; acoustic methods; sensor networks

COMPARATIVE ANALYSIS OF THE EVOLUTION OF THE DYNAMICS OF BUILT-UP LAND BETWEEN THE ADMINISTRATIVE-TERRITORIAL UNITS OF VALEA LUPULUI AND BÂRNOVA, IAŞI COUNTY IN THE PERIOD 2015-2025

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Abstract:

The country's major cities are facing the phenomenon of rapid urban expansion, also known as urban sprawl, which manifests itself through an intense process of transformation of peri-urban areas into residential or industrial areas. This phenomenon affects large urban centers and is characterized by the migration of the population from the city center to the outskirts.
Due to the phenomenon of the expansion of large urban centers, neighboring areas also experience a development materialized through a complex process of increasing well-being, through actions aimed at environmental protection, social development, economy, territorial planning, education and vocational training, science and research, all having as a starting point the potential of the respective territory.
Urban or rural landscaping, general and particular architecture of localities are supported by topography, cadastre and territorial organization activities.
The issue of human settlement expansion is a research topic, and through this article I want to highlight the territorial changes that have occurred following the acceleration of the construction process in the rural area bordering the city of Iași, studying the dynamics between urban and extra-urban areas, the evolution of the number of buildings, the impact of the reduction of agricultural area and the evolution of the land fund between the administrative-territorial units of Valea Lupului and Bârnova, Iași county, during the period 2015-2025.
For this purpose, I used graphic and alphanumeric information from the Database of the Iași Cadastre and Real Estate Advertising Office, the Valea Lupului General Urban Plan, the Bârnova General Urban Plan, Google Earth images and statistical data from the National Institute of Statistics of Iași.
Following the processing of graphic and numerical data using the AutoCAD Map program, maps were generated that highlight the territorial transformation of the two administrative-territorial units. I hope that this result will help in the application of appropriate management by local and municipal authorities in terms of taking measures and finding solutions to solve new rural and urban administration challenges.

Key words: phenomenon of rapid urban expansion, territorial changes, graphic information, number of the constructions

SECTION 5.
Mechanical engineering; Industrial engineering; Materials engineering; Engineering and management

KYNETIC STUDY ON TITANIUM HYDRIDING VIA THERMOGRAVIMETRIC METHOD, FOR HYDROGEN ISOTOPES STORAGE APPLICATIONS

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Abstract:

In the context of increasing demands for efficient hydrogen isotope storage in nuclear and non-nuclear energy applications, metal hydrides have gained significant attention as safe and viable storage methods. Their reversible absorption capability, high volumetric storage density, and stability under radiation exposure make them suitable candidates for advanced energy systems. However, the practical use of metal hydrides is often constrained by the kinetics of hydrogen absorption and desorption processes, which play a decisive role in material performance. The present paper aims to investigate the hydrogenation kinetics of titanium powder and to determine the activation energy associated with the hydriding process, in the context of hydrogen storage materials. Titanium was selected due to its low density and high affinity for hydrogen, forming stable and reversible metal hydrides. The experimental study was conducted on titanium powder activated at 800 °C for 1 h under argon atmosphere. Hydrogenation experiments were subsequently performed at three different temperatures: 300 °C, 400 °C, and 500 °C, with a holding time of 20 h under hydrogen. After hydrogenation, the samples were cooled under argon. Experimental data, including mass variation, temperature, and time, were extracted and processed to analyse the hydriding kinetics. The reaction rate curves and conversion degree evolution were evaluated to identify the dominant kinetic mechanisms, while Arrhenius analysis was employed to estimate activation energies. The kinetic analysis reveals a multi-stage process, characterized by an initial surface-controlled reaction, followed by diffusion-controlled growth and a final equilibrium stage. The variation of activation energies and preexponential factors confirms the transition between these controlling mechanisms. The results show that hydrogen absorption proceeds most rapidly at 300 °C, while higher temperatures lead to a slight decrease in absorption rate and stabilization of the final hydrogen uptake, indicating the influence of diffusion and microstructural effects. Kinetic modelling and Arrhenius analysis demonstrate that the hydriding process is not governed by a single mechanism, but evolves from surface-controlled reactions to diffusioncontrolled growth, followed by equilibrium saturation. In conclusion, the titanium–hydrogen system exhibits a complex, temperature-dependent kinetic behaviour characteristic of metal hydride formation, confirming the suitability of titanium-based materials for hydrogen isotope storage applications.

Key words: hydrogen isotope storage; titanium hydride; metal hydrides; hydriding kinetics; thermogravimetry, Arrhenius analysis.

”Gheorghe Asachi” Technical University of Iasi, Romania
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ANALYSIS OF THE POSSIBILITIES OF OBTAINING METALLIC STRUCTURES FOR DENTAL APPLICATIONS BY 3D PRINTING

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Abstract:

Additive manufacturing technologies, commonly referred to as 3D printing, have gained increasing importance in the field of dental engineering due to their capability to produce complex, patient-specific metallic structures with high dimensional accuracy. In recent years, metal-based additive manufacturing has been intensively investigated as an alternative to conventional subtractive manufacturing techniques, offering improved design freedom, material efficiency, and customization potential. Within this general research context, the present work addresses the applicability of metal additive manufacturing technologies for dental applications. The main purpose of this study is to analyze and compare the possibilities of obtaining metallic structures used in dentistry through modern 3D printing processes. The research focuses on the evaluation of the most relevant metal additive manufacturing techniques employed in this domain, namely Selective Laser Melting (SLM), Selective Laser Sintering (SLS), and Direct Metal Laser Sintering (DMLS). Emphasis is placed on identifying the technological capabilities and limitations of these processes in relation to dental requirements.
The methodology of the research is based on a systematic analysis of recent scientific literature, technical reports, and experimental studies published in the field of metal additive manufacturing for dental applications. The analyzed data are structured according to process parameters, material characteristics, dimensional accuracy, mechanical performance, surface quality, and biocompatibility. Particular attention is given to metallic materials commonly used in dentistry, such as cobalt–chromium alloys and titanium-based alloys. The main results of the analysis indicate that metal additive manufacturing technologies enable the fabrication of highly complex dental structures with improved fit and customization compared to conventional methods. However, the reviewed studies also highlight several limitations, including surface roughness, residual stresses, and the need for post-processing operations to achieve clinically acceptable properties.
Metal 3D printing represents a promising manufacturing route for dental structures, offering significant advantages in terms of design flexibility and material efficiency. Nevertheless, further optimization of process parameters and post-processing techniques is required to fully exploit its potential in dental engineering applications.

Key words: additive manufacturing; metal 3D printing; dental applications; cobalt–chromium alloys; titanium alloys; materials engineering.

ESTIMATION OF MEASUREMENT ERRORS IN RADAR TRAJECTORIES USING THE LEAST SQUARES METHOD

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Abstract:

Radar systems are widely used for the detection, tracking, and monitoring of moving objects such as aircraft, missiles, and other airborne targets. The accuracy of coordinate measurements obtained from radar systems plays a crucial role in navigation, air traffic control, and defense applications. However, radar measurements are inevitably affected by various sources of uncertainty, including thermal noise, signal fluctuations, environmental conditions, and hardware limitations. As a result, the measured coordinates of moving objects contain random errors that may significantly influence the accuracy of trajectory estimation. The statistical analysis and estimation of these measurement errors therefore represent an important problem in radar data processing and tracking system evaluation. The purpose of this study is to develop and analyze a method for estimating the root mean square (RMS) errors of radar coordinate measurements based on the statistical processing of trajectory data. The research focuses on the application of trajectory approximation techniques in order to reduce the influence of random measurement noise and to obtain reliable estimates of measurement accuracy. The proposed methodology is based on the approximation of measured radar trajectories using the least squares method. Polynomial approximation is applied to experimental trajectory data to model the motion of the observed object. Orthogonal polynomial functions are used as a basis for the approximation, which simplifies the computational procedure and improves numerical stability. After obtaining the approximated trajectory, the deviations between measured coordinates and the approximated trajectory are analyzed as random measurement errors. Standard methods of mathematical statistics are then applied to estimate the mean values, variances, and confidence intervals of these errors. In particular, the chi-square distribution is used for constructing confidence intervals for the variance of the measurement errors. The obtained results demonstrate that the use of polynomial trajectory approximation effectively reduces the influence of random fluctuations in radar measurements and provides reliable estimates of the statistical characteristics of coordinate errors. The analysis shows that the proposed approach allows for a more accurate evaluation of radar measurement accuracy and improves the reliability of trajectory analysis. In conclusion, the presented method can be effectively used for statistical processing of radar trajectory data and for evaluating the accuracy of radar coordinate measurements. The proposed approach may also be applied in the development and improvement of radar tracking algorithms and radar data processing systems.

Key words: radar tracking, radar measurements, trajectory approximation, least squares method, measurement error estimation, statistical data processing, root mean square error.

THEORETICAL ESTIMATION OF TARGET DETECTION PROBABILITY IN SCANNING RADAR SYSTEMS

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Abstract:

Radar systems designed for airspace surveillance must ensure reliable detection of moving targets under various operational conditions. A key characteristic of such systems is the probability of target detection, which determines the effectiveness of radar monitoring and tracking processes. In practice, detection characteristics are often obtained through large-scale experimental tests involving operational radar systems and numerous target flights. These tests require significant financial and organizational resources. Consequently, the development of theoretical approaches for estimating detection probabilities is an important task in modern radar engineering. The objective of this research is to develop a computational method for determining unconditional probabilities of target detection for surveillance radar systems that perform periodic scanning of a solid angle using a narrow antenna beam. The study focuses on the detection of radar signals with random amplitude and initial phase, which corresponds to realistic reflections from moving objects such as aircraft or missiles. The methodology is based on classical radar detection theory and the Neyman–Pearson optimal detection criterion. First, the energy potential of the radar system is calculated using the radar equation. This calculation ensures that the required probability of correct detection is achieved at the maximum operational range for a given probability of false alarm. Using these parameters, conditional probabilities of correct detection are determined for targets located at different distances within the radar coverage zone. In the next stage, a method for calculating unconditional detection probabilities is developed. The model assumes that the radar performs cyclic scanning of the observation space, while the target moves toward the radar with constant velocity and remains within the scanning sector. The target trajectory is divided into small segments corresponding to radar scanning cycles. For each segment, the probability of detection is evaluated, and cumulative detection probabilities are obtained by sequential probabilistic calculations that account for previous detection events. The proposed algorithms were implemented in computer programs that allow the calculation of detection probabilities for various radar and target parameters. Numerical experiments were carried out to analyze the influence of target velocity and radar scanning time on detection performance. The results demonstrate that increasing target velocity or the scanning period reduces the probability of early detection and shifts detection boundaries closer to the radar. The developed approach provides an effective analytical tool for evaluating radar detection performance and can significantly reduce the need for expensive experimental testing.

Key words: radar detection, probability of detection, surveillance radar, radar equation, Neyman–Pearson criterion, radar signal processing, radar performance modeling.

AUXETIC KNITTED MATERIALS

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Abstract:

A material’s Poisson’s ratio (PR) is the ratio of transverse contraction strain to longitudinal extension strain in the direction of the stretching force. Usually, textile materials have a positive Poisson’s ratio, whereas auxetic materials have a negative Poisson’s ratio (NPR), meaning they expand laterally when stretched and contract laterally when compressed. Poisson's ratio is the negative ratio of transverse strain to longitudinal strain in the linear elastic range. This unique property makes them useful in various fields, such as medicine, agronomy, the packaging industry, the fashion industry, and the military. Flat weft knitting technology belongs to the second category and offers a sustainable perspective compared to other textile manufacturing technologies due to the shortened production cycle. Auxetic textile materials can be developed using two approaches. The first uses auxetic yarns to produce auxetic fabrics, while the second uses conventional yarns to create fabric section geometries that enable auxetic deformation. In this research various weft-knitted structures were designed with M1plus® software and manufactured by using a Stoll CMS 502HP E 2.5.2 automatic flat knitting machine. The structures were formed by employing front and reverse loops in different patterns according to the re-entrant geometric structure, the double arrowhead, and the hexagonal re-entrant geometry, using acrylic, cotton, and cashmere yarns. The auxetic behaviour of each fabric sample was then examined by measuring dimensional changes during stretching and then calculating the Poisson’s ratio. The results indicate that using different geometries, the knitted samples display a more or less pronounced auxetic effect, depending on the raw material used. With identical knitting patterns, acrylic yarns exhibit a more negative Poisson’s ratio, while cotton yarns show the least negative value due to their lower elasticity. The auxetic effect is determined by the three-dimensional geometry of knitted fabrics, which allows deformation by opening the folded structure. This study may help identify various applications of auxetic knitted fabrics, particularly in the medical field for scaffolds in tissue engineering or as smart bandages for healing superficial wounds.

Key words: Textiles, knitted fabrics, yarns, negative Poisson’s ratio.

INNOVATION: ASSESSING THE VARIABLES INFLUENCING BUSSINESS PROCESS AND PRODUCT INNOVATION

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Abstract:

Innovation has become a must for companies to improve their organizational resilience, to increase their financial performance and to respond to external challenges. Based on the object being innovated, innovation can be classified in two types: product innovation and business process innovation. A product innovation can trigger the need for a business procees innovation, resulting in the two types being intertwined in practice. Since innovation triggers economic growth, both companies and countries are looking into generating more innovation by policies, activities and funding. To evaluate whether their endeavours are reaching their targeted goals, they need to measure innovation. Organisation for Economic Co-operation and Development (OECD)/Eurostat are providing a standardized approach to evaluate innovation across organizations and countries, enabling not only measurement, but also comparative analysis between entities. This approach includes a standardized questionnaire, which is applied in more than 80 countries, and is continuously improved based on the feedback obtained. The results obtained by applying this questionnaire, which were published by OECD, represent the data used in this research. By using a quantitative methodology, this study explores the variables that influence business process innovation and product innovation. The hypotheses are multifold and have been tested using statistical methods. Firstly, the study analyses whether the research and development (R&D) expenditures influence both business process innovation (H1) and product innovation (H2). Hypotheses H1 and H2 are invalidated by statistical means. Secondly, the research assesses whether the share of persons employed in innovation-active firms, in total employment in 2020, has an influence on both business process innovation (H3) and product innovation (H4). Both hypotheses (H3, H4) are validated statistically, showing a positive influence between the analyzed variables. Thirdly, the study proves whether the turnover of the firms is influenced by product innovation (H5) and by business process innovation (H6). Hypotheses H5 and H6 are validated statistically. The conclusions of this research expand the existing scientific knowledge in innovation, by revealing the relationships between business process innovation, product innovation, R&D expenditure, share of employees and turnover of the firms. It also provides recommendations for managers aiming to increase innovation and turnover.

Key words: Product Innovation, Business Process Innovation, OECD survey, R&D expenditures, Turnover.

THE RELATIONSHIP BETWEEN DIGITAL MARKETING AND FIRM PERFORMANCE: A SYSTEMATIC LITERATURE REVIEW OF ROMANIAN STUDIES

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Abstract:

In the current economic landscape, digital marketing has emerged as a critical determinant of firm performance, especially in emerging markets such as Romania. The increasing adoption of digital technologies by Romanian companies, accelerated by the effects of the COVID-19 pandemic and the rapid growth of internet speed, has created the need for a deeper understanding of how digital marketing strategies influence business outcomes, and to derive relevant insights for academic and managerial implications. This paper aims to conduct a systematic literature review of studies published in international scientific databases (Web of Science, Scopus) that investigate the relationship between digital marketing and firm performance in the Romanian market. Using inclusion and exclusion criteria based on the methodology proposed by Lamé (2019), the review identifies and analyzes articles published between 2019 and 2025 that focus on the Romanian business environment and address the impact of digital marketing on financial and non-financial performance indicators. A total of 16 papers were evaluated. The findings reveal that the reviewed literature can be structured around three main themes: the impact of digital marketing capabilities on the financial performance of Romanian enterprises, the role of e-marketing orientation and technology adoption in enhancing online SME performance, and the influence of e-commerce adoption and digital transformation on the competitiveness and growth of Romanian firms. This paper adds to the gap of knowledge that digital marketing capabilities have a positive effect on customer relationship performance, marketing effectiveness, and the financial performance of companies in Romania. The results suggest that digital marketing capabilities have a positive effect on customer relationship performance, marketing effectiveness, and the financial performance of companies operating in Romania. Moreover, the adoption of e-marketing and digital technologies is associated with improved business outcomes for SMES, although barriers such as limited digital literacy, lack of infrastructure, and insufficient strategic alignment persist.

Key words: digital marketing, firm performance, systematic literature review, Romania, SMEs, digital transformation.

CHARACTERISATION OF KNITTED FABRICS USING THE NATURAL FREQUENCY METHOD

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Abstract:

Spacer fabrics are three-dimensional structures produced by knitting two separate layers, joined by yarns in various connecting ratios, and are among the most widely used materials for manufacturing protective products against vibrations. Mechanical vibrations affect workers who operate vibrating tools such as dumpers, scrapers, or excavators, as they are exposed to hand-arm, foot-transmitted, or whole-body vibration, which can cause permanent occupational diseases, including disorders of the circulatory system, sensory nerves, and joints of the hands and arms. The spacer fabrics were designed using Stoll M1plus® pattern software and produced on the CMS 330TT E7.2 multigauge flat knitting machine from Stoll by Karl Mayer. The knitted fabrics were varied by using two sets of yarns for the outer layers, one, comprised two cotton yarns, Nm 50/1, and the second comprised one cotton yarn, Nm 50/1, doubled with one elastomeric yarn. The outer layers were connected by a polyester yarn in different binding ratios (1×1, 1×3, 1×5, and 1×7), and the stitch density was varied by using three different stitch cam positions (NP): NP11 (tight), NP12 (medium), and NP13 (loose). The free vibration method was used to measure the natural frequencies of vibration of the knitted fabrics, values which are important for avoiding the resonance phenomenon. The results indicate that stitch density significantly influences natural frequencies, an increase in stitch density leads to greater stiffness and, consequently, higher natural frequencies. The yarn binding ratio also clearly influences the natural frequencies determined for the two sets of knitted fabrics developed in this study. For all structures, both before and after finishing, a progressive decrease in natural frequencies was recorded as the binding yarn ratio increased from 1:1 to 1:7, regardless of the value set for NP. This trend indicates a progressive reduction in structural stiffness as the binding yarn ratio increases.

Key words: weft knitted spacer fabrics, free vibrations, natural frequencies.

A COMPREHENSIVE REVIEW OF BEARING CURRENT PHENOMENA IN ELECTRIC VEHICLE DRIVE SYSTEMS

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Abstract:

The increasing adoption of electric vehicles (EVs) has brought renewed attention to the reliability and durability of drivetrain components, particularly electric motor bearings. Bearing currents induced by high-frequency voltage potentials from inverter-fed motors have become a significant source of premature bearing failure in electric powertrains. Rolling bearings represent essential elements in electric machines, having a direct influence on their efficiency, operational stability, and lifespan. The rapid expansion of pulse width modulation (PWM) inverter-based drive systems has introduced new electrical stress factors within motors, among which bearing currents have become a critical concern. These parasitic currents can pass through the bearing contacts, causing surface deterioration such as pitting and fluting. Over time, this degradation accelerates wear, diminishes the operational lifetime of the motor, and may ultimately lead to unexpected system failure Current research on bearing current-related degradation primarily focuses on three main aspects: the physical mechanisms responsible for current generation, the key influencing parameters governing these phenomena, and the development of equivalent circuit models to describe current paths through the motor system. This paper presents a comprehensive analysis of the electrical currents passing through bearings used in electric vehicles. The mechanisms of current generation, including common-mode voltage, capacitive coupling, and electromagnetic induction, are examined in depth. Furthermore, the effects of various operating conditions such as motor speed, load, inverter switching frequency, and temperature on the amplitude and frequency of bearing currents are evaluated. The resulting electrical and thermal stresses that accelerate bearing degradation are discussed based on both experimental results and simulation models. Current mitigation strategies, including the use of insulated bearings, grounding techniques, and advanced inverter control methods, are assessed in terms of their effectiveness and limitations. Finally, the paper outlines future research directions aimed at developing integrated design and diagnostic approaches to predict, monitor, and minimize bearing current effects, thereby enhancing the reliability and lifespan of electric vehicle drivetrains.

Key words: Bearing currents, Electric vehicle powertrains, Inverter-fed motors, Bearing degradation mechanisms, Electroerosion.

STATE-OF-THE-ART OF 3D PRINTING IN REMANUFACTURING WITHIN INDUSTRY 4.0

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Abstract:

Industry 4.0 is redefining production processes through the integration of advanced digital technologies with the principles of sustainability and circular economy, generating new paradigms in the design, manufacturing, and maintenance of industrial systems. In this context, traditional remanufacturing faces significant limitations, including restricted access to spare parts, long procurement times, and high costs associated with worn or discontinued components, which negatively affect operational efficiency and system availability. This paper presents a state-of-the-art review of the application of 3D printing in remanufacturing within the Industry 4.0 framework, highlighting current research trends, technological advancements, and emerging operational models. The study is based on a systematic and critical review of recent scientific literature, considering relevant publications from major scientific databases and focusing on recent developments in the field, covering both the theoretical foundations of Industry 4.0 - such as key concepts, principles, and enabling technologies - and the evolution of additive manufacturing in industrial applications. Particular attention is given to widely adopted additive manufacturing technologies, with emphasis on FDM (Fused Deposition Modeling), due to its accessibility, cost-efficiency, and suitability for rapid repair and on-demand production. In addition, existing workflows and frameworks for repair-oriented additive manufacturing are examined, including integrated approaches such as 3DP4R (3D Printing for Repair), which illustrate the typical stages of remanufacturing processes, from part assessment and digital redesign to fabrication and functional validation.
The analysis of the literature indicates that 3D printing plays a significant role in enabling rapid, flexible, and customized remanufacturing solutions, contributing to reduced downtime, lower operational costs, and extended equipment lifespan. Furthermore, these technologies support the transition toward decentralized and circular production models. However, several challenges remain, including variability in mechanical properties, post-processing requirements, and issues related to standardization, quality assurance, and traceability. In conclusion, 3D printing represents a key enabling technology for remanufacturing in Industry 4.0, with growing research interest and significant industrial potential, while also requiring further investigation to address current technical and organizational limitations.

Key words: Industry 4.0, Remanufacturing, 3D Printing for Repair.

CIRCULAR ECONOMY PRACTICES WITHIN INDUSTRY 5.0 ORGANIZATIONAL MANAGEMENT

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Abstract:

The accelerated changes in the economic environment and the increasing pressures on natural resources are leading organizations to rethink and reconfigure their management models oriented towards sustainability. In this context, Industry 5.0 brings a new perspective on organizational development, characterized by the collaboration between advanced technologies and human factors, promoting a human-centered approach, resilience, and social responsibility. In this way, the circular economy becomes a central element in redefining organizational strategies, through promoting the reuse of resources and the reduction of waste, but also through supporting responsible production and consumption models. This approach helps create a balance between economic performance and environmental protection. The study aims to analyze how circular economy practices are integrated in the management of organizations within Industry 5.0, highlighting their contribution to the growth of sustainability and operational efficiency. The analysis is realized through a literature review approach, following the main research directions of recent years. The methodological approach consists of the selection and evaluation of relevant academic sources, identified in international databases, through some specific keywords, like circular economy, Industry 5.0, organizational sustainability, and management, to capture recent contributions and emerging trends in the field. The results highlight the fact that the implementation of the circular economy, supported by technologies like artificial intelligence and automation, contributes to the optimization of resource consumption, reduction of impact on the environment, and increasing organizational performance. In addition, these practices can stimulate innovation and can strengthen the competitive advantage of organizations. However, the integration process involves some difficulties, related to costs, adapting organizational structures, and changing the managerial mindsets. To conclude, the adoption of the circular economy, in the context of Industry 5.0, represents an essential direction for assuring sustainable development in the long run, contributing at the same time to the growth of organizational resilience in the face of current challenges.

Key words: organizational sustainability, circular economy, Industry 5.0, organizational management, artificial intelligence, innovation.

SOLAR-ASSISTED HEAT PUMP SYSTEMS FOR RESIDENTIAL HEATING IN COLD CLIMATES: A TECHNICAL REVIEW

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Abstract:

Solar-assisted heat pump (SAHP) systems represent a central pathway for decarbonizing residential heating by coupling vapor-compression heat pumps with solar thermal or photovoltaic/thermal (PV/T) collectors. The reviewed literature demonstrates that integrating solar energy with air, water, or ground-source heat pumps consistently enhances system performance by increasing evaporating temperatures, reducing compressor power demand, and mitigating seasonal performance degradation under cold-climate operation. Direct-expansion configurations, where refrigerant evaporates within solar collectors, achieve high thermal utilization and simplified layouts, while indirect-expansion systems offer improved reliability, flexible component integration, and compatibility with thermal storage units. PV/T-assisted systems further improve overall exergy efficiency by simultaneously generating electricity and low-grade heat, with reported reductions in PV module temperature exceeding 25% and heating COP values approaching 6.0. Hybrid ground-source heat pump (HGSHP) systems supported by solar regeneration address long-term soil thermal imbalance, a major limitation of conventional GSHPs in heating-dominant regions. Studies confirm that solar-assisted ground recharge stabilizes borehole temperatures, reduces required drilling depth, and improves seasonal performance factors. Advanced hybrid architectures combine multiple heat sources like solar, air, ground or biogas, coordinated through intelligent control strategies such as ANN-based prediction, multi-objective genetic optimization, and dynamic COP-based source switching. These methods reduce cycling losses, enhance operational stability, and achieve up to 33% reductions in energy use and CO_2 emissions. Thermal energy storage, including stratified tanks and phase-change materials, further increases solar utilization and system flexibility. Emerging designs such as graded heat storage, dual-source heat pumps, and multi-mode PV/T–GSHP couplings demonstrate significant potential for achieving near-zero-energy residential buildings, particularly in cold climates where solar contribution compensates for reduced air-source performance. Overall, the collective evidence confirms that SAHP systems, especially when hybridized with PV/T collectors, ground regeneration and advanced control, offer substantial improvements in efficiency, reliability, and environmental performance. Future research should prioritize long-term field validation, optimization of solar regeneration strategies, advanced PV/T materials, and unified performance assessment frameworks to support large-scale deployment in diverse climatic regions.

Key words: Photovoltaic/thermal energy, Performance degradation, Ground regeneration, Hybrid systems, Thermal energy storage, Intelligent control strategies.

DEVELOPMENT OF A SPECIALIZED FIXTURE FOR TENSILE TESTING OF LIFTING EYES USED IN DOCK LEVELER HANDLING

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Abstract:

This paper presents the design, development, and validation of a novel adaptation device for tensile testing machines, specifically engineered to evaluate the mechanical performance of lifting eyes used in dock leveler handling operations. The study addresses a critical gap in current testing practices, where conventional tensile setups fail to accurately reproduce the complex loading conditions generated during real handling scenarios, particularly those induced by forklift interaction. The proposed fixture is designed for direct integration into the grips of a standard tensile testing machine and consists of two main assemblies, namely an upper and a lower component. This configuration enables the realistic simulation of load transfer mechanisms, closely replicating the boundary conditions and force application encountered in service. The design process incorporated geometric optimization and appropriate material selection to ensure high structural stiffness, durability, and minimal interference with the measured response of the tested component. A systematic design methodology was employed, including analytical dimensioning and structural verification to ensure safe operation under loading conditions of up to 4000 N. Special attention was given to achieving stable alignment and repeatable positioning of the lifting eyes, thereby enhancing the consistency and reliability of experimental results. The fixture was further evaluated in terms of its capability to minimize parasitic stresses and ensure uniform load distribution. Experimental investigations carried out using the developed device demonstrate its effectiveness in providing reproducible and representative data for the assessment of lifting eye performance. The results indicate a significant improvement in testing fidelity compared to conventional methods, enabling a more accurate evaluation of structural behavior under realistic loading conditions. The proposed solution contributes to improved safety assessment and design optimization of lifting components in industrial applications. Moreover, the methodology and design principles presented in this study can be extended to the development of specialized testing devices for other mechanically loaded components, supporting broader advancements in experimental mechanics and industrial testing practices.

Key words: design, simulation, device, tensile, lifting.

GUI FOR REAL-TIME MONITORING OF FDM 3D PRINTING USING SERIAL DATA

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Abstract:

Additive manufacturing based on Fused Deposition Modeling (FDM) is increasingly aligned with Industry 4.0 principles, where real-time data acquisition, process transparency and digital monitoring are essential for improving process reliability and repeatability. In this context, FDM printing systems can be treated as cyber-physical systems, where the physical process is continuously observed and correlated with digital information.
This research aims to develop a graphical user interface (GUI) for real-time monitoring of FDM 3D printing using serial data acquisition. Experiments are performed on a Creality Ender 3 S1 Pro printer, from which process parameters are collected via serial communication. The monitored variables include nozzle temperature, bed temperature, instantaneous heating power, feedrate and the current layer position determined from the Z-axis coordinate. The acquired data are structured and displayed in a clear format, allowing direct interpretation of the process state during printing. The experimental methodology is based on a Taguchi design of experiments (DOE), where key process parameters are varied, namely nozzle temperature, bed temperature, layer height, infill pattern and number of perimeters. During each experimental run, real-time data is recorded and visualized through the developed GUI. In parallel, the printed part is monitored using a GoPro camera, allowing the operator to observe the physical state of the process. When a defect such as warping, layer detachment or material accumulation is detected, the process can be interrupted, and the exact process conditions at that moment are recorded. The results demonstrate that the proposed GUI enables continuous monitoring of process parameters and improves process transparency. The determination of the current layer allows precise localization of defects, while the recorded data supports correlation between parameter settings and process outcomes. In conclusion, the developed system provides an effective tool for real-time monitoring and analysis of FDM printing, supporting experimental studies and contributing to improved understanding and optimization of the manufacturing process.

Key words: Industry 4.0, Principles, GUI-based monitoring, Taguchi DOE, FDM 3D printing, Serial communication.

DYNAMIC ANALYSIS AND PERFORMANCE EVALUATION OF INERTER FRACTIONAL NONLINEAR QUASI-ZERO STIFFNESS ISOLATOR ON A MULTI-SPAN BRIDGE UNDER MOVING LOAD

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Abstract:

In this paper we propose a new vibration isolator system, which combines the advantages of a quasi-zero stiffness (QZS) isolator, a damper exhibiting fractional properties and an inerter, to reduce the vibrations of a multi-span continuous beam bridge excited by moving loads. The inerter produces a fictitious mass amplification effect to improve the controller performance and the fractional order takes into account the previous state of the viscoelastic material. After formulating the dynamics equation using beam theory, the amplitude response is determined analytically using the averaging method. The results obtained from the analytical study are validated using the direct numerical simulation method (Newton–Leipnik method). By comparing the isolation performance of the FQZS (fractional quasi-zero stiffness) isolator and the IFQZS (inerter fractional quasi-zero stiffness) isolator, it is shown that the addition of inertance can significantly suppress the tendency of the curve to slope to the right, allowing us to have a wider isolation frequency range on force transmissibility while improving the efficiency of the isolator. One also shows that increasing the fractional parameter contributes to a decrease in the vibration amplitude of the structure, the amplitude of the force transmitted and the area in which unstable solutions appear. However, beyond a certain value of the fractional parameter, we observe an increase in the latter. In order to further extend the study, bifurcation diagram, phase portrait, time history and power spectral density are explored.

Key words: Quasi-zero stiffness, Multi-span continuous beam bridge, Inerter, Transmissibility, Fractional order, Moving loads, Bifurcation diagram.

THE SUSTAINABILITY OF DIGITALIZATION MANAGEMENT IN HIGHER EDUCATION INSTITUTIONS

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Abstract:

Romanian institutions, including higher education organizations, are currently undergoing an accelerated digitalization process. In many cases, this transition still represents a basic shift from analog to digital formats - primarily the replacement of paper-based workflows with digital ones, partial automation, and the selective adoption of Industry 4.0 tools. Meanwhile, global developments have progressed toward Industry 5.0, a stage that emphasizes balance between humans, technology, and the environment. Its aim is to enhance institutional efficiency while reintroducing human-centric elements and tailoring processes to individual needs, thus generating added value for institutions, users, and long-term environmental sustainability through responsible resource use. However, the digitalization trajectory in Romania differs significantly from that of more technologically mature countries, where advancements have been gradual and structured. Romanian institutions experienced a sudden leap during the COVID-19 pandemic, implementing Industry 4.0 practices without having fully completed the transition associated with Industry 3.0. This discontinuity has led to operational inconsistencies and increased pressure on human resources. At the same time, discussions on Industry 5.0 concepts coexist with the persistent need to automate fundamental administrative and institutional processes. As a result, human, technological, and material resources are often used inefficiently, a notable example being the continued reliance on substantial amounts of paper despite the availability of digital solutions. Considering these contextual factors - along with the requirement to align institutional digital infrastructures with those of partner organizations and to address the digital skills gap among administrative staff - the digitalization of Romanian higher education institutions can be described as fragmented and conceptually abstract. From a management perspective, it becomes essential to clearly identify the current stage of development, expose systemic weaknesses, and outline realistic steps needed to achieve meaningful technological progress. Such progress must go beyond the mere duplication of analog processes in electronic format and instead focus on generating tangible benefits for institutional actors, improving operational efficiency, and supporting measurable advancements in environmental sustainability.

Key words: Digitalization, Industry 5.0, Higher education, Sustainability, Human-centric processes, Institutional efficiency.

CAD/CAM APPROACHES FOR MACHINING A MECHANICAL PART ON A VERTICAL CNC MACHINING CENTER

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Abstract:

In the current context of digital manufacturing, the competitiveness of CNC machining processes depends not only on dimensional accuracy and surface quality, but also on the ability to reduce machining time and improve productivity while maintaining the functional requirements of the part. The paper addresses the application of CAD/CAM methods to the machining of a mechanical part on a vertical CNC machining center, with emphasis on the analysis of alternative machining variants from the perspective of execution time. In the current context of digital manufacturing, the efficiency of CNC machining processes is increasingly influenced not only by dimensional accuracy and surface quality, but also by the way in which toolpaths are defined and machining operations are organized. Starting from this premise, the study investigates a mechanical part with medium geometric complexity, whose configuration requires machining in two setups and involves several categories of operations, including contour milling, bore machining, drilling, recess machining, and slot milling. The analyzed part, manufactured from C45 steel round stock, was modeled in a CAD environment and programmed using a CAM system. The research approach is based on the development of the machining process in a CAM environment, virtual simulation and validation of toolpaths, comparative analysis of machining times, and the identification of the operations with the highest contribution to the total machining duration. After establishing the initial machining plan, the critical operations were selected and alternative machining variants were proposed and evaluated comparatively. The analysis focused on the influence of toolpath configuration, tool engagement conditions, and operation sequence on the estimated machining time. The results highlight that the optimization applied to the selected operations leads to a reduction in the total machining time, demonstrating that the careful adaptation of machining variants to the geometric characteristics of the part can improve the time efficiency of the process. The contribution of the study consists in the comparative evaluation of alternative CAD/CAM-based solutions for critical operations and in the identification of practical directions for reducing machining time in the case of parts manufactured in multiple setups.

Key words: CAM, machining, CNC, part, time.

ARTIFICIAL INTELLIGENCE APPLICATIONS IN GARMENT MANUFACTURING: A MULTIPLE CASE STUDY AND IMPLEMENTATION FRAMEWORK

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Abstract:

The garment manufacturing industry is currently undergoing a profound transformation driven by the adoption of Industry 4.0 technologies, with Artificial Intelligence (AI) emerging as a key enabler of digitalization and process optimization. Despite the increasing interest in AI applications across manufacturing sectors, its integration within garment production systems remains uneven and insufficiently structured, particularly in small and medium-sized enterprises. This creates a significant gap between technological potential and practical implementation. The purpose of this paper is to investigate how AI is currently applied in garment manufacturing and to develop a structured framework that supports its systematic implementation in production environments. The research is based on a qualitative multiple case study methodology, involving the analysis of selected industrial examples where AI technologies are applied in areas such as real-time quality control, predictive maintenance, automated sewing, and production planning. The case studies were selected based on relevance, technological maturity, and availability of documented results. The analysis highlights that computer vision systems are predominantly used for defect detection and quality control, achieving high levels of accuracy and enabling real-time monitoring. Predictive AI solutions contribute to reducing equipment downtime and improving operational efficiency, while AI-driven planning systems support better decision-making in complex production environments. However, the study also identifies several challenges, including high implementation costs, data availability issues, and integration complexity. Based on the comparative analysis, a conceptual AI implementation framework is proposed, structured in five main stages: data collection, data processing, AI model development, system integration, and continuous monitoring and optimization. This framework provides a structured approach for integrating AI technologies into garment manufacturing systems, addressing both technical and organizational aspects. The results of this study contribute to bridging the gap between theoretical research and industrial practice, offering practical insights for the adoption of AI in garment manufacturing. The proposed framework can support decision-makers in improving production efficiency, reducing defects, and advancing the digital transformation of the garment industry.

Key words: Artificial Intelligence; Garment Manufacturing; Industry 4.0; Digital Transformation; Case Study; Production Optimization; Smart Manufacturing.

PERTURBATION ANALYSIS OF KINEMATIC TRAJECTORIES USING FRACTAL DYNAMICS FOR THE DETECTION OF EXPERIMENTAL ERRORS IN PATIENTS WITH RHEUMATOID ARTHRITIS

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Abstract:

In the context of finger biomechanics and biomechatronic systems, joint motion trajectories exhibit complex variations that are difficult to represent using conventional deterministic models. To overcome these limitations, a mathematical framework is introduced in which nominal trajectories are subjected to controlled fractal perturbations generated through the iterative dynamics associated with Mandelbrot theory. For joint motion analysis, the proposed system employs time series of joint angles acquired from experimental measurements and reconstructs the actual trajectory of the distal phalanx relative to a reference trajectory derived from data recorded in healthy subjects. For this purpose, a graphical user interface (GUI) was developed in MATLAB for the kinematic analysis of the index finger, modeled as a serial kinematic chain with three degrees of freedom. The superposition of these trajectories enables direct evaluation of discrepancies and automatic computation of error indicators, including perturbations in Cartesian coordinates (XY), along the normal direction to the trajectory, and in the joint angle space. The results indicate that the introduction of fractal perturbations provides a more accurate representation of the natural variability of motion by capturing local kinematic instabilities and nonlinear deviations from the nominal trajectory. Compared with nominal trajectories, fractal-based models show a higher capacity to distinguish between stable and unstable motion regimes, which is relevant for applications in motion analysis, rehabilitation, and the optimization of biomechatronic systems. The automatic comparison between actual and reference trajectories represents an effective approach for detecting errors in kinematic assessment systems. Integrating these analyses into an interactive graphical environment provides a useful tool for the validation of experimental data and for improving the accuracy of biomechanical assessment in patients with rheumatoid arthritis.

Key words: finger motion analysis, fractal perturbation, trajectory comparison, joint kinematics, measurement error analysis.

STRONTIUM BASED PHOSPHATE CONVERSION COATINGS APPLIED ON METALLIC BIOMATERIALS – A BRIEF REVIEW

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Abstract:

This review provides a synthetic perspective on recent advancements in strontium-based phosphate (Sr-P) chemical conversion coatings applied to metallic biomaterials, with a primary focus on titanium (Ti) and magnesium (Mg). Titanium remains the gold standard in orthopedic and dental implantology due to its superior biocompatibility and mechanical properties; however, its bioinert nature limits direct chemical bonding with bone tissue. In contrast, magnesium is a promising biodegradable metal that eliminates the need for a secondary surgical intervention, yet it suffers from an excessive corrosion rate in physiological environments, leading to subcutaneous hydrogen gas accumulation and the premature loss of mechanical integrity. The phosphate chemical conversion (PCC) technique represents an efficient, cost-effective, and versatile solution to overcome these limitations by fabricating protective and bioactive layers directly onto the metallic substrate. Strontium is integrated into these coatings due to its unique dual capacity to stimulate bone formation by enhancing osteoblast proliferation while simultaneously inhibiting bone resorption through the regulation of osteoclast activity. Research indicates that the performance of Sr-P coatings is dictated by critical process parameters, including temperature, pH, and ionic concentration. On titanium substrates, adjusting the pH between 2.50 and 3.25 transforms the deposition morphology from sporadic plates to dense microcrystals of $SrHPO_4$ and $Sr_3(PO_4)_2$, significantly enhancing corrosion resistance and cellular adhesion. For magnesium, hydrothermal treatment at temperatures ranging from 80 to 200 °C favors the formation of a dual-layered structure—comprising an inner $Mg(OH)_2$ layer and an outer strontium apatite (SrAp) layer—which drastically reduces the initial biodegradation rate. Recent studies have explored multi-element systems, such as strontium-zinc-phosphate (SZP) and calcium-strontium-zinc-phosphate (CSZP) coatings. These hybrid coatings not only improve mechanical properties but also induce macrophage polarization toward the anti-inflammatory M2 phenotype, thereby accelerating osteogenesis and angiogenesis through the sustained release of biofunctional ions. Furthermore, doping with zinc or calcium refines the crystal size, shifting original diamond-like or rhomboidal structures toward micro/nanoscale lamellar textures favorable for preosteoblast anchoring and spreading. This analysis confirms that strontium-based conversion coatings represent an essential technological frontier for the development of next-generation implants capable of ensuring rapid osseointegration and long-term stability in complex clinical applications.

Key words: strontium phosphate, conversion coatings, metallic biomaterials, phosphating.

DEVELOPMENT OF AN EXPERIMENTAL MODEL FOR PROCESSING ADVANCED MATERIALS

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Abstract:

For machining surfaces with high hardness, a good method with high processing efficiency is electrochemical machining (ECM). The main advantage of electrochemical machining is obtaining high precision and very smooth surfaces, without tool wear and without the appearance of stresses or thermal deformations in the material. In this article, I present the design and testing of an experimental model under laboratory conditions, using equipment and electrolyte solutions in accordance with the process requirements. After the experiments are completed, the next stage involves validating the model by evaluating its performance in relation to various technological parameters, such as the type and concentration of the electrolyte and the applied voltage, as well as by analyzing the quality of the resulting surfaces. Completing the prototype optimization process will enable improvements in the uniformity of the machined surfaces, energy efficiency, and operational stability through constructive and technological adjustments. The ultimate goal of this work is to verify the proper functioning of the electrochemical processing system and to identify the most efficient ways to use this technology for processing complex materials. This article presents a study on the electrochemical processing of advanced chromium–cobalt alloys, materials widely used in biomedical, aerospace, and industrial applications due to their high resistance to corrosion, wear, and elevated temperatures. The influence of the main process parameters (voltage, current, current density, temperature, electrolyte pressure and flow rate, and working gap) on the anodic dissolution rate, surface quality, and process stability is analyzed. The study examines two types of electrolytes: sodium chloride (NaCl, 5% concentration) and systems based on 5% sodium carbonate and 4.7% citric acid. The electrochemical mechanisms, experimental results, advantages, and limitations of each electrolyte are discussed, along with optimization directions for future studies. Chromium–cobalt alloys are recognized for their exceptional mechanical and chemical properties and are widely used in orthopedic and dental implants, wear-resistant components, and highly corrosive environments. In conclusion, the developed experimental model represents an efficient and versatile tool for advanced material processing, supporting both scientific research and future industrial optimization and implementation.

Key words: Electrochemical machining, ECM, electrolyte, linear actuator, DC power source.

A CONCEPTUAL FRAMEWORK FOR IDENTIFYING BEST MANAGEMENT PRACTICES IN SMART MAINTENANCE

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Abstract:

Over time, and alongside technological progress, various types of maintenance have emerged. This evolution has moved from repairing equipment right before a failure occurs to a technological process that relies on continuous measurement and monitoring of operating parameters, making it possible to anticipate failures before they appear. Today, maintenance is strongly supported by the development of digital technologies. Although its importance and technological transformation have grown significantly, the managerial dimension of smart maintenance remains insufficiently explored, especially when it comes to identifying best practices and defining criteria for evaluating managerial performance. In this context, the aim of this paper is to identify and define the best management practices in the field of smart maintenance. Methodologically, the research adopts a conceptual approach based on a review of the specialized literature, with the goal of identifying a set of managerial best practices. These practices are structured according to the main managerial functions: forecasting, planning, organizing, coordinating, and controlling. The results of this study contribute to linking these managerial functions with the continuous technological development of smart maintenance. Additionally, the paper proposes a set of performance indicators (KPIs) that can support and enhance the continuous improvement of management strategies in relation to smart maintenance activities. In addition, the study highlights the growing need for managerial clarity in a context where industrial systems are becoming increasingly connected and data-driven. While digital tools provide unprecedented visibility into equipment behavior, their real value only emerges when managers are able to transform this information into appropriate decisions, aligned processes, and well-coordinated teams. Therefore, smart maintenance requires not only technological preparedness but also a mature managerial framework capable of integrating the human, organizational, and digital dimensions. By highlighting these best practices and associated performance indicators, the paper provides a practical reference point for organizations that wish to strengthen their maintenance strategies and face the challenges of digital transformation with greater confidence and a well-established direction in all essential aspects. This conceptual formulation offers a theoretical contribution for both researchers and practitioners interested in optimizing performance within increasingly complex industrial and digital environments.

Key words: Management, Smart Maintenance, Performance, Industry, 2026 Trends.

STRUCTURAL RESPONSE OF A PROTECTIVE BRAKE SYSTEM SHIELD UNDER THERMAL AND DYNAMIC LOADING

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Abstract:

The integration of compact brake systems in modern vehicles imposes severe operating conditions on protective components located in the engine compartment. These components are subjected to combined thermal loading and vibration excitation from the powertrain and road inputs, which can significantly influence their stiffness, deformation behaviour and structural reliability. This study addresses the structural response of a sheet-metal protective shield designed for a valve block unit, with emphasis on the interaction between thermal effects and dynamic loading. The geometry of the component is defined by packaging constraints imposed by adjacent systems and mounting interfaces, leading to a non-uniform structural layout with local geometric discontinuities and free-edge regions. The component is made from S355MC structural steel, commonly used in automotive sheet-metal applications due to its good formability and adequate mechanical strength. The material provides sufficient load capacity, while its forming characteristics allow the realization of complex geometries. However, material behaviour can be influenced by temperature variations, especially in the engine compartment environment, where thermal gradients affect stiffness and local stress distribution. An theoretical finite element model was developed to evaluate the structural response under typical operating conditions. Modal analysis was performed to identify the natural frequencies and dominant deformation modes, highlighting critical areas associated with reduced stiffness. Transient dynamic analysis was further used to capture the structural response under vibration loading. Thermal loading conditions were introduced in the model to account for temperature gradients and localized deformatiom effects. The results show that increased temperature levels lead to a reduction in structural stiffness and an amplification of deformation amplitudes in critical regions. At the same time, dynamic excitation contributes to local stress intensification, especially in areas with geometric discontinuities such as bends and mounting areas. The study demonstrates that the coupled effect of thermal and vibration loading plays a key role in the structural performance of sheet-metal protective components.

Key words: Sheet-metal, stiffness, deformation, vibration.

CONTROL STRATEGY AND SIMULINK IMPLEMENTATION FOR AN OMNIDIRECTIONAL ROBOT WITH OBSTACLE AVOIDANCE CAPABILITIES

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Abstract:

This paper presents a complete study on the design, kinematic analysis, structural optimization, and performance enhancement of an omnidirectional robotic platform intended for autonomous navigation in environments with predefined trajectories and dynamic obstacles. The proposed system is based on a mobile robot equipped with omnidirectional wheels, enabling holonomic motion and high maneuverability, which are essential for applications in modern industrial environments such as logistics, automated transport, and flexible manufacturing systems. The research focuses on the development of a complete kinematic model, including both inverse and forward kinematics, which establishes the relationship between the robot's motion and the angular velocities of its wheels. Starting from the rigid body motion equations, the model is derived to accurately describe the robot's behavior in planar motion. This formulation enables precise trajectory tracking and facilitates the implementation of control strategies capable of minimizing positional and orientation errors. Furthermore, the structural design of the robotic platform is analyzed, considering key aspects such as wheel configuration, geometric dimensions, mass distribution, and stability, all of which significantly influence system performance and reliability. To enhance the autonomy of the system, an obstacle avoidance strategy is integrated into the control architecture. This strategy is based on real-time sensor data processing and reactive navigation principles, allowing the robot to detect and avoid obstacles while maintaining its intended trajectory. The combination of trajectory tracking and obstacle avoidance ensures safe, flexible, and efficient operation in dynamic environments. A key contribution of this work is the development of a complete simulation framework using MATLAB/Simulink, which integrates the kinematic and dynamic models, control algorithms, sensor inputs, and environmental interactions into a unified platform. The simulation environment enables detailed analysis of system behavior under various operating conditions, including different trajectories, obstacle distributions, and control parameters. The results obtained from simulations demonstrate improved trajectory tracking accuracy, effective obstacle avoidance, and enhanced robustness of the robotic system. The proposed methodology provides a solid foundation for future experimental validation and real-world implementation, contributing to the advancement of autonomous omnidirectional robotic platforms in industrial applications.

Key words: onidirectional wheels, kinematic, autonomous, trajectory tracking, path.

INTEGRATING SUSTAINABILITY INTO ROAD FREIGHT TRANSPORT COMPANIES IN THE REPUBLIC OF MOLDOVA: BETWEEN POLYCRISIS, COMPLIANCE AND COMPETITIVENESS

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Abstract:

This article starts with the idea that sustainability in freight road transport companies, must be concept as a holistic vision of environment in which they operate. Present days are marked with geopolitical, energy source, climate and economic s polycrisis. This is the key factor that makes companies to aim their attention on surviving, on kipping on operational resilience and to strengthen the cost control. Such uncertain business environment, make climate objectives to be deprioritized. Here appears a gap, from one size exists pression on climate risks mitigation, from the other part freight road transport remain to be one of the most climate impacting sector with CO2 emisions, noise pollution, high energy consumption and infrastructure deterioration. We propose to analize the level of readiness for change and for sustainable transition of transport companies from Republic of Moldova for one part, for another one to propose a practic framework for easier integration of sustainable practices in their operational management. The findings indicate a tendency toward a low level of sustainability maturity among freight transport companies. A single company answered that they monitor sustainable values, other 26 companies responded negatively. The majority of firms limits to complying with Euro emissions standards. Another observation is that the need for decarbonisation, which imply significant investitions from public and private sector, highs necessity for additional solutions neutral for techologies. So, it appears tendence for changing tax politics, slow transition from vignettes to real kilometres taxes, noise taxes, and taxes on infrastructure impact. On national level, the pression on transport sector is amplifying with introducing objective till 2030, to transfer 30% of road transport for rail transport. The maine vulnerability of freight road transport companies, are the limits of internal sources in condition of the external environment pression. Here appeares the necessity of simple tools, that are easy and real in execution. In conclusion we can say that steps to do in applying sustainable practices in transport sectors, can be in improving durable objectives, calculating and monitoring of foot print values and adoption of ESG base values.

Key words: sustainability integration, road freight transport, polycrisis, framework, foot print, decarbonization.

MICROWAVE HEATING AND PHYSICAL PHENOMENA OF MICROWAVE HEATING OF MATERIALS – A REVIEW

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Abstract:

Microwave heating represents a research direction of growing importance within advanced processing technologies, being intensively studied for its superior energy efficiency and enhanced process performance compared to conventional thermal methods. This work contributes to the understanding of the physical mechanisms governing electromagnetic field-material interaction and assesses the current state of applications of this technology. The research analyzes the physical phenomena underlying microwave heating, characterizes the relevant material properties-such as dielectric permittivity, loss factor, and electromagnetic field distribution-and classifies materials according to their response in the microwave field. A systematic and comparative analysis of the specialized literature underpins the identification of the principal advantages and limitations of microwave heating relative to classical heating approaches. The results confirm that microwave heating enables rapid, volumetric energy transfer, leading to significant reductions in processing time and measurable improvements in energy efficiency. Enhanced physical and structural properties of treated materials are documented across multiple application domains. Persistent challenges include field non-uniformity, process control complexity, and high equipment costs, highlighting the need for more accurate simulation tools and adaptive control strategies. From a strategic-forecasting perspective, bibliometric and patent-landscape analyses indicate an accelerating adoption of microwave heating in industrial and research applications. S-curve diffusion models suggest that the technology is transitioning from rapid growth toward maturity in conventional heating processes, while simultaneously entering an early-stage emergence phase in advanced micro- and nanoscale material processing. Qualitative foresight methods-including expert-based Delphi panels and scenario analysis-point to potentially disruptive advances in selective microwave heating, reactive sintering, and bio-compatible material treatment. These insights support prioritizing investments in process simulation, adaptive control systems, and fundamental research on material-field interactions, aligned with interdisciplinary technology roadmaps. In conclusion, microwave heating emerges as a versatile and high-potential technology with broad application prospects, requiring further research to optimize existing processes and to expand its implementation into new domains.

Key words: Microwave heating, dielectric properties, materials, technology forecasting, S-curve analysis, strategic foresight.

ROLE OF MANUFACTURING ROUTES IN TAILORING β-TYPE Ti–Mo–Nb–Sn ALLOYS FOR BIOMEDICAL APPLICATIONS

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Abstract:

Biomedical alloys, particularly titanium-based alloys, have gained popularity in the field of orthopaedics and dental applications due to their outstanding biocompatibility, corrosion resistance, and favorable mechanical properties. However, the manufacturing route plays an important role in determining the final properties of these alloys, particularly in terms of microstructural homogeneity, phase stability, and defect control. Conventional processing techniques such as vacuum arc remelting (VAR), powder-based additive manufacturing, and sintering methods each offer distinct advantages and limitations in controlling composition, porosity, and contamination. The recent shift in focus towards novel β-type Ti alloys further emphasizes the importance between processing techniques and the properties of alloys, in particular, the Ti–Mo–Nb–Sn alloy system serves as a relevant case study for understanding how manufacturing routes influence alloy performance. Due to the differing melting points and diffusion behaviors of the alloying elements, achieving a stable and homogeneous β-phase structure requires careful optimization of processing parameters. Processing routes directly affect grain refinement, phase distribution, and defect formation, which in turn influence mechanical properties such as elastic modulus, strength, and ductility. Powder-based additive manufacturing techniques can enable fine microstructural control but may introduce porosity, while remelting techniques improve chemical homogeneity at the expense of higher costs and processing complexity. Experimental studies on Ti–Mo–Nb–Sn alloys demonstrate that appropriate selection and control of manufacturing methods can produce a refined β-phase microstructure with reduced elastic modulus and favorable mechanical performance. Furthermore, corrosion resistance and biocompatibility are also closely linked to the resulting microstructure, reinforcing the importance of processing in biomedical applications. In conclusion, manufacturing routes are a key factor in tailoring the properties of advanced β-type titanium alloys, with the Ti–Mo Nb–Sn system highlighting how processing routes influence phase stability and performance. This presentation aims to analyze the influence of processing routes on mechanical parameters, with future perspectives on optimizing processing techniques, improving defect control, and evaluating the long-term safety of the implant.

Key words: Manufacturing Techniques, β-type Ti Alloys, Ti-Mo-Nb-Sn, Phase Stability, Biocompatible Implants, Parameter Sway.

STRATEGIC FORECASTING METHODS FOR MICRO AND NANOTECHNOLOGIES

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Abstract:

Strategic forecasting is a central instrument for decision-making in the knowledge-based economy, where rapid technological change demands structured anticipatory methods. Micro and nanotechnologies represent a particularly challenging domain, characterized by accelerated innovation, interdisciplinary convergence, and radical uncertainty, which render classical single-method approaches insufficient. The ability to anticipate emerging technological trajectories constitutes a critical competitive advantage for both organizations and research institutions. This research aims to conduct a structured critical analysis of the main strategic-forecasting methods documented in the specialized literature, evaluating their theoretical foundations, strengths, and limitations in the context of micro- and nanotechnology domains. A secondary objective is to identify the methodological gaps that justify the development of a novel integrated forecasting framework within the doctoral thesis. The methodology is based on a systematic literature review structured across three categories. Quantitative methods analyzed include time-series extrapolation, S-curve diffusion models (logistic and Gompertz), bibliometric and scientometric analysis, and patent-landscape analysis. Qualitative methods examined comprise the Delphi method, prospective scenario planning, strategic roadmapping, and expert judgment. As an illustrative application, the field of microwave processing technologies is reviewed, with a focus on electromagnetically assisted pasteurization processes. This case study highlights how the convergence of functionalized micro- and nanomaterials and high-frequency electromagnetic fields generates technological trajectories that are difficult to capture by traditional methods, requiring the integration of experimental data, patent trends, and interdisciplinary expertise. Results show that quantitative methods, while objective and replicable, are largely retrospective and fail to capture disruptive innovations. Qualitative methods offer flexibility but are susceptible to cognitive bias and lack standardized validation. Hybrid approaches represent the most promising direction, yet their implementation remains inconsistent, with few validated frameworks enabling systematic integration of bibliometric data, patent indicators, and expert opinion. Three major gaps are identified: methodological fragmentation, over-reliance on descriptive forecasting, and inadequacy of existing models for convergent and emerging technologies. In conclusion, the literature confirms the need for an integrated, adaptive strategic-forecasting framework designed for micro- and nanotechnology domains. The identified gaps justify the doctoral objective of developing a hybrid methodology that combines quantitative rigor, qualitative foresight, and AI-based analytical tools into a robust decision-support framework for emerging-technology forecasting.

Key words: Strategic forecasting, technology foresight, bibliometrics, microwave heating, electromagnetic field, pasteurization process.

ANALYTICAL MODELING AND ADVANCED EXPERIMENTAL ANALYSIS OF NATURAL FREQUENCIES IN PRINTED CIRCUIT BOARDS

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Abstract:

This study presents a comprehensive theoretical and experimental investigation of the vibrational behavior of printed circuit boards (PCBs), with emphasis on the identification of natural frequencies, mode shapes, and spatial stress distribution under dynamic loading conditions. The theoretical framework is based on classical plate formulations, namely Kirchhoff–Love plate theory and Reissner–Mindlin plate theory. These models enable the prediction of modal characteristics as a function of material properties, geometry, and boundary conditions. The Kirchhoff–Love theory is applicable to thin PCB structures where shear deformation is negligible, while the Reissner–Mindlin formulation extends the analysis to multilayer or moderately thick boards by incorporating transverse shear effects, improving accuracy for real engineering structures. Since analytical models cannot fully represent real electronic assemblies with mounted components and complex constraints, experimental validation is essential. This is achieved using Laser Doppler Vibrometry (LDV), enabling non-contact, high-resolution measurement of structural response. The experimental approach includes full-field out-of-plane scanning, three-dimensional vibration analysis, and single-point 3D sensing. These methods provide detailed information on operating deflection shapes and reveal localized regions of high vibration amplitude across the PCB surface, offering a direct visualization of structural dynamics that cannot be captured by conventional point sensors. The testing methodology is aligned with vibration requirements defined in ISO 16750-3, ensuring relevance for automotive electronic systems operating under harsh dynamic environments. The combined theoretical and experimental framework enables accurate correlation between predicted and measured modal behavior. The obtained results are directly applicable in identifying critical stress regions, optimizing component placement, improving solder joint reliability, and reducing the risk of fatigue-induced failures in electronic assemblies. These analyses support engineering decisions during design and validation stages by enabling early-stage assessment of structural performance before prototype or production implementation. The integration of plate-based analytical modeling with high-resolution 3D vibrometry provides a consistent methodology for evaluating and controlling the dynamic response of PCB structures under realistic operating conditions.

Key words: printed circuit boards, vibration analysis, plate theory, Laser Doppler Vibrometry, modal identification.

INVESTIGATIONS INTO THE TRIBOLOGICAL, THERMOMECHANICAL AND CORROSION RESISTANCE PROPERTIES OF BRAKING SYSTEMS MATERIALS

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Abstract:

The braking system represents one of the most critical components of a vehicle in motion, being subjected to extreme stress conditions. The present study provides a synthesis of the most recent research reports concerning friction materials in braking systems, categorized into three distinct sections. The first part comprises works within the field of thermomechanics. This category presents topics such as design criteria, defects induced by thermal exposure, and the influence of temperature on various material types. Simulations presented in these studies reveal that disc geometry directly influences heat dissipation and the resulting mechanical stress. The second part discusses the tribological aspects of the interaction between the brake disc and the pad, utilizing direct measurements of wear and the material contact interface. System performance is correlated with the formation of the transfer film (Third Body Layer). Furthermore, the influence of materials and binders is discussed, such as the incorporation of nano-carbon into phenolic resins, which results in an increase in tensile strength by up to 77% and prevents high-temperature fading. Various tests indicate an inverse correlation between the coefficient of friction (COF) and rotational speed, yet a direct correlation with sliding velocity, which stabilized the friction layer. A key conclusion of this section is that the intentional reduction of the COF decreased abrasive wear by an order of magnitude and eliminated destructive vibrations. The final section synthesizes studies addressing the corrosion of friction materials. To inhibit the phenomenon of galvanic adhesion during standstill, the studies include solutions such as replacing copper with zinc additives, forming a protective oxide layer without compromising the tribological efficiency of the pads. The analysis within each chapter includes finite element numerical simulations, while empirical data were collected through dynamometer testing, pin-on-disc tribological tests, and electrochemical evaluations. Surfaces were characterized using scanning electron microscopy, X-ray spectroscopy, and thermogravimetric analysis. In conclusion, this paper outlines subjects that may serve as starting points for future research directions, as the design of a safe and durable braking system represents a summation of multidisciplinary requirements.

Key words: Brake pad, Friction and wear, tribological properties, thermal stability.

CYBERSECURITY CHALLENGES IN HEALTHCARE ORGANIZATIONS. THE ROLE OF SCIENTIFIC RESEARCH AND ARTIFICIAL INTELLIGENCE IN STRENGTHENING INSTITUTIONAL RESILIENCE

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Abstract:

The accelerating digitalization of healthcare systems has fundamentally transformed the operational landscape of medical institutions, introducing unprecedented efficiencies while simultaneously expanding the attack surface available to malicious actors. In an era where patient data, clinical workflows, and critical infrastructure are increasingly interconnected, cybersecurity has evolved from a technical concern into a core organizational and managerial challenge. High-profile breaches targeting hospitals, pharmaceutical companies, and health information networks have demonstrated that cyber attacks in the healthcare sector carry consequences far beyond data loss, directly threatening patient safety, institutional continuity, and public trust. This paper aims to examine the nature and typology of cybersecurity challenges faced by healthcare organizations, with a particular focus on the managerial and governance dimensions of institutional vulnerability. Furthermore, the research investigates the strategic role that scientific inquiry and artificial intelligence-driven tools play in strengthening the resilience of healthcare institutions against evolving cyber threats. The research methodology combines a systematic literature review of peer-reviewed publications, institutional reports, and industry frameworks, including NIST, ISO 27001, and HIPAA compliance standards, with a comparative analysis of AI based security control implementations documented across healthcare settings. The study draws on interdisciplinary sources spanning cybersecurity engineering, health informatics, and organizational management to construct a holistic analytical framework. The findings indicate that traditional, rule-based security approaches are increasingly insufficient in addressing the dynamic and sophisticated nature of contemporary cyber threats. AI-powered mechanisms, including anomaly detection, predictive threat modeling, and automated incident response, demonstrate measurable improvements in detection accuracy and response time within clinical environments. Moreover, the research highlights that institutional resilience is not solely a technological outcome, but a product of integrated governance structures, continuous staff training, and research-informed policy development. The paper concludes that embedding scientific research and artificial intelligence into the cybersecurity governance frameworks of healthcare organizations is not merely a technological upgrade, but a strategic imperative. Future research directions include the development of sector-specific AI governance models and the empirical validation of resilience metrics in real-world clinical settings.

Key words: cybersecurity governance, healthcare organizations, artificial intelligence, institutional resilience, cyber risk management, scientific research.

ESTIMATION OF MASS LOSS IN MUSEUM TEXTILES THROUGH IMAGING-BASED METHODS

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Abstract:

The long-term preservation of museum textile collections requires reliable, non-destructive or minimally invasive methods for assessing material degradation. Mass loss — a critical indicator of fibre deterioration — is traditionally measured gravimetrically, a method that demands physical sampling and is therefore unsuitable for irreplaceable heritage textiles. This study proposes an imaging-based methodology for estimating mass variation in museum-grade textiles by quantifying fibre compactness changes within yarn cross-sections, monitored continuously throughout accelerated ageing cycles. The mass of museum textiles could be useful for producing faithful replicas if the originals deteriorate beyond recovery. Since direct gravimetric measurement requires physical sampling, mass is instead calculated from yarn diameters obtained from microscopic images. Yarn diameter represents a practical expression of yarn fineness; however, the diameters measured microscopically on aged museum textiles do not correspond to the true fineness of the yarns as originally spun, because mechanical wear and laundering progressively alter fibre packing within the yarn cross-section. To address this, the study determines the fibre packing compactness coefficient for textile samples, before ageing and at successive stages of abrasion and laundering cycles for representative natural fibres textile materials. The yarn diameter depends on packing fraction or yarn compactness degree which is defined as the ratio of specific volume of fibres in yarn to specific volume of yarn. A correlation is established between the packing fraction within the yarn and the cumulative mechanical wear sustained by each sample. By knowing the packing fraction of fibres inside old yarns, it becomes possible to back-calculate the true original fineness. This recovered fineness value is an essential parameter for estimating the original mass per unit area of the textile. Results demonstrate that this imaging-based method provides a statistically robust and non-destructive pathway to yarn fineness value recovery across the tested materials. The proposed methodology offers a scientifically grounded tool for mass estimation and replica specification in textile conservation practice.

Key words: museum textile, fibre packing fraction, yarn diameter, woven fabric mass.

RISK MANAGEMENT IN GLOBAL TRADE SYSTEMS

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Abstract:

Risk management in customs administration is increasingly centered on trade-related vulnerabilities, particularly in the context of complex global supply chains and evolving methods of customs fraud. This study examines specific risks associated with international trade operations, with a focus on practices such as undervaluation, misclassification of goods, origin fraud, and the misuse of preferential tariff regimes. These risks directly affect revenue collection, market fairness, and regulatory compliance, making their effective management a priority for customs authorities. The objective of this research is to analyze the mechanisms through which trade-related risks manifest within customs clearance processes and to evaluate the effectiveness of current risk management practices in identifying and mitigating such threats. The study is based on a review of specialized literature, combined with analytical and comparative methods, including system-based analysis and synthesis. Particular emphasis is placed on transactional risk indicators, data inconsistencies in customs declarations, and anomalies in trade patterns. The findings highlight several critical vulnerabilities, including the deliberate underreporting of customs value to reduce duties, incorrect tariff classification to exploit lower duty rates, and false declarations of origin to benefit from preferential trade agreements. Additionally, the research identifies risks related to the fragmentation of shipments (“split consignments”) to avoid detection thresholds, as well as the use of intermediary companies to obscure the real economic operator. Another significant issue is the limited interoperability between customs information systems at national and international levels, which restricts the ability to perform comprehensive risk assessments based on complete trade data. The paper concludes that strengthening trade-focused risk management requires the development of advanced analytical tools, improved access to real-time trade data, and enhanced cooperation between customs administrations and international partners. A more precise targeting of high-risk transactions would contribute to increased revenue protection, more efficient allocation of control resources, and improved compliance within the international trade environment.

Key words: Trade-related risk, customs valuation, tariff classification, origin fraud, customs compliance.

TESTING METHODOLOGIES FOR EVALUATING THE ADHESION OF 3D PRINTED POLYMERS ON TEXTILE SUBSTRATES

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Abstract:

The integration of additive manufacturing with textile substrates has emerged as an important research direction in materials engineering, industrial engineering, and textile-based product development, enabling the creation of hybrid structures for wearable systems, protective garments, smart textiles, and fashion applications. In these composites, the quality of the interface between the printed polymer and the textile support is a decisive factor for mechanical integrity, durability in use, and functional performance. At the same time, the literature shows that, despite the rapid growth of this field, there is still no universally adopted testing standard dedicated specifically to polymer–textile interfaces produced by direct 3D printing. The purpose of this study is to synthesize and critically structure current knowledge regarding the testing of adhesion between 3D printed polymers and textile substrates, with emphasis on the most relevant experimental methods, influential process parameters, and reported performance ranges. The paper is based on a systematic analytical review of peer-reviewed studies addressing adhesion testing in 3D printed textile composites. The analysis highlights that the most frequently used experimental methodologies are T-peel, 90° and 180° peel tests, tensile and pull-off tests, and, less frequently, shear tests. Reported testing configurations commonly involve universal testing machines, specimen widths of about 25–50 mm, and crosshead speeds between 10 and 100 mm/min, depending on the selected protocol. The reviewed studies also show that adhesion is mainly governed by mechanical interlocking, supported by thermal bonding and, in certain cases, chemical interactions at the interface. The main results indicate that adhesion performance is strongly influenced by nozzle and bed temperature, nozzle–fabric distance, fabric porosity and roughness, fiber composition, and surface pretreatments such as alkaline or plasma activation. For optimized systems, reported adhesion values range from about 3 N/mm to over 5 N/mm, while some configurations reach forces around 30 N. Overall, the review confirms that adhesion testing is essential for process optimization and material selection, but also underlines the need for standardized protocols and more realistic durability studies for future industrial and wearable applications.

Key words: 3D printing on textiles; adhesion testing; polymer–textile composites; peel test; fused deposition modeling; textile engineering.

STRUCTURAL AND FUNCTIONAL MODIFICATIONS OF HIGH-PERFORMANCE FABRICS DESIGNED FOR MULTI-HAZARD IMPACT PROTECTION SYSTEMS

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Abstract:

In the demanding sectors of defense, emergency response, and heavy industry, technical textiles must provide multi-functional protection against a spectrum of mechanical and thermal hazards. While the integration of flame retardant (FR) properties is a non-negotiable safety requirement for military gear and personal protective equipment (PPE), the chemical and structural modifications necessary to achieve these standards often conflict with the requirements for mechanical resilience and environmental shielding. This study evaluates the compromise between fire safety and structural performance by comparing a standard virgin polyester (PES) fabric with an FR-modified variant. The latter utilizes 100% FR PES yarns and a high-density FR-slurry coating. The experimental analysis, conducted within the framework of research on impact-resistant materials, focuses on the degradation of key performance indicators. Testing according to SR EN ISO 13934-1 and SR EN ISO 13937-4 revealed that the transition to FR components leads to a significant loss in mechanical integrity. Tensile strength decreased by approximately 26% in the warp direction and 30% in the weft, while tear resistance—a critical factor for durability in field conditions—dropped by nearly 50%. Furthermore, despite the increased weight and density of the FR coating, the hydrostatic pressure head was reduced by roughly 33%, indicating a decline in the fabric’s barrier efficiency. These findings underscore the technical challenges in designing high-performance composites that do not sacrifice impact protection for fire safety. The results provide a quantitative basis for future optimization of multifunctional textiles where maintaining high energy-absorption capacity is as vital as thermal protection.

Key words: Flame Retardant, Mechanical Strength, Hydrostatic Pressure, Impact Resistance, Technical Textiles.

PHOSPHATE CONVERSION COATINGS FOR MAGNESIUM ALLOYS: A SHORT REVIEW

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Abstract:

Magnesium alloys represent a promising alternative to conventional metallic materials used in implantology, due to their controlled degradation and biocompatibility. However, their electrochemical instability in physiological environments accelerates corrosion, limiting their clinical use. In this context, surface protection through phosphate-based chemical conversion coatings has become an important area of research. This paper analyzes the role of these coatings in controlling the degradation of magnesium alloys, highlighting the mechanisms of formation and the main types of layers formed. The phosphating process involves the local transformation of the metal surface through chemical reactions that form insoluble compounds that act as a barrier between the material and the aggressive environment. Depending on their composition, the coatings can range from zinc phosphates, designed for corrosion protection, to calcium phosphates, used primarily in biomedical applications due to their similarity to the mineral structure of bone. Furthermore, doping these layers with ions such as strontium or zinc enables adjustment of their properties from both chemical and biological perspectives. Results reported in the literature indicate that these coatings reduce the degradation and improve tissue interaction. At the same time, the development of complex systems, such as multilayer coatings or those doped with multiple ions, meets the current need to simultaneously optimize anticorrosive performance and bioactivity. Despite their advantages, these coatings still have limitations related to porosity and stability, which necessitate further research in this field. Overall, the phosphate conversion coatings offer a suitable solution for improving the performance of magnesium alloys, with real potential for the development of next-generation biodegradable implants.

Key words: magnesium alloys; phosphate conversion coatings; corrosion protection; biocompatible alloys; surface enhancements.

EFFECT OF THERMAL TREATMENT TEMPERATURE ON SURFACE MORPHOLOGY AND ELECTROCHEMICAL BEHAVIOR OF COPPER FOILS

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Abstract:

Copper-based materials are widely investigated for electrochemical applications due to their tunable surface properties and accessible fabrication methods. In this study, copper foils were thermally treated at 400, 600, and 800 °C to induce controlled surface restructuring and to evaluate its impact on electrochemical performance. A clear temperature-dependent morphological transition was observed. At 400 °C, the surface is predominantly characterized by nanowire-like structures, while increasing the temperature to 600–800 °C leads to the formation of progressively porous surface architectures. X-ray diffraction (XRD) analysis confirmed temperature-dependent phase evolution, indicating the formation and reorganization of copper oxide phases under different thermal regimes. Electrochemical characterization was carried out in 0.5 M NaOH using cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). CV measurements, performed in the scan rate range of 5–100 $mV \cdot s^{-1}$, revealed an increase in current response with increasing scan rate, suggesting improved charge transfer kinetics and enhanced electroactive surface area. The cathodic current varied from −0.17 mA to −2.38 mA, while anodic currents ranged between 0.12 mA and 2.6 mA, depending on the thermal treatment conditions. Samples treated at higher temperatures exhibited distinct electrochemical behavior, which can be associated with increased surface porosity, modified oxidation states, and changes in charge transfer resistance. These findings demonstrate a strong correlation between thermally induced surface morphology and electrochemical performance. Overall, the results highlight thermal treatment as a simple and effective strategy for tailoring copper surfaces with tunable electrochemical properties, with potential applications in electrocatalysis and energy-related systems.

Key words: copper foils, thermal treatment, surface morphology, nanowires, porous structures, cyclic voltammetry, electrochemical impedance spectroscopy, copper oxides

MECHANISMS AND STRUCTURAL PERFORMANCE OF Fe-Mn-Si-Cr SHAPE MEMORY ALLOYS

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Abstract:

Iron-based shape memory alloys (SMAs), specifically the Fe–Mn–Si system, offer an economical and high-performance alternative to traditional Ni–Ti systems for large-scale structural applications due to their low cost, high mechanical strength, and ease of processing. Unlike Ni–Ti alloys, where the transformation is thermoelastic, the shape memory effect in Fe–Mn–Si is mechanically induced. The fundamental mechanism involves a diffusionless, reversible martensitic transformation from γ-austenite (fcc) to ε-martensite (hcp). This transformation is governed by the slip of Shockley partial dislocations, which chang the atomic stacking sequence from ABCABC to ABAB. While Mn stabilizes the austenite phase, Si is essential for promoting -martensite formation. Shape recovery occurs when the ε stress induced martensite transforms back into austenite upon heating above the temperature, typically achieving 3–4% deformation recovery. However, excessive deformation can induce undesirable α’-martensite (bcc), which reduces the overall efficiency of the shape memory effect. A technologically vital phenomenon is retained recovery (recovery stress), which occurs when the reverse transformation is mechanically constrained during heating. Under these conditions, the material develops high internal stresses ranging from 200 to 400 MPa. These stresses are essential for the functionality of couplings, fastening devices, active structural reinforcements, and seismic dampers. The addition of 5–10% Cr is a critical optimization strategy. Chromium reduces stacking fault energy (SFE), facilitating the formation of ε-martensite bands and increasing the mechanical strength of the austenite. This allows the development of recovery stresses exceeding 400 MPa in certain compositions. Furthermore, Cr enhances corrosion resistance through the formation of a passive layer, which is vital for the toughness of smart structures in aggressive environments. Finally, performance is sensitive to the strain rate: low rates favor the transformation and smoother recovery, whereas high rates promote plastic slip and undesirable phases. Experimental studies further indicate that a specific composition range of 25–30% Mn, 4–6% Si, and 5–10% Cr is optimal for achieving a superior balance between shape memory capacity, structural stability, and long-term fatigue resistance.

Key words: Fe–Mn–Si–Cr shape memory alloys, shape memory effect, martensitic transformation, contrain recovery, strain rate.

MOBILITY AND LOCOMOTION MECHANISMS FOR MOBILE ROBOTS – A REVIEW

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Abstract:

The increasing deployment of autonomous mobile robotic platforms in dynamic, human-shared environments has established mobility as a fundamental and multidisciplinary challenge within the Industry 4.0 paradigm, wherein the selection of an appropriate locomotion mechanism directly determines operational safety, maneuverability, and energy efficiency in collaborative settings. Against this background, the present study aims to deliver a systematic and analytically rigorous examination of locomotion mechanisms employed in mobile robotics, with sustained emphasis on their kinematic and dynamic governing principles, application-specific suitability, and compliance with international safety standards. The research adopts a structured methodological framework that integrates theoretical kinematic and dynamic modeling with a comparative architectural evaluation of predominant locomotion paradigms, developing a comprehensive taxonomic classification encompassing differential drive, Ackermann steering, omnidirectional wheel configurations, tracked platforms, legged systems, and hybrid transformable morphologies, each critically assessed in terms of structural constraints, control requirements, and domain-specific performance characteristics. Advanced motion control strategies, including nonlinear formulations, Model Predictive Control, and learning-based methodologies such as reinforcement learning and neural adaptive control, are systematically examined in the context of nonholonomic constraint satisfaction, wheel slip compensation, and dynamic payload variation management. The findings substantiate that no universally optimal locomotion solution exists across the full spectrum of operational contexts, as wheeled configurations retain dominance in structured indoor environments owing to their mechanical simplicity and superior energy conversion efficiency, while omnidirectional platforms confer enhanced maneuverability in spatially constrained settings demanding holonomic motion, and tracked or legged systems extend operational viability to unstructured terrains at the cost of elevated energy consumption and mechanical complexity. A multi-criteria performance analysis further delineates the inherent trade-offs among maneuverability, dynamic stability, and conformance with ISO/TS 15066 and ISO 3691-4 safety standards, confirming that locomotion selection must be strictly guided by operational context, payload requirements, and human-centered safety constraints. In conclusion, the synthesized findings provide a principled basis for context-aware selection of locomotion mechanisms, while converging trends in hybrid architectures and data-driven control paradigms outline prospective research directions toward versatile, energy-efficient, and safety-compliant autonomous mobile robotic systems.

Key words: Mobile robots, locomotion mechanisms, kinematic modeling, dynamic modeling, motion control, collaborative environments.

RESEARCH ON THE FLUID FLOW AND HEAT TRANSFER PHENOMENA SPECIFIC TO FLUID–METAL INTERACTION DEVELOPED WITHIN THE CONSTRUCTION OF NAVAL STRUCTURES

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Abstract:

This study considers thermo-fluid phenomena during fluid–metal interactions, which are important for the shipbuilding and welding-related manufacturing processes. In naval construction, operations involving molten metals are characterized by concurrent heat transfer, fluid flow, and phase transformations, each of which considerably affects the quality of structural joints and final components. In practice, welding thin plates represents a difficult case study, because small variation in process parameters or operator control can quickly influence stability and quality. Research of this topic, under real working conditions, will be in the focus. The research analyzes and numerically characterizes molten metal behavior under thermally driven conditions using a physics-based modeling approach. The analysis specifically examines how heat transfer, surface-tension variations, and density-driven forces influence flow structures within the molten zone, to enhance process understanding and to support industrial optimization. The theoretical approach is based on the fundamental conservation laws of mass, momentum, and energy, extended to include thermal transport equations and phase transition modeling. Buoyancy effects are studied by using the Boussinesq approach, while surface-driven flow is represented by Marangoni convection. Computational Fluid Dynamics (CFD) is used to capture these transient and nonlinear phenomena. In addition, practical observation supported by the use of a welding simulator allows the study of the influence of the working parameters (travel speed, working angle, and movement stability) on the quality of the process. Results show a strong connection between the thermal conditions and the fluid motion. Temperature variations produce significant changes in the fluid flow development, while surface tension effects generate localized circulation zones within the molten pool. These mechanisms directly affect the pool stability and the evolution of geometry during processing. Overall, the findings show that CFD-based modeling is an effective tool for examining complex fluid–metal interactions in the naval manufacturing domain. The approach can support enhancements in process control strategies and structural quality in industrial applications.

Keywords: fluid–metal interaction, computational fluid dynamics (CFD), heat transfer, naval engineering, welding processes, phase change, thermo-fluid modeling.

INVESTIGATIONS ON THE FLUID FLOW INSIDE DEVICES DESIGNED FOR THE AUTOMOTIVE INDUSTRY. CASE STUDY: COOLING SYSTEMS DESIGNED FOR PLASTIC INJECTION TOOLS

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Abstract:

The study presents the state of the art regarding the cooling process in injection moldings from both numerical and experimental perspectives. Investigation on how coupled simulations of fluid flow and heat transfer can be used to predict defects in the plastic injection tools, such as shrinkage and warpage, was studied by Chiang et al. The results emphasize the impact of non-uniform mold temperatures. Other relevant paper authored by Gaoa et al. identifies the most suitable Reynolds number for the flow of the coolant material. Results indicate that the optimal value is around 20,000, to ensure efficient heat transfer without excessive pressure losses. Hassan et al. studied other important issue: how the position and geometry of cooling channels influence the temperature distribution and the polymer solidification. Their work analyses the trade-off between fast cooling and uniformity and concludes that to improve the productivity of the process, the cooling time should be minimized and at the same time a homogeneous cooling should be necessary for the quality of the product, which means that the minimum cooling time is not achieving uniform cooling throughout the mold. A broader perspective is provided by Wagner and Nóbrega, who examine how CFD methods are used to optimize the design of the cooling channel, with a special focus on conformal channels that improve temperature uniformity and reduce cycle time. The importance of uniform cooling is also explored in the research work of St. Jacques, where thermal gradients across the part thickness are identified as the main cause of warpage. Furthermore, Dimla et al. analyze how the optimized channel geometry can enhance heat removal and improve surface quality. Finally, in the work of Coca-Gonzalez and Jimenez-Martinez discusses the main factors leading to deformation, with cooling conditions, pressure, and material properties playing a key role are discussed and an overview of upcoming techniques aimed at fully mitigating and measuring this phenomenon in real time during manufacturing processes is presented. Overall, all studies underline that cooling is the most critical stage of the process, directly influencing defects, cycle time, and final quality of the product obtained by plastic injection.

Key words: plastic injection moulding, cooling performance, pressure drop, fluid flow, Reynolds number, optimization.

THE EFFECT OF POST-PROCESSING TECHNIQUES ON THE MECHANICAL PROPERTIES AND MICROSTRUCTURE OF AM-MG ALLOYS FOR BIOMEDICAL DEVICES

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Abstract:

Biodegradable magnesium (Mg) alloys demonstrate significant potential for application across various industries, including aerospace, automotive, and electronics, primarily due to their capacity to reduce component weight. Magnesium and its alloys have attracted considerable attention in the medical field, owing to their biodegradability and relatively low elastic modulus, which is comparable to that of human bone. Such degradable implants eliminate the need for secondary surgical removal. Furthermore, their mechanical compatibility with human bone, combined with excellent biocompatibility, renders them suitable candidates for medical devices such as cardiovascular stents, orthopedic implants, and bone scaffolds. In the recent years, additive manufacturing has emerged as a highly promising technology for producing prototypes and components with complex geometries. In biomedical applications, magnesium exhibits substantial potential for the development of customized implants with optimized geometries, thereby reducing the risk of rejection and improving ergonomic outcomes. The capability to fabricate near-net-shape components with intricate designs has generated significant interest in the additive manufacturing (AM) of Mg alloys, signaling a broader transformation in manufacturing practices. However, the AM of Mg alloys present considerable challenges due to their inherent material properties, including high susceptibility to oxidation, gas entrapment, a high thermal expansion coefficient, and a low solidification temperature. These factors can lead to defects such as porosity, lack of fusion, cracking, delamination, residual stresses, and microstructural inhomogeneity, all of which adversely affect the mechanical, corrosion, and surface properties of additively manufactured Mg alloys. Among the various approaches employed to enhance the performance of biodegradable Mg alloys and mitigate these challenges, post-processing treatments have proven to be particularly effective. These techniques enable modification of the microstructure, and consequently the corrosion behavior and mechanical properties, without altering the alloy composition or geometry. This paper reviews post-processing strategies applied to additively manufactured Mg alloys, including heat treatment, hot isostatic pressing, and mechanical treatments, with a focus on their influence on microstructural evolution as well as mechanical and corrosion performance.

Key words: Additive manufacturing, treatment, post-processing, biocompatibility, corrosion, devices.

MATHEMATICAL MODELING AND THERMODYNAMIC ANALYSIS OF STIRLING ENGINE PERFORMANCE

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Abstract:

This paper presents a physico-mathematical model of a Stirling engine operating under non-ideal conditions. The model take into account non-ideal heat transfer processes between the working gas and the heat source and the heat sink. Pressure and temperature inside the functional spaces are determined based on energy balance equations. Heat exchange between the working gas and the external reservoirs is modelled with constant heat transfer coefficients, enabling evaluation of non-ideal heat transfer effects. The engine functioning was numerical simulated. The numerical results were used to assess the influence of heat transfer over the engine performance. The proposed approach provides a framework for analysing non-ideal thermodynamic processes in Stirling engines and can serve as a basis for further numerical development.

Key words: Stirling engine; thermodynamic modeling; heat transfer; numerical analysis.

GREEN AESTHETICS IN CLOTHING: A STUDY WITHIN THE CONTEXT OF SUSTAINABILITY

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Abstract:

Green aesthetics in clothing remains an ambiguous and insufficiently explored concept, despite the increasing necessity of sustainability within the fashion industry. In recent years, sustainability has been addressed mainly through environmental, technical, and economic perspectives, while the aesthetic dimension has often been forgotten or treated as secondary. However, aesthetic value plays a crucial role in shaping consumer behavior, influencing emotional attachment to garments and, therefore, their lifespan. This paper argues that aesthetics and sustainability should not be treated as separate domains, but rather as interdependent dimensions of contemporary fashion design. The aim of this research is to explore and clarify the concept of green aesthetics in clothing within the broader context of sustainability. More specifically, the study seeks to highlight the necessity of integrating aesthetic values with environmental and ethical considerations, suggesting that sustainability in fashion cannot be fully understood or effectively implemented without addressing its aesthetic dimension. The research is based on a critical literature review that brings together perspectives from aesthetics, sustainable design, and fashion studies. It examines how aesthetic perception in clothing is constructed through emotional, and cultural factors, and how these can be aligned with sustainable principles. Special attention is given to the need to extend aesthetic discourse from the field of art to everyday products, such as clothing, and to reconsider the criteria by which beauty is evaluated in a sustainability-driven context. The theoretical analysis suggests that green aesthetics can function as a unifying framework, combining visual appeal with ethical awareness and lifecycle thinking. In conclusion, this research supports the idea that sustainability should no longer be discussed independently of aesthetics, and that aesthetic judgment itself must evolve in relation to sustainable values.

Key words: aesthetics, green, beauty, clothing, visual perception, consumer behaviour.

COMPARATIVE EXPERIMENTAL EVALUATION OF A CURRENT TRANSFORMER AND A HALL-EFFECT CURRENT PROBE USED FOR MONITORING ACTIVE ELECTRICAL POWER ABSORBED BY AC DRIVE MOTORS

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Abstract:

This paper presents a detailed comparative experimental study on the use of two distinct methods for measuring the instantaneous alternating current (AC) absorbed by an electric motor that drives a mechanical system (for example, an automotive gearbox or the mechanism of a machine tool such as a lathe). The first method is based on a toroidal AC current transformer, while the second uses a Hall-effect current probe, which is considered in this context to exhibit near-ideal behavior and high fidelity in reproducing the real signal. The AC current waveforms obtained using the two methods are thoroughly analyzed and subsequently used to determine the active electrical power absorbed by the motor. This active electrical power is directly correlated with the mechanical power delivered to the driven system, thus serving as a key indicator for evaluating the performance and efficiency of the motor–load assembly. The experimental results highlight a well-known phenomenon reported in the literature: compared to the Hall-effect current probe, AC current transformers introduce a positive phase shift in the measured signal. More precisely, the waveform of the current measured with the transformer appears to “lead” the actual current in the circuit. This positive phase shift has direct consequences for power analysis, as it artificially increases the phase difference between voltage and current. As a result, the calculation of active electrical power becomes inaccurate, typically being either underestimated or overestimated depending on the operating conditions. To address this drawback, the paper proposes a method for compensating the phase error introduced by the current transformer. In addition, the study examines the limitations of current transformers under dynamic conditions, particularly during severe transient regimes characterized by rapid current variations. It is shown that, in such situations, these devices may exhibit significant errors, signal distortions, or additional delays, making them less suitable for applications that require accurate capture of fast transient phenomena. In conclusion, the paper provides an in-depth comparative analysis of the two measurement techniques, highlighting both their advantages and limitations, and proposes practical solutions for improving measurement accuracy in real-world applications.

Key words: AC drive electromotor, mechanical systems, active electrical power, AC instantaneous current, AC current transformer, Hall-effect current probe.

IN-SITU QUALITATIVE AND QUANTITATIVE ANALYSIS OF WELDED METALLIC MATERIALS USING OPTOELECTRONIC AND SPECTROMETRIC METHODS FOR WELDING PROCESS MONITORING

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Abstract:

Modern welding processes of metallic materials, particularly those based on laser sources, are characterized by a high degree of complexity, resulting from the interaction between electromagnetic radiation, the material, and the surrounding environment. In the interaction zone, a thermal plasma is generated, whose emitted radiation carries relevant information regarding chemical composition, temperature, and process stability. In this context, the development of fast and reliable real-time monitoring methods represents a key direction for improving the quality and efficiency of industrial processes. The aim of the work is the development and integration of optoelectronic and spectrometric systems capable of performing in-situ qualitative and quantitative analysis of welded metallic materials, as well as real-time monitoring of the laser welding process. The proposed approach is based on the use of plasma-emitted optical radiation as a primary source of information for process characterization and evaluation of its energetic state. The experimental methodology involved the design, development, and testing of a set of complementary optoelectronic devices, including portable systems without an excitation source, based on the analysis of natural plasma radiation, portable systems with an integrated laser excitation source, a modular spectromicroscope for advanced material characterization, and an optoelectronic detector based on a PiN photodiode for rapid monitoring of optical emission. These systems were integrated into an experimental setup dedicated to the measurement and control of the Nd:YAG laser welding process. Experimental investigations were carried out on AISI 304L stainless steel and P235TR1 carbon steel using TIG, MMA, and pulsed Nd:YAG laser welding processes. The experimental results demonstrate accurate identification of the main chemical elements and quantitative determinations with deviations below 1% compared to reference values. Additionally, the optoelectronic signal showed a direct correlation with pulse energy and the thermal state of the plasma, enabling the evaluation of process stability. Compared to conventional analytical methods, the analysis time was significantly reduced from tens of minutes to a few seconds.

Key words: laser welding, in-situ analysis, optoelectronic systems, spectrometry, thermal plasma, process monitoring.

ENHANCING THE TRIBOLOGICAL PERFORMANCE OF BIODEGRADABLE ZnCu AND ZnCuTi ALLOYS THROUGH SEVERE SHOT PEENING

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Abstract:

Zinc (Zn)-based alloys are recognized as promising next-generation biodegradable materials for temporary medical implants due to their biocompatibility and moderate degradation rates. However, their clinical application is often limited by inherently poor mechanical strength and low wear resistance in the as-cast state. This research investigates surface engineering through severe shot peening (SSP) as a strategy to address these limitations. The study evaluates the comparative influence of shot peening treatment on the microstructure and tribological behavior of two systems: binary ZnCu and ternary ZnCuTi alloys. Samples were processed using ceramic beads (B100) with variable exposure times, achieving coverage levels of 100%, 500%, and 1000% (Severe Shot Peening). The experimentation methodology involved 3D optical profilometry for surface topography mapping, scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) for microstructural and chemical characterization, and dry wear tests using a pad-on-disc configuration (20N load). The results demonstrate a dramatic transformation of surface topography, with the arithmetic roughness (Ra) increasing 28-fold, from ~0.20 µm to a maximum of 5.84 µm. Advanced roughness descriptors (Rsk and Rku) were identified as critical predictors of friction performance, revealing that intermediate coverage (500%) can be detrimental due to peak-dominated topographies. Conversely, the 1000% SSP treatment induced superior surface consolidation. Wear resistance analysis showed a significant progressive improvement, with a maximum reduction in worn volume of 61% for ZnCu and 60% for ZnCuTi at the highest coverage level. A significant "smoothing effect" was observed within the wear tracks, where initial asperities flattened into protective plateaus. The discussion highlights the synergistic effect of grain refinement, strain hardening, and, in the case of ZnCuTi, the micro-rolling bearing effect of TiZn16 intermetallic compounds. In conclusion, severe shot peening at 1000% coverage is validated as an effective solution for maximizing the durability of biodegradable Zn implants, providing a nanocrystalline hardened layer that stabilizes the degradation process under mechanical load.

Key words: Biodegradable alloys, Severe Shot Peening, Wear resistance, ZnCuTi, Surface topography, Strain hardening.

A SHORT REVIEW ON PNEUMATICALLY ACTUATED SOFT GRIPPERS

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Abstract:

Soft robotics has appeared as an alternative to the limitations of traditional rigid robotic systems, which struggle to safely interact with unstructured or delicate objects. While conventional rigid manipulators offer precision and repeatability, they lack adaptability and compliance. This makes them less suitable for tasks such as handling fragile items or operating in complex biological settings. Soft robots are made from compliant materials that allow them to deform continuously. This enables safer interaction, better contact with objects, and greater adaptability to variations in shape and environment. Within this field, soft robotic grippers represent one of the most significant and widely developed applications. Grasping is a fundamental capability required in many fields, including medical and surgical applications, rehabilitation and prosthetics, agriculture and harvesting, food handling and packaging industries, industrial manufacturing and automation, underwater exploration and marine biology, space applications and more. Soft grippers can adapt their shape to the object, making it possible to handle irregular, soft, or fragile items more effectively. As a result, these grippers provide a practical solution where conventional rigid robotics is insufficient.

This paper presents a review of pneumatic soft gripper designs reported in the literature, covering three categories: soft, hybrid, and adaptive systems. It focuses on their structural configurations, materials, and actuation principles, as well as their reported performance in terms of load capacity. Most of these systems rely on pneumatic actuation and are made from elastomeric materials such as silicone, thermoplastic elastomers (TPE), and thermoplastic polyurethane (TPU), which allow large deformation and safe interaction. The presented designs illustrate the wide range of applications of soft grippers, from handling lightweight and fragile objects to more demanding tasks involving higher loads. This paper aims to provide an overview of current developments and serve as a reference for the design of future pneumatic soft gripper.

Key words: Soft Robotics, Soft Gripper, Pneumatic Actuator.

KINEMATIC MODELING OF AN H-BOT PICK-AND-PLACE MANIPULATOR

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Abstract:

Cartesian manipulators remain highly relevant in industrial automation because they provide direct translational motion, a workspace that is easy to parameterize, and relatively simple inverse kinematics. In practical pick-and-place scenarios, Cartesian architectures remain particularly attractive because their task space and configuration space are closely related, which simplifies motion planning and control.

Among planar positioning systems, the H-Bot architecture occupies a distinct place. It uses two rotary drives connected by a single H-shaped timing belt arranged around a gantry-type mechanism; the motors remain fixed on the frame, while the carriage or end-effector moves in the x-y plane. This architecture is valued for its compactness and reduced moving mass, and it is sufficiently established to appear in industrial motion-control environments as a dedicated kinematic transformation.

In this paper, a complete kinematic formulation is developed for an H-Bot-based pick-and-place manipulator equipped with a ball-screw-driven vertical axis actuated by a rotary motor. The ideal forward and inverse kinematics are first established by expressing the planar motion through the pulley radius r and the vertical motion through the screw lead p. The model is then augmented by introducing a parasitic gantry rotation and a translational correction vector acting at the tool center point. Closed-form expressions are derived for forward kinematics, inverse kinematics, and differential kinematics. A numerical example is also provided to illustrate the overall pick-and-place cycle, the horizontal positioning errors generated by the H-Bot stage, and the corresponding corrected motion. The proposed formulation preserves the simplicity of Cartesian command generation while explicitly representing architecture-specific deviations characteristic of H-Bot systems.

Key words: H-Bot Manipulator; Pick-and-Place Robot; Augmented Kinematic Model; Parasitic Gantry Rotation; Differential Kinematics

A REVIEW ON TENDON-DRIVEN SOFT ROBOTS

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Abstract:

Soft robotics emerged as a response to the limitations of classical rigid-body robots in environments where uncertainty, close physical interaction, and delicate contact dominate the task. Foundational and recent reviews converge on the view that compliance is not merely tolerated but deliberately exploited to improve safety, adaptability, and environmental conformity. At the same time, broad reviews of soft actuation and soft-robot design show that contemporary soft robots span pneumatic, hydraulic, tendon-driven, magnetic, electroactive, and thermally driven systems, each occupying a different point in the trade space defined by portability, force density, controllability, and integration complexity.
Among these actuation families, tendon-driven systems are especially significant because they allow the actuators to remain proximal while force is transmitted to a compliant body through routed tensile elements. This architecture is particularly attractive for continuum manipulators, wearable robots, and compact end-effectors, where low distal mass and high geometric adaptability are essential. In the continuum-robotics literature, tendon actuation is consistently treated as one of the dominant actuation principles, and recent tendon-driven continuum robots (TDCRs) focused reviews explicitly center the discussion on the interplay between architecture, tendon-path assumptions, and model selection.
This review synthesizes representative literature on tendon-driven soft robots, with particular emphasis on mechanical architectures, because the architectural solution strongly conditions tendon routing, stiffness distribution, transmission efficiency, sensing requirements, and ultimately the choice of mathematical model and controller. The review then discusses modeling, sensing/state estimation, and control algorithms, highlighting friction, hysteresis, tendon routing losses, and shape observability as the main obstacles to precise and repeatable operation.

Key words: Tendon-Driven; Soft Robots; Continuum Robots; Mechanical Architecture; Shape Sensing; Model Predictive Control; Reinforcement Learning; Wearable Soft Robots

DIRECT AND INVERSE POSITION KINEMATICS OF A 2-DOF ANKLE REHABILITATION PLATFORM

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Abstract:

The ankle joint complex plays a major role in gait stabilization, load transfer, posture adaptation, and balance recovery. Consequently, ankle rehabilitation is a central component of functional restoration after ligament injuries, musculoskeletal trauma, neurological disorders, and post-operative limitations affecting lower-limb mobility. In rehabilitation robotics, the mechanical structure must reproduce clinically meaningful therapeutic motions while maintaining a geometrically consistent relationship between the device and the anatomical ankle center. For this reason, rigorous position kinematics remains a prerequisite for mechanism analysis, numerical simulation, control-oriented development, and subsequent dynamic modeling.

This paper develops a position-kinematic model for a two-degree-of-freedom ankle rehabilitation mechanism designed to reproduce the two dominant therapeutic motions of the human ankle, namely pronation-supination and plantar flexion-dorsiflexion, about a common anatomical center. The modeling strategy is carried out in two complementary stages. First, two equivalent kinematic models are introduced in order to clarify the geometry of the reduced motions, the adopted sign conventions, and the simulation-oriented loop-closure relations. Second, a complete spatial kinematic model is formulated for the coupled mechanism. For the inverse position problem, explicit expressions are obtained for the actuator coordinates as functions of the prescribed therapeutic output coordinates. For the direct position problem, closed-form relations are written for the equivalent one-degree-of-freedom mechanisms, whereas the complete spatial mechanism is reduced to a scalar nonlinear equation in the plantar flexion-dorsiflexion coordinate, followed by explicit recovery of the pronation-supination coordinate. A numerical simulation study is included in order to validate the reduced and spatial models, quantify the actuator demand, and relate the kinematic results to the actual constructive dimensions of the CAD model. The resulting formulation is directly suitable for numerical simulation, workspace evaluation, singularity analysis, dimensional synthesis, and subsequent dynamic modeling.

Key words: Ankle Rehabilitation Mechanism; Direct Kinematics; Inverse Kinematics; Spatial Mechanism; Numerical Simulation

KINEMATIC MODELING OF A SMALL-TOOTH-DIFFERENCE PLANETARY INVOLUTE REDUCER

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Abstract:

Planetary gear mechanisms based on internal-external involute gear pairs with a small difference between the numbers of teeth represent an important family of compact reducers. Their practical interest follows from the fact that a very large transmission ratio may be obtained when the difference between the tooth numbers is small, while the overall radial dimensions of the mechanism remain limited. Such solutions are especially relevant when compactness, coaxial arrangement, high reduction ratio, and relatively simple constructive integration are required. The use of internal gear pairs with small tooth-number difference has been studied from several complementary viewpoints, including geometric feasibility, minimum admissible tooth-number difference, interference avoidance, contact-ratio preservation, and profile-shift correction. These aspects are essential because, as the tooth-number difference decreases, the center distance becomes very small and the risk of involute interference, trochoidal interference, or insufficient contact ratio increases. Consequently, a kinematic model of such a reducer must be connected to the actual constructive arrangement through which the useful output motion is extracted.

This paper develops an ideal kinematic model for a pin–hole-coupled planetary reducer in which an eccentric carrier drives two externally toothed satellites meshing with a fixed internally toothed central gear. In contrast to retained-satellite mechanisms, the satellite self-rotation is used as the useful output motion and is transmitted to the output shaft through a rod–hole coupling. The proposed formulation distinguishes between the orbital motion of the satellite centers, the gear-imposed self-rotation of the satellites, and the output motion of the disk and shaft. Closed-form relations are obtained for the position, velocity and acceleration of the main kinematic points, and the geometric compatibility of the pin–hole coupling is clarified. A numerical simulation is performed for a unit tooth-number difference, illustrating the high reduction ratio, the opposite direction of output rotation, and the consistency of the rod–hole kinematic condition. The model provides a compact analytical basis for subsequent dynamic, contact, tribological and efficiency studies of this class of reducers.

Key words: Small Tooth-Number Difference; Planetary Involute Reducer; Internal-External Gear Pair; Pin-Hole Output Coupling; Output Shaft Kinematics

ANALYSIS OF NANOFIBER MEMBRANES FOR USE IN MULTILAYER FABRIC STRUCTURES

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Abstract:

This study aims to develop high-performance nanofiber membranes that can be utilized in multilayer fabric structures for outerwear applications such as jackets, coats, and footwear. The multilayer fabric system consists of an inner layer, a middle layer, and an outer layer. The outer layer acts as the first line of defense against environmental factors, providing protection against wind and external conditions. The intermediate layer generally plays a role in thermal insulation and in controlling air permeability, while the inner layer is in direct contact with the skin and contributes to the removal of moisture from the body surface. Within this study the membrane structure is designed to function as an intermediate layer compatible with structures in which knitted fabrics are used in the inner and outer layers. The electrospinning method will be used to produce the target membrane. Electrospinning is an effective technique that enables the production of nanoscale fibers with high surface area and controlled pore structure. Nanofiber membranes, which are produced by this method, act as a barrier against external factors such as water and wind, while allowing water vapor transmission, thereby enhancing clothing comfort. In this way, the nanofiber membranes intended to be integrated with knitted fabrics are expected to compensate literatüre low wind resistance of knitted structures resulting from their porous literatüre. At the same time, due to the high water vapor permeability of nanofiber membranes, the breathability of the multilayer fabric can be preserved without compromising its lightweight. Thus, the developed multilayer fabric structure is expected to simultaneously provide essential barrier properties such as windproofness and waterproofness, together with superior breathability and optimal thermal comfort.

Within the scope of the study, various nanofiber membranes will be produced using different electrospinning durations and incorporated into the designed multilayer structures. Both the physical characterization of these membranes such as thickness, mass per unit area, and morphological analyses, and their thermal comfort properties, including thermal resistance, air permeability, and water vapor transmission, will be tested. The results will be comparatively evaluated in accordance with the defined objectives and expected performance.

Key words: Nanofiber membrane, multilayer fabric, electrospinning, thermal comfort, permeability.

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