DEEP TECH 2M

BOOK OF ABSTRACTS

DEEP TECH OPEN SCIENCE DAY 2024

1ST DEEP TECH OPEN SCIENCE DAY CONFERENCE
APRIL 5, 2024, KRAGUJEVAC, SERBIA

European Institute of Innovation & Technology

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Editors: Fatima Živić, Ana Kaplarević-Mališić,

Nenad Grujović, Boban Stojanović

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ПРИРОДНО-МАТЕМАТИЧКИ ФАКУЛТЕТ 1972 КРАГУЈЕВАЦ

Preface

FIRST DEEP TECH OPEN SCIENCE DAY CONFERENCE 2024 has been designed as the Science Fair - forum and exhibition of research results in all areas of science and innovation. Deep Tech brings together different fields of science that provoke major changes in the world today, such as:

- Advanced Materials and Manufacturing
- Aerospace
- Artificial Intelligence and Machine Learning
- Biotechnology
- Blockchain
- Web 3.0
- Electronics
- Photonics
- Quantum Computing
- Robotics
- Semiconductors (Microchips)
- Sustainable Green Energy and Clean Technologies

The conference presented an opportunity to gather young researchers and renowned scientists. The conference aimed to bring together young and senior researchers for networking, brainstorming, and promotion of science to scholars, students, prospective PhDs and young people and offers students the opportunity to experience the practices of science and engineering.

Deep Tech Open Science Day Conference 2024, in the form of the exhibition fair, was held on April 5, at Faculty of Engineering, University of Kragujevac. The Conference was opened by the vice-rector of University of Kragujevac, Vladimir Rankovic, dean of the Faculty of Engineering, Prof. Dr. Slobodan Savić, dean of the Faculty of Science, Prof. Dr. Marija Stanić, the State Secretary, Ministry of Science, Technological Development and Innovation, Prof. Dr. Miroslav Trajanović, CEO of MIND – Milanović Industries Group, Darko Djorić, the coordinator of the Innovation Incubator of University of Kragujevac, Nemanja Jovičić and Conference General Chair, Prof. Dr. Fatima Živić, Faculty of Engineering, University of Kragujevac.

Conference Organizing Committee, Prof. Dr. Fatima Živić and Prof. Dr. Nenad Grujović, from Faculty of Engineering, Prof. Dr. Boban Stojanović and Prof. Dr. Ana Kaplarević-Mališić, from Faculty of Science, University of Kragujevac, delivered the talks related to the Conference background:

- What is Deep Tech?
- Additive Technologies and Innovations
- Spinoff companies – the path from the research to market
- Why do we need market validation of research thesis?

Panel discussion "STARTUPS: yes or no?" was held with panelists: Dr. Vesna Rašković Depalov, EEN Serbia – BINS, Novi Sad, Dr. Nevena Mihailović, founder of HerbaLab cosmetics, research associate at the Institute of Chemistry, Faculty of Science, University of Kragujevac and Nemanja Jovičić, coordinator of the Innovation Incubator of the University of Kragujevac who discussed the Research commercialization, Intellectual property

rights in multidisciplinary teams, Experiences of startup founders – what is the most challenging?, and How can the Innovation Incubator of the University of Kragujevac help in founding the startup.

More than 90 research groups presented their works as physical exhibits, posters and virtual presentations, including two high school student teams and several student teams, as well as more than ten companies that have joint research with University of Kragujevac. Different state-of-the-art scientific areas were presented. Conference had more than 500 visitors, including researchers, university students and PhDs, and high school students from three secondary schools, who have discussed scientific topics with researchers and made contacts for further collaborations.

Deep Tech Open Science Day Conference 2024 was jointly organized by the Faculty of Engineering and Faculty of Science, University of Kragujevac, as the first scientific Conference of such concept in Serbia, with scientific articles presented through exhibits, sample model, real systems and machine elements, virtual show and simulations, providing hands-on experience on science for young and prospective researchers. The objective of the Conference and training event was to promote and educate on Deep Tech and science to the HEI academics and non-academics, researchers, and young people, as well as to the companies and general public and to enable networking between the HEI innovation ecosystem stakeholders. Most participants were from the Faculty of Engineering and Faculty of Science, but there were also participants from the Faculty of Philology and Art, Faculty of Economics, Faculty of Medical Sciences, and Institute for Information Technologies from University of Kragujevac, as well as from companies that have joint research with University of Kragujevac, Serbia.

The Conference was very successful with participation of the large number of young people – young researchers and prospective researchers and PhD students. The Conference model of scientific research fair showed that such a new concept of scientific work presentation is very well accepted by the young people who actively participated during the whole time of the Conference. Special contribution to the Conference was participation of the "Lego musketeers" team of the high school students who won the 1st Prize at national championship, the 1st Prize in finals of the Lego league in Slovenia and won Engineering Excellence award 1st place at FLL Florida Sunshine Invitational world event on June 19 – 22, 2024 – First Lego League Florida Sunshine Invitational, USA.

Images from the Deep Tech Open Science Day Conference 2024
http://deeptech2m.eu/index.php/2023/12/25/prvi-deeptech-otvoreni-dan-nauke/

Kragujevac, 2024

Conference Chair
Prof. dr Fatima Živić

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Why do we need market validation of the research thesis?
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Terence Bowden, Dermot Brabazon, Dublin City University, Dublin, Ireland

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What is Deep Tech?

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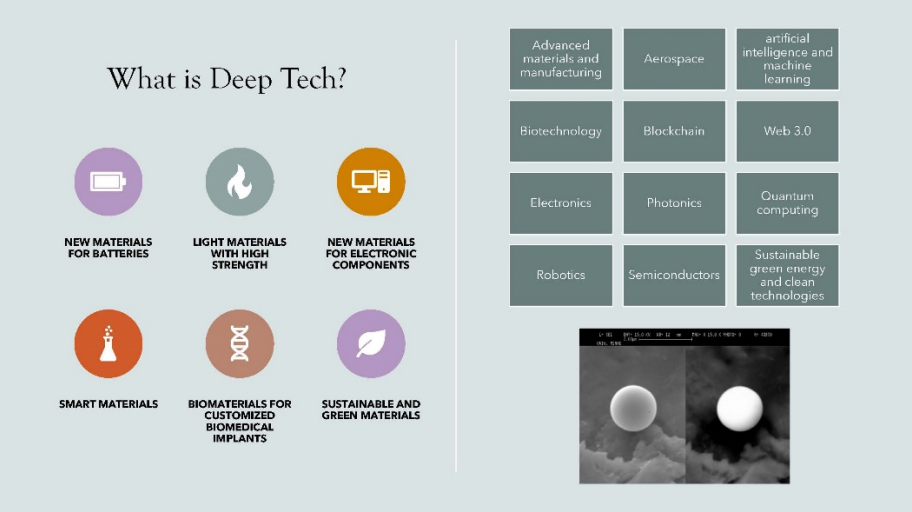
Graphical abstract



Abstract

Deep Tech brings together different fields of science that provoke major changes in the world today, including advanced materials and manufacturing; aerospace; artificial intelligence and machine learning; biotechnology; blockchain; Web 3.0; electronics; photonics; quantum computing; robotics; semiconductors (microchips); sustainable green energy and clean technologies (The Deep Tech Talent Initiative, 2024). Deep Tech promises breakthrough scientific discoveries and engineering innovations for solving global challenges nowadays. The world needs solutions to the climate changes, renewable energy sources, resilience of the industry in the turbulent market changes, new drugs and pandemics prevention, customized medicine for the aging population, smart and sustainable materials, green technologies, clean water and soil, food safety, circular economy, and other.

Deep Tech startups and companies have been working on complex challenges, based on the breakthrough scientific discoveries, such as Covid vaccines. Multidisciplinary teams with high technology expertise are the basis of the deep tech ventures. Practical applications in deep tech requires a long time since they are based on research results that commonly need time. Hence investment into deep tech is a capital risky investment but promises huge earnings when successful. One of the big challenges in deep tech ventures is the fact that these technologies commonly have no known previous concept. Deep tech is moving boundaries and disrupt knowledge with completely new ideas, solutions and breakthroughs, such as new advancements in artificial intelligence (AI), biotechnology or quantum computing, but companies in sectors such as mobility, agriculture, green energy and advanced manufacturing also start to join deep tech.

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Advanced materials have seen significant breakthroughs in recent years. New energy storage and harvesting materials have emerged, including the ongoing research for new and improved batteries. Light materials with high strength are studied in automotive, rail and airspace industries, whereas some of them have started to be used, such as carbon fiber composites providing lower weight, better efficiency, lower fuel consumption and decreased carbon footprint. New materials for electronic components, such as graphene, organic semiconductors, metamaterials, nanomaterials, photonic coatings have already showed possibilities for products with very small sizes, fast response and significantly better energy efficiency. Smart materials that react to the external stimuli, including nanocomposites, energy harvesting systems, piezoelectric and shape memory materials, self-healing structures, smart hydrogels or electroactive polymers are only some of the new advanced materials with excellent lab results. Customized biomedical biomaterials have advanced, but still most of them are in lab research phases and clinical trials are needed for their further possible clinical use. One of the major directions in material development today is towards sustainable green materials that can be recycled and reused and do not pollute the environment, such as biodegradable plastics that will solve one of the biggest problems of plastic pollution.

Research of sustainable biomaterials for biomedical implants has been related to the structure architecture, interactions between the cells and composite matrix, governing influences on the cell response, cell migration on the implant surfaces, cell adhesion, differentiation and proliferation (Brankovic, 2024; Nježić, 2022). Engineering problems and design of new material structures (Milenkovic, 2021) have considered range of influential factors, such as design of new composite structures, or stress and strain occurring due to the dynamic nature of implant behavior withing the body, to provide guidance for better understanding and implant designs, including with smart materials. The future in material science is expected to bring new materials that will enable smart, sustainable and green products in all industrial sectors, including human health and wellbeing.

Keywords: Deep Tech; Advanced Materials; Medical Implants; Biomaterials; Piezoelectric materials

Acknowledgment: This paper is funded through the EIT's HEI Initiative DEEPTECH-2M project, supported by EIT Digital, coordinated by EIT RawMaterials, funded by the European Union.

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Additive Technologies and Innovations

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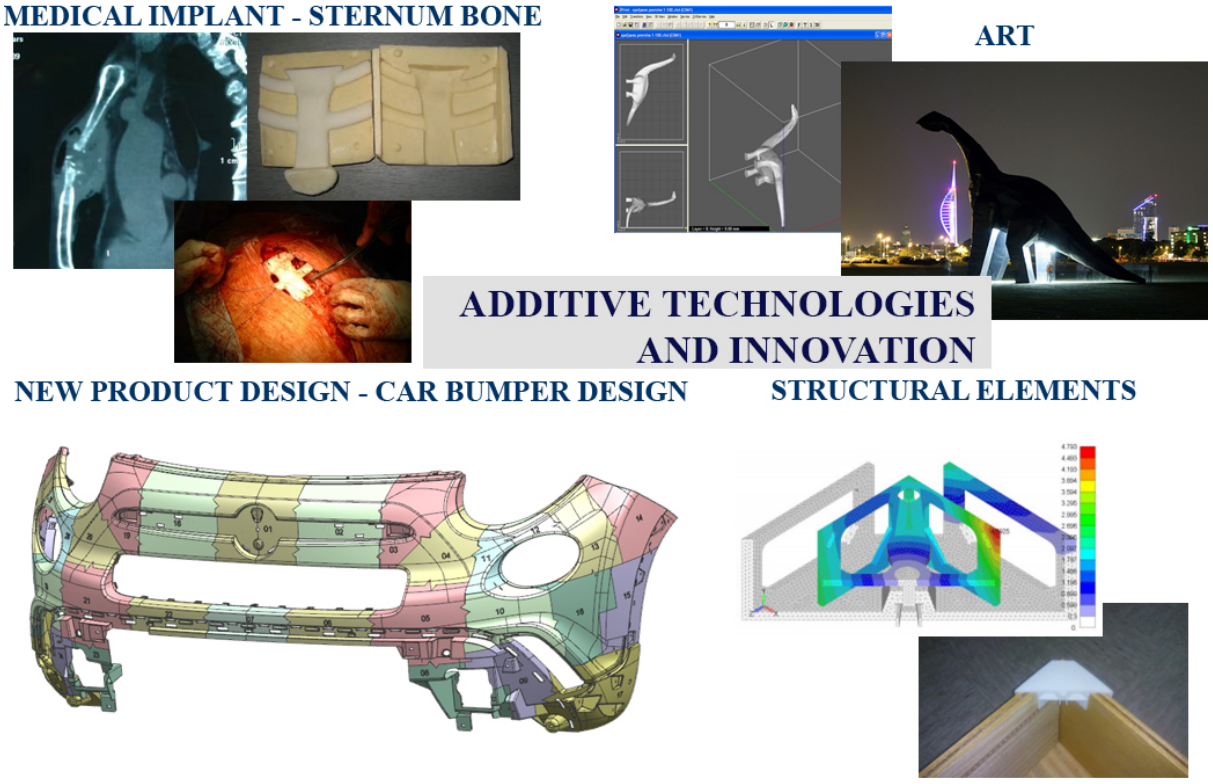
Graphical abstract



Abstract

Additive Manufacturing (AM) technologies have brought in the breakthrough in production technologies for customized products in a range of areas, including medical implants, art and architecture, tool design, different physical demonstrators in education, rapid prototyping in the design of devices, materials, new machines, and new product development (Grujović et al., 2009, Stojkovic et al., 2010). Additive technologies have allowed freedom of design in comparison to traditional subtractive technologies that have different limitations from aspects of volumetric complexity of the final product. Custom made medical implants enable the most significant advancements in medical treatments and especially in the case of complex shapes and structures for regenerative surgeries. A number of commercially available medical implant solutions for bone tissue replacements still relate only to the limited scope of traditionally used implants, such as joints replacements. For example, in the case of thoracic surgeries, such as thoracic reconstruction or traumatic rib fracture repair,

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there are no widely available implant solutions. Sternum bone reconstructive surgery needed for the treatment of cancer patient, was performed in 2008, by using 3D printed polymer mold to form polymethyl methacrylate (PMMA) bone cement in a shape of the sternum bone during the clinical surgery, thus saving the life of otherwise terminal patient (Stojkovic et al., 2010). More recent work has improved the implant material by reinforcing PMMA with medical grade titanium wires and some commercial solutions have started to appear. Essentially, additive technologies are the only production technology that can produce such highly customized implants, based on the patient CT scans, in a matter of days. To use traditional production technologies in these applications would need very costly and time demanding design of the tools and impossible to make in days time frame. Innovation can be observed through a systematic approach, but breakthrough innovations, such as deep tech solutions requires dedicated highly professional team with multidisciplinary expertise, like in the case of medical implants made by 3D printing, where collaboration between engineers, and medical doctors are of the utmost importance. Further development of AM technologies will incorporate 4D printing as the new approach to make bioactive implants (Slavkovic et al., 2023).

Keywords: Additive Manufacturing; Sternum Bone; Medical Implants; Thoracic Reconstruction

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Spinoff companies - The Path from Research to Market

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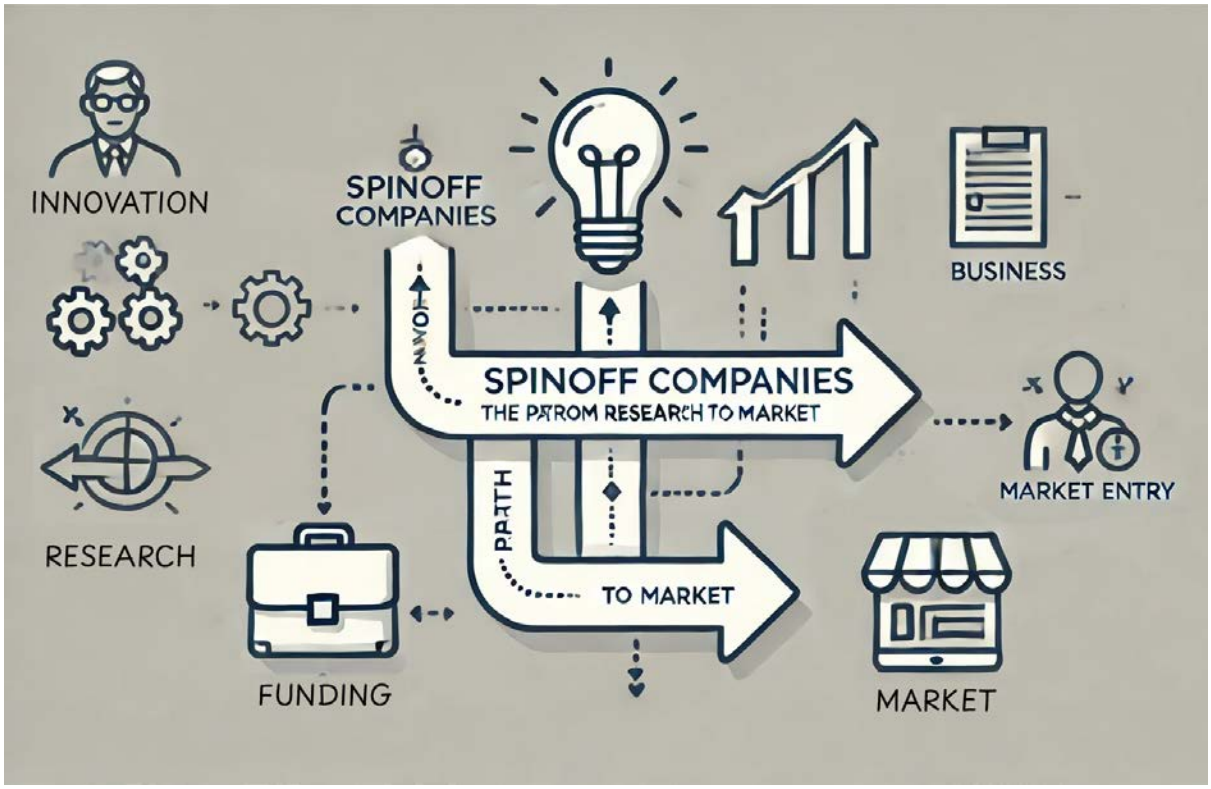
Graphical abstract



Abstract

As a university professor who embarked on the entrepreneurial path by founding a spinoff company, this lecture provides a personal reflection intertwined with academic insights into the intricate journey of translating research into market impact. Through a blend of narrative storytelling and scholarly analysis, this lecture delves into the motivations driving the establishment of the spinoff company, including the desire to see research innovations reach fruition and make a tangible difference in society. It explores the challenges encountered along the way, from navigating intellectual property landscapes to securing funding and building a team with diverse expertise. Moreover, this lecture highlights the symbiotic relationship between academia and entrepreneurship, emphasizing the role of academic research as a catalyst for innovation and the spinoff company as a vehicle for commercialization. It examines the collaborative opportunities and tensions that arise when academia intersects with the business world, shedding light on strategies for effectively managing these dynamics. Furthermore, this lecture reflects on the broader implications of spinoff entrepreneurship for

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academic institutions, industry partners, and the innovation ecosystem at large. It underscores the importance of fostering a supportive environment that encourages entrepreneurial endeavors while maintaining academic rigor and integrity. By sharing insights gleaned from personal experiences and academic scholarship, this lecture aims to inspire and inform aspiring researchers, entrepreneurs, and university stakeholders embarking on their own spinoff journeys. It offers practical advice, theoretical frameworks, and thought-provoking reflections on the transformative power of spinoff entrepreneurship in bridging the gap between research and market impact.

Keywords: Deep Tech; Spinoff; Entrepreneurship; Academic Institutions

Acknowledgment: This paper is funded through the EIT's HEI Initiative DEEPTECH-2M project, supported by EIT Digital, coordinated by EIT RawMaterials, funded by the European Union.

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Problem/Solution Fit in the Lifecycle of DeepTech Startups

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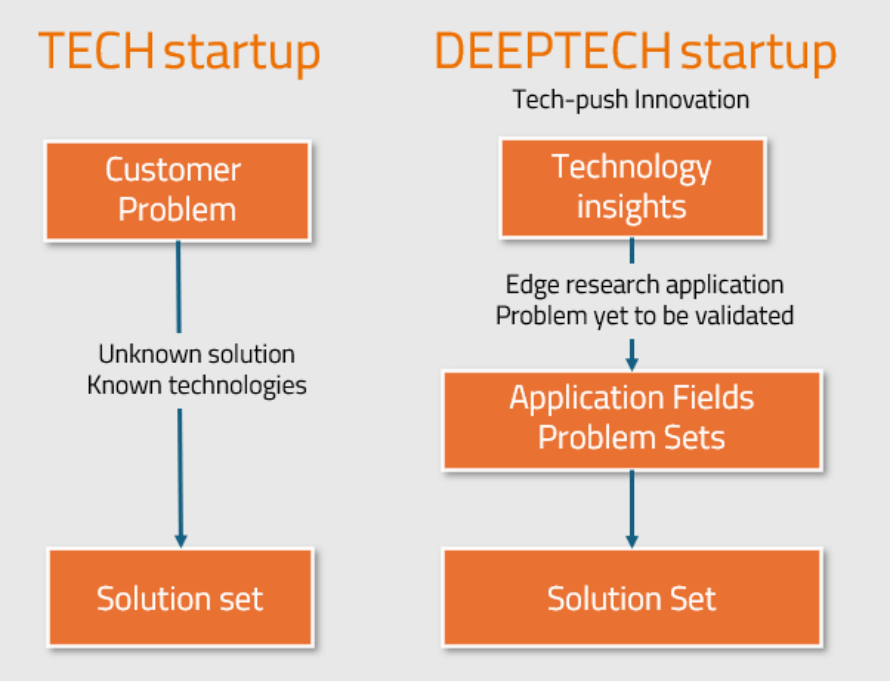
Graphical abstract



Abstract

Innovative startups aim to create products or services, addressing some poorly satisfied user needs, with potential for exponential business growth. Technologies used in problem solution are mature or edge but known. The first step towards product creation is user-centered design process, which should provide good problem/solution fit, resulting with frame for minimal viable product creation. The User-centered design process starts with valid problem recognition. The solution is reached through ideation, where it is conceptualized by addressing recognized user needs and defined leaning on suitable and available technologies.

DeepTech startups engage scientific advances and breakthroughs to create disruptive technologies and offer unique values to users and customers. Due to moving technology frontiers nature, concrete user need may not exist yet. User-centered design process must be conducted, if startup team wants to create sellable

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product, but design methodology must be adapted. Since the main idea is to commercialize results of scientific investigations, the first task in design research is to find potential application field, then to recognize existing unsatisfied user needs or even speculate a new one. Therefore, finding the problem to be solved by future product is more complex and time-consuming process. In this paper existing methodologies and experiences in DeepTech problem/solution fitting will be presented.

Keywords: Deep Tech; Problem validation; Research commercialization; Customer development

Acknowledgment: This paper is funded through the EIT's HEI Initiative DEEPTECH-2M project, supported by EIT Digital, coordinated by EIT RawMaterials, funded by the European Union.

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DeepTech vs ShallowTech

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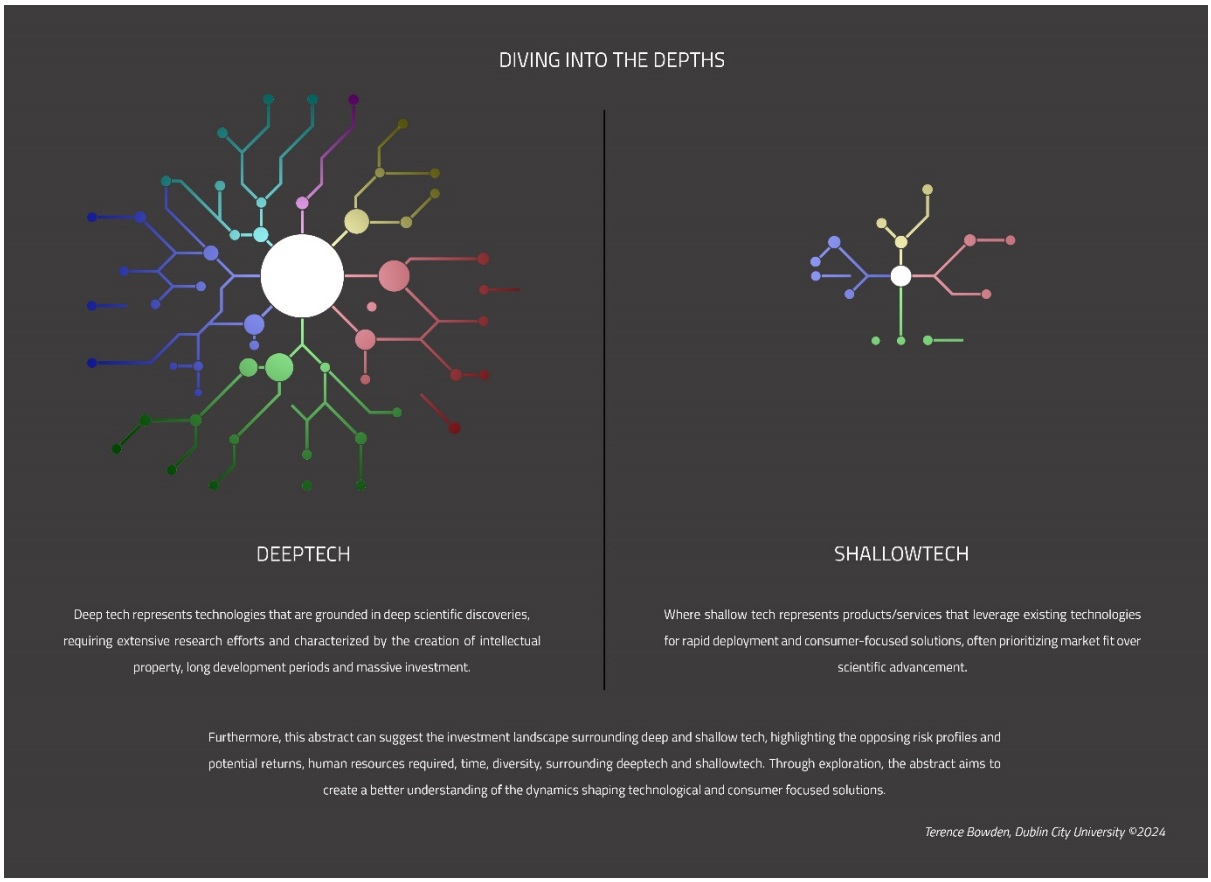
Graphical abstract



Abstract

In the evolution of Technology advancements, the grey-scale between deeptech and shallowtech has become a hot topic for debate and for the understanding the areas of scientific break-through and commercialisation. In this article we cut through the grayscale as we dive into the differences between both and investigate the patterns.

Where deeptech represents technologies that are grounded in deep scientific discoveries, requiring extensive research efforts and characterized by the creation of intellectual property, long development periods and

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massive investment, on the other hand, shallowtech represents products/services that leverage existing technologies for rapid deployment and consumer-focused solutions, often prioritizing market fit over scientific advancement.

Furthermore, this article investigates the investment landscape surrounding deep and shallow tech, highlighting the contrasting risk profiles and potential returns, time, diversity in teams through examples. Through exploration, the aim is to create a better understanding of the dynamics shaping technological and consumer focused solutions.

Keywords: Deep Tech; Shallow Tech; Startups; Innovate

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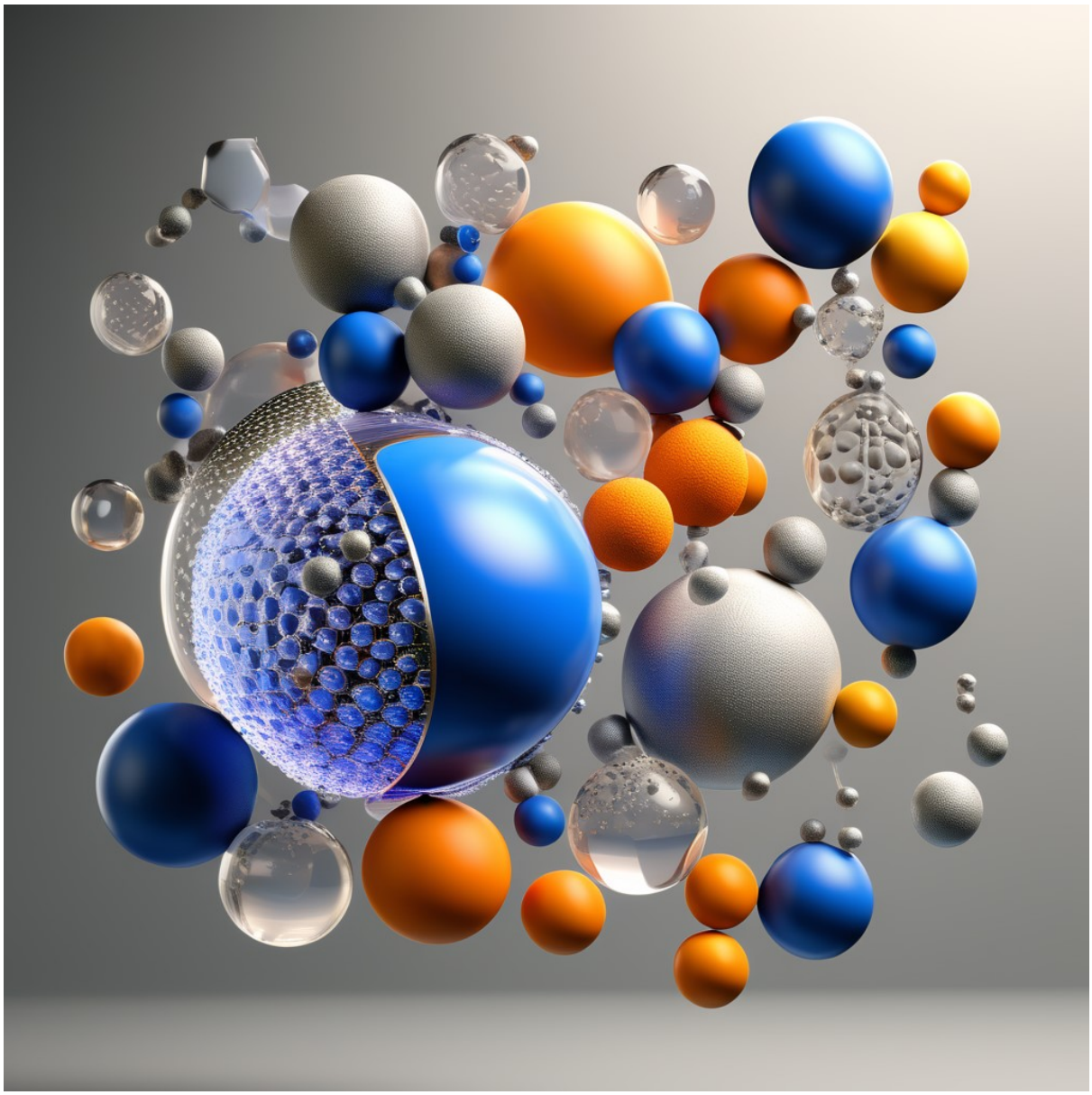
1. ADVANCED MATERIALS



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Impact of isorhamnetin on 5-fluorouracil resistant colon cancer cells

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Abstract

The most important cytostatic for the treatment of colon cancer is 5-fluorouracil (5-FU), whose efficacy is usually reduced by resistance development after long-term usage of this drug. So far, several strategies have been developed to prevent and overcome drug resistance in general, but without success. However, isorhamnetin, plant flavonol, has great potential to resolve this important problem due to its significant impact on obtained 5-FU resistant colon cancer cell lines. Although resistant cell lines do not fully represent in vivo conditions, they are an important model system for preclinical in vitro testing of active substances. Therefore, we aim to investigate the potential of isorhamnetin to overcome 5-FU resistance in colon cancer cells by analyzing its effects in vitro.

Considering that isorhamnetin shows great potential to interact with and inhibit key molecular targets of 5-FU resistance in colon cancer cells, our research may provide the opportunity to develop novel therapeutic approaches to overcome this significant problem. When cells with a 5-FU resistant phenotype are treated with isorhamnetin, which has modulatory potential, restoration of sensitivity to 5-FU can be expected. In addition, the use of isorhamnetin as a supplement to 5-FU therapy could provide a more effective treatment, which will contribute to overcome the 5-FU resistance in colon cancer cells.

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Recombinant spider silk – a promising biomaterial for tissue and biomedical engineering

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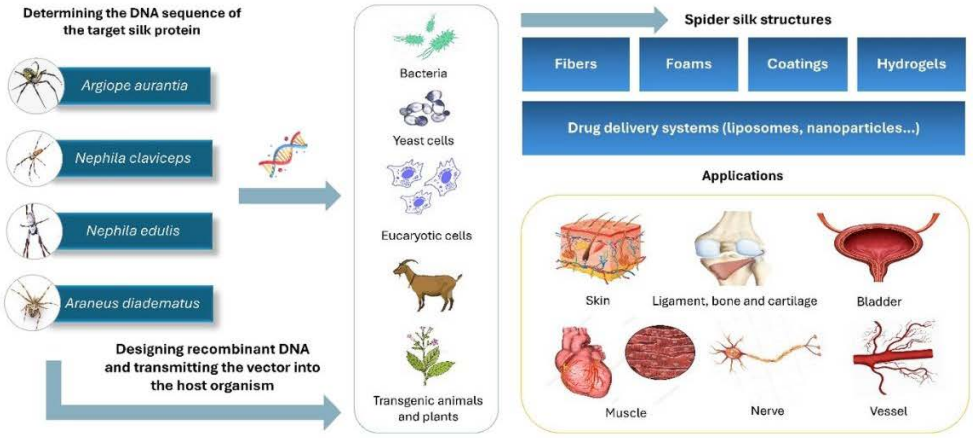

Abstract

Spider silk is widely recognized as one of the toughest and most resilient existing materials. Among all the types of silk produced by spiders, dragline silk is the best researched. Recent advances in biotechnology have made it possible to produce this material artificially through recombinant methods, surpassing the limitations of natural synthesis. This can be achieved using host organisms such as bacteria, yeasts, insect and mammal cell cultures, transgenic plants, and animals. The resulting spider silk fibers and proteins exhibit exceptional structural and mechanical properties, making it a promising alternative for repairing damaged tissue and promoting new tissue growth in biomedical engineering.

Depending on the intended application, spider silk can be utilized in various forms, such as fibers, coatings, or 3D constructs. Skin, bones, muscles, ligaments, peripheral nerves, and blood vessels have been reconstructed with promising results using spider silk in tissue engineering research. Additionally, spider silk is an excellent option for developing bio-inks used in biofabrication and designing organ-on-a-chip and tissue-on-a-chip technologies to simulate physiological processes in an organ or organ system. Due to its biocompatibility, biodegradability, and non-toxicity, spider silk is an excellent base for targeted drug delivery systems development, including liposomes, micelles, dendrimers, and nanoparticles. With all these benefits, spider silk is an ideal candidate for further research and clinical trials with the goal of commercialization.

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Bone Graft in Orthopedic Surgery

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Abstract

Bone transplantation is one of the most commonly used techniques in the field of acute and reconstructive orthopedic surgery. It is the method of choice in treating bone defects in the form of damage or deficiency, promoting bone healing, restoring skeletal integrity, and improving treatment outcomes. The key aspect of bone transplantation as a treatment method is the bone graft. One of the main characteristics of the bone graft is the ability to provide structural support and stimulate the physical growth of bone, through the following mechanisms:

1. Osteogenesis (ability to create new bone cells),

2. Osteoinduction (ability to stimulate undifferentiated cells to differentiate into the bone cells)

3. Osteoconduction (providing a 3D network as a scaffold to serve as a support for the previous two processes).

Standard bone grafts in clinical practice can be autografts, allografts or synthetic grafts.

Autografts: Bone tissue is harvested from the patient's own body. Common donor sites include the hip, tibia, and femur. Autografts are often considered the gold standard because they contain live cells and growth factors that promote bone healing.

Allografts: Bone tissue is harvested from a non-patient donor, typically from a cadaver. Allografts are processed and sterilized while preserving the structural integrity of the bone.

Synthetic grafts: Made from biocompatible materials such as ceramics, polymers, or metals. Synthetic grafts can be designed to mimic the properties of natural bone and promote new bone growth. They are used when autograft or allograft options are not feasible or when specific mechanical properties are required.

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Development of Electrospun Chitosan-based Nanofiber Dressing with Incorporated Antibiotics for Tissue Regeneration

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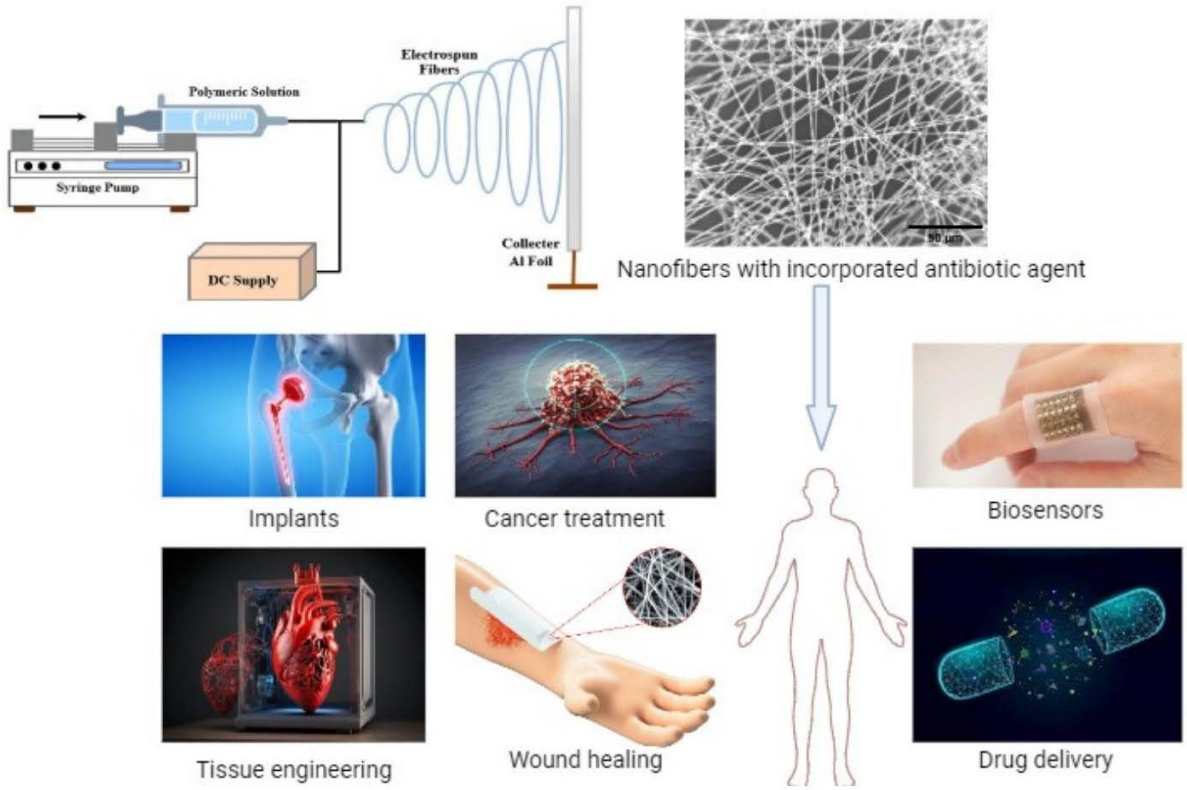
Graphical abstract



Abstract

In recent decades, the application of advanced materials in the field of regenerative medicine has become increasingly attractive. Artificial polymeric materials obtained by versatile electrospinning techniques have emerged as promising candidates in the field of tissue engineering. Chitosan is one of the most important biopolymers for the production of nanofibers due to its superior micro- and nanoscale performance, non-toxicity, biodegradability, biocompatibility, and ability to mimic the extracellular matrix (ECM) of the damaged

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organ/tissue. The possibility of incorporating antibiotics into nanofiber mats extends the range of applications and makes the resulting materials antibacterial, which is important in the field of tissue regeneration. Considering this, the fabricated chitosan nanofibers with ciprofloxacin hydrochloride (CH) are capable of accelerating wound healing along with antibacterial effects during the tissue regeneration process.

Due to the exceptionally superior properties of nanomaterials, they offer a lot of potential in many fields, particularly in biomedicine, tissue engineering, drug delivery, biosensing, medical implants, etc. Many nanomaterials have been used in various therapies, including the treatment of cancer, diabetes, infection, and inflammation. The most recent application of nanomaterials in medicine is as a carrier system in the mRNA-based COVID-19 vaccine.

Application of magnetocaloric materials in cooling systems

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Abstract

The aim of this research is to explore the potentials of magnetic cooling technology, based on the application of advanced magnetocaloric materials and the magnetocaloric effect. Magnetic cooling is a cooling technology based on the ability of any magnetic material to change its temperature and entropy under the influence of a magnetic field. Magnetic cooling is rapidly gaining the chance to become the dominant cooling technology in the near future. This development will be aided by the current availability of a wide range of advanced materials. Additionally, this research includes the results of the simulation of temperature change of the gadolinium magnetocaloric material when subjected to an external magnetic field. The simulation was conducted using the COMSOL software package.

The future potentials and prospects of magnetic cooling are remarkably promising. Further development of materials, device designs, and control systems is expected to enable their commercial application in various fields such as cooling devices, heat pumps, electronics cooling, and other energy-efficient applications. One of the advantages of magnetic cooling compared to conventional systems is the speed at which cryogenic temperatures can be reached, which means that one significant application is in systems operating at extremely low temperatures. Magnetic cooling technology is emerging as a promising alternative to conventional cooling, with devices based on it being more environmentally friendly, energy-efficient, having low levels of noise and vibration, and capable of operating over a wide range of temperatures.

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Hybrid polymer composites epoxy/PVB reinforced with single-wall/double-wall carbon nanotubes

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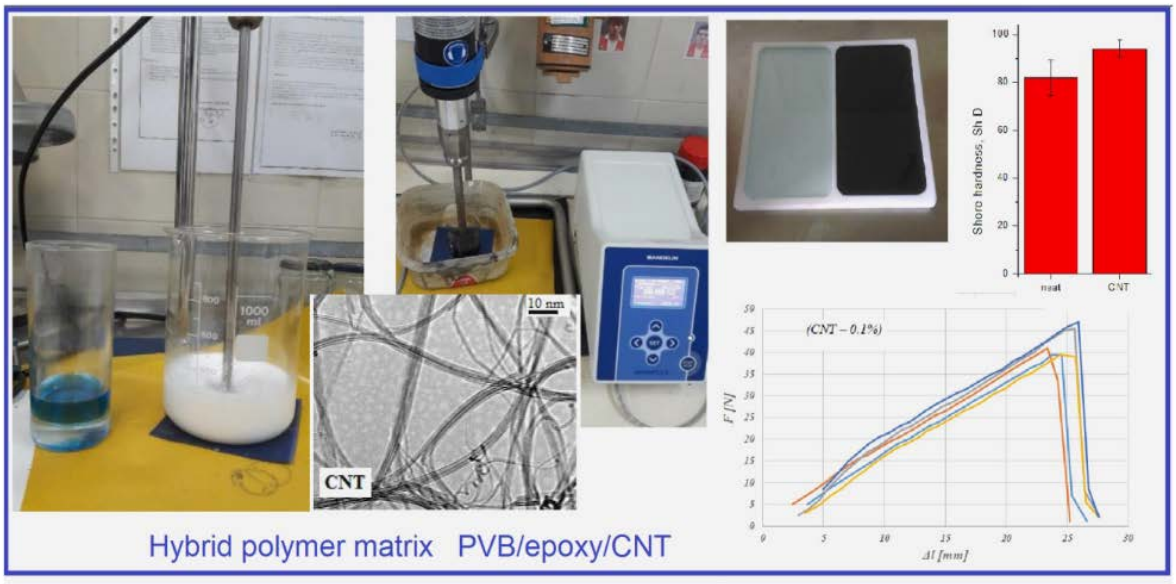
Graphical abstract:



Abstract

Extensive research is carried out in the field of composite materials, which are increasingly replacing conventional materials. This research considers the application of carbon nanotubes (CNTs) as reinforcement of a hybrid polymer matrix, consisting of epoxy resin and polyvinyl butyral, PVB. This combination was chosen to achieve good adhesion to many materials, for future application in structural, laminated and sandwich composites, for many industries. CNTs consist of cylindrically bent single-layer sheets of carbon atoms (graphene), having excellent electrical properties, thermal and mechanical resistance. The preparation of the composite matrix consists of ultrasonic dispersion of CNTs in ethanol, dissolution of PVB in this dispersion, and homogenization with an epoxy system. Tensile strength and hardness were determined and compared to the neat, non-reinforced hybrid matrix.

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Material description: Carbon nanotube composite materials represent a very attractive alternative to conventional composite materials due to their incredible mechanical, electrical, thermal and chemical properties. These materials are characterized by very high tensile strength, low density, and excellent thermal conductivity. In addition, they are characterized by increased wear resistance. Such composite materials are widely used in sports equipment for bicycle frames, tennis rackets, hockey sticks, skis, kayaks, as well as in the textile industry for antistatic and electrically conductive textiles, bulletproof vests and in the automotive and space industries.

Acknowledgement: The authors acknowledge the support of this research from the Serbian Ministry of Education, Science and Technological Development (grant- contract No. 451-03-66/2024-03/200325).

Density measurement of ZA-27 and A356 alloy based nanocomposites using analytical balance

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Abstract

Nanocomposites made of Za-Al alloy and A356 alloy are used in various industrial applications. In the scope of this research, analytical balance KERN YDB-03 was used in order to measure density of prepared blocks obtained from ZA-27 and A356 alloys. Therefore, the experiment was done by measuring the mass in two different ways (solid sample and when the sample is immersed in distilled water). The difference in measured mass can was used to obtain the density of material. Difference between experimental (measured) density and theoretical density the porosity of material was determined. The porosity indicates whether the material acquisition technology (kompocasting method) is performed well or needs to be improved and indicates on presence of some imperfections within the nanocomposite structure.

Kompocasting method for obtaining mentioned material has very spread utilization. Casting is well known method to experiment with material characteristics. The porosity of material is closely related to the structural imperfections of obtained and exanimated nanocomposites based on ZA27 and A356 alloy. The contribution of this work is based on the quantification of mentioned imperfections by calculating porosity by measuring density of prepared samples which is compared to the theoretically obtained results. The application of these nanocomposites is crucial for many different industry areas (electronic industry, aviation industry, as well as in the car industry).

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Hardness measurement of ZA-27 and A356 alloy based nanocomposites

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Abstract

Increasingly strict construction requirements initiated the development of different materials. The increasing trend of utilization of contemporary materials, alloys, superalloys, and composites is notable. Hybrid composites based on A365 matrix and nanocomposites on ZA-27 alloy find the spread utilization. The hardness of the mentioned material has crucial importance, due to that, the experiment was performed using CSM Nano Hardness Tester (NHT2). Device measure hardness of material by placing the sample in the clamping tool and by pressing with an indenter into the surface whose characteristics, i.e. hardness, is measured. The Berkovich pyramid is used for pressing, where the depth of indentation is limited. This method is contact, without the destruction because the surface destruction is made on the micro/nano level.

The usage of „Nanoindenter & Micro Scratch Tester" for measuring the hardness has advantage of isolation of the measuring system from vibrations from the environment. Based on that the results are very reliable and accurate. Experiment was done with accurate technology, sensors and measuring devices which were connected with computer and software with aim to additionally achieved reliability and accuracy. The many investigations of these materials are already done, because they represent the good basis for production of different parts used in the mechanical engineering. Nanocomposites with ZA-27 alloy have very spread usage in the systems for power transmission, especially as bearing alloys and manufacturing of bearings. Hybrid composites with A356 matrix are used in the car industry in numerous vehicle elements.

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Evaluation of Deformation Strengthening in Modern Sheet Metals

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Abstract

Deformation strengthening i.e. strain hardening is very significant phenomenon in almost all metal materials especially in contemporary sheet metal materials. It consists in the increase of stress properties of strength, and appears as a consequence of realized plastic deformation. This extensive research includes 8 sheet metals of different materials. There are 4 steel sheets: low carbon steel DC04 (thickness 0.8 mm), austenitic stainless steel X5CrNi18-10 (2,0 mm), austenitic stainless steel X5CrNiMo17-12-2 (2,0 mm) and spring steel 51CrV4 (0.6 mm). Also there are sheets of following materials: brass CuZn37 (thickness 0.8 mm), Al alloy AlMg3 (1.5 mm), Al alloy AlCu4Mg1Mn (1.0 mm) and pure copper Cu-DHP (0.8 mm). The deformation strengthening was investigated through the strengthening curves and the exponent of the deformation strengthening i.e. strain hardening exponent.

Knowledge of formability is very important in the technological processes of modern sheet metal processing. Within that, the phenomenon of deformation strengthening has a special place. Knowledge of strengthening curves and strengthening parameters has a direct application in the formation of sheet metal processing technology, for example in the automotive industry and the vehicle industry in general.

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Graphical abstract

EVALUATION OF DEFORMATION STRENGTHENING IN MODERN SHEET METALS

Srbislav Aleksandrovic, Djordje Ivkovic, Marko Delic

Table 1. Overview of total results

Strengthening factor - Results in total			
1) Steel DC04			
First method	0,173		
Second method	0,236		
Third method	/	/	/
2) Steel X5CrNi18-10			
First method	0,359		
Second method	0,377		
Third method	0,392	0,387	0,488
3) Steel X5CrNiMo1712-2			
First method	0,480		
Second method	0,463		
Third method	0.219	0.376	0.400
4) Steel 51CrV4			
First method	0,261		
Second method	0,257		
Third method	0.183	0.196	0.195
5) Alloy AlMg3 (ENAW 5754)			
First method	0,223		
Second method	0,221		
Third method	0.142	0.135	0.163
6) Alloy AlCu4Mg1Mn (ENAW 2024 T3 air)			
First method	0,204		
Second method	0,196		
Third method	0.136	0.152	/
7) Copper Cu-DHP (DVP 1 Cu. 38)			
First method	0,190		
Second method	0,186		
Third method	0.093	0.149	0.159
8) Brass CuZn37			
First method	0,521		
Second method	0,455		
Third method	0.452	0.535	0.558

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Material color influence on press-fitting printing material characteristics

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Abstract

This research paper considers an experimental approach to determining the parameters necessary for the calculation of a compressed assembly of a 3D-printed plastic housing and a radial ball bearing. The housing was produced using FDM (Fused Deposition Modeling) technology and PET-G filament with a cross-section of 1.75 mm. In order to test color influence on material characteristics, two color specimens were made. Printed bearing seats were made in printing resolution 0.2 mm. The experiment was conducted on samples where the required compression force and the force of assembly between the bearing and the housing were examined. The bearing seats have a nominal measurement smaller by 0.2 mm in the model than the bearing being in-stalled. The dimensions of the housing openings were measured after printing to determine roundness.

Practical application of this method lays in fact that using this data, obtained experimentally, results can be put into the expressions for forces required to assemble and disassemble the parts, and friction coefficients can be derived from them. These coefficients can be used as guidelines for calculating and designing 3D-printed openings into which metal parts are pressed, having in mind material color, since different pigments are obtained from different sources that can affect final material characteristics

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New Sustainable Composites for Fused Deposition Modeling (FDM) 3D printing in Furniture Industry

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Abstract

With the emergence of additive manufacturing (AM) technologies the demand for new materials increases, especially composite materials for use in different sectors, including the furniture industry. Various elements need to be replaced on the wood furniture over the years of use and sometimes it is difficult to find available appropriate replacement elements. Fused Deposition Modeling (FDM) 3D printing is excellent technology to produce custom made elements according to the requirements. However, commercially available materials are largely lacking to fulfill the growing demands at the market. Custom made materials, including composites for FDM 3D printing, can be fabricated in the form of a filament, by using various technologies, thus opening new directions in material development. Some novel materials include composites with graphene or carbon nanotubes (CNTs) incorporated in polymer matrix for better strength, or sustainable composites, such as those with wood waste particles or fibers mixed into the polymer matrix.

We propose a composite made of polymer matrix with the addition of 40%recycled wood, for application in wood-related and furniture industries. Variation of processing parameters of 3D printing (printing temperature, speed, infill design, etc.), together with varying the type of polymers for the composite matrix, different percentages of reinforcements (wood waste recycled in a form of particles and/or fibers), and their size and shapes, can indicate suitable material candidates. Additionally, optimization of 3D printing and post-processing by considering also the costs, while preserving structural and mechanical properties, has been done by using numerical optimization methods. FDM 3D printed parts in wood-related industries can find application in various fields, from prototyping within the design of new products, fabricating real product parts and the rapid production of customised tools. New composites that will use recycled wood can offer different benefits, including production of sustainable green materials that can be used across a range of industries.

Tribological properties of different 3D printed polymer samples

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Abstract

The disadvantages of conventional ABS material were overcome with the ABS+ polymer material, which is the most used in the production of prototypes. PLA bronze has slightly worse tribological characteristics than common PLA material. The experiment was performed on block-on-disk tribometer in dry sliding conditions. Blocks for investigation had dimensions 15x10x6.35 mm, disk diameter 35 mm, material for making disk steel 50CrMo4. During the experiment normal load and sliding speed remain constant, 80 N and 0.5 m/s respectively. Sliding distance was 150 m. The obtained results confirm the hypothesis that PLA bronze has slightly worse tribological characteristics than PLA, while ABS+ has better tribological properties than conventional ABS polymer.

ABS+ represent the multifunctional material for 3D printing, especially for production of prototypes. The advantages compered to ABS polymer are increased hardness and resistance to friction and wear. The printing is easier and faster, and is not necessary to print in a closed chamber. ABS+ is possible chemically and mechanically change in order to use it in the production of highly specialized and unique products. ABS+ is used in the industry, where the production of prototypes and different parts for final usage needs increased endurance. PLA bronze it is not reliable with extremely bad technical and operational characteristics. The results shown that the volume of the worn part is the highest in PLA bronze, while the coefficients of friction were huge in all experiments.

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The wear resistance of PETG polymers obtained by 3D printing

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Abstract

PETG polymers in comparison with others express many advantages, the shrinkage coefficient is minimal and adsorption of humidity almost non-existent. PETG polymers are also investigated on tribometer where coefficient of friction is recorded by software and width of the wear track is measured. The wear track of PETG polymers were the smallest in comparison with others investigated polymers, which led to the smallest volume of the worn part. The wear track was measured by using the universal microscope, and with the aim to prevent possible mistakes, one sample was measured five times.

PETG polymers have spread utilization in different areas. Until recently was unimaginable that elements made from polymers work on higher temperatures and in conditions where friction and wear are intense. The usage of PETG polymers overcome those problems, and the mentioned polymer was used even for bearing elements and operation at temperature up to 70 °C. Another advantage is good adhesive bonds during printing, which are directly connected with tribological and mechanical characteristics. Furthermore, exceptional accuracy when making elements is also an advantage. PETG polymers are used for conceptual methods, for making protypes, for making transmission elements, for production of auxiliary means and semi-transparent computer cases.

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Tribocorrosion of Advanced Materials

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Abstract

Developing and implementing new materials are processes that are achieved through their research in different fields and inspecting their specific factors which have impact on their functionality in process. Medical grade stainless steel, AISI 316LVM or Al- based alloys are materials commonly used for thermal application in automotive parts and their tribological properties, such as wear and other tribological aspects are extensively studied. Corrosion behavior and ways for its prevention are also being studied from different aspects in order to find its application. However, synergic effects and causality between contact loading and corrosion still need research. From the macro aspects, corrosion occurring at micro and nano level are often being considered negligible. However, micro- and nano- scale corrosion can have major consequences on the thin surface layers and further on the macro- scale material behavior. In this research, tribocorrosion of medical grade steel and Al- based materials is studied considering influential factors that have impact on longer functional life. It was demonstrated on two examples of traditional engineering materials that tribocorrosion occurs in the case of relative motion under influence of corrosive environment. Even if it is at micro and nano level, it can cause serious structural failures. Phenomenon of tribocorrosion require better understanding in order to explain sudden and unpredicted failures which have origin in stress corrosion cracking.

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Tribology Behavior of The Epoxy Primer Coating on the Shot Blasted Aluminium Alloy AlMg4.5Mn0.7

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Abstract

Preparation of surface layers of metallic materials is often achieved with mechanical techniques. It does not require any additional equipment for removal and disposal of toxic by-products like it is the case with chemical preparation. It presents low-cost, available solutions for many industries. In our research, we conducted experiments to determine tribological properties of metals prepared with mechanical surface modification technique. The base material was aluminium alloy AlMg4.5Mn0.7 (EN AW 5083-H111) prepared with shot blasting technique. Medium for blasting was white cast aluminium. The achieved surface roughness was Rz=38.908 μm. Afterwards, samples were coated with epoxy primer (Lankwitzer EvoCor 164 2- component). Tribological tests were conducted on nanotribometer. Normal load was 100 mN, under linear reciprocating motion. Experimental testing showed that tribological tests with low values of loads can be used for quality testing of thin coatings as well as influence of mechanical surface preparation on adhesive properties of the coating. The research study was aimed at better understanding of the tribological behavior of coated aluminium alloys applied in railway industry.

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2. BIOTECHNOLOGY AND LIFE SCIENCES

Advancements in gamma knife dosimetry: Developing the FOTLEKS Monte Carlo software for enhanced 3D dose calculation in medical physics

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Abstract

The FOTLEKS package, a Windows application, embodies a significant advancement in medical physics, particularly in the precise administration of radiation therapy using the Leksell Gamma Knife. By employing advanced Monte Carlo techniques, it calculates 3D dose distributions within a patient's head, leveraging high-resolution CT scan geometries. The package comprises two principal programs. The first, FOTELP-COLL, accurately models the physics, true shape, and dimensions of the Co-60 photon source, simulating the transport of radiation and generating emission spectra of photons and electrons at the primary collimator's exit. The second program, FOTELP-KNF utilizes the preprocessed emission spectra to calculate the 3D dose during a 60-second irradiation period. With its user-friendly interface, FOTLEKS provides a comprehensive platform for planning and implementing radiation therapy.

Beyond its immediate impact in medical physics, the FOTLEKS package's sophisticated Monte Carlo techniques for simulating radiation transport and 3D dose distribution calculations offer numerous practical applications. In the field of oncology, it could significantly refine the planning and delivery of radiation therapy for various types of cancer, leading to treatments that are both more effective and less harmful to patients. In industrial radiography, used for non-destructive testing, FOTLEKS technology could improve the accuracy of defect detection in materials, ensuring higher safety and quality standards in manufacturing processes. Additionally, its advanced simulation capabilities could enhance the development of radiation shielding materials, offering better protection for personnel in high-radiation environments such as space missions, nuclear power plants, and radiology departments. This broad spectrum of applications underscores the transformative potential of FOTLEKS across healthcare, industry, and safety protocols, marking a significant step forward in the practical application of radiation physics.

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The ongoing impact of climate change on fish species in aquatic ecosystems in Serbia

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Abstract

Considering the ongoing effects of climate change (higher temperatures and more temperature fluctuations, and unpredictable precipitation patterns) and severe anthropogenic activitities on aquatic ecosystems and fish species, the main goal of the research was to predict the response of fish species to environmental changes.

The specific objectives of the research were:

i) to identify which fish species could be considered as ecological indicators and to examine the key resilience traits and local sustainability of commercially important fish species due to climate change;

ii) to analyze the association between stressors such as habitat destruction, invasive species, pollution, population growth, and over-exploitation and climate change, expecting that climate change will amplify the effects of these stressors;

iii) to integrate machine learning algorithms with traditional ecological methodology for predictions.

The lack of scientific studies and systematic monitoring of climate change's impact on biodiversity, especially in aquatic ecosystems, has been recognized as one of the system's problems in Serbian sustainable adaptation measures due to climate change (the Law on Climate Change Official Gazette of the Republic of Serbia, No. 26/2021 and the new Programme for Adaptation to Changed Climate Conditions with an Action Plan in December 2023). Also, implementation of AI tools in ecological studies will improve performance and reduce costs, resulting in cost-effective management of aquatic ecosystems. Moreover, collaboration among scientists of different fields and policy-makers is essential and enables focus on strategic priorities in a warmer world.

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Prediction of Soil Types Using Plant Chemical Profiles: Application of Machine Learning in Plant Ecology

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Abstract

The chemical composition and physical structure of soil act as a set of ecological factors affecting the distribution of plant species, their differentiation, and metabolism. Plant secondary metabolites, in addition to their biological activities, also influence the ecological adaptation of plants. It is known that there is a difference in the qualitative and quantitative composition of secondary metabolites of certain plants depending on the type of substrate they are present on, which is of great importance in the cultivation of medicinal plants and their application in biomedical research. By examining the chemical profile of plant samples, it is possible to infer the type of soil using two algorithms - recursive partitioning implemented in the R package rpart and random forest algorithm implemented in the R package. Based on the results, it can be observed that the estimated reliability of the model is 90%in predicting the type of soil based on the chemical profile of the plant.

The scientific and technological potential of this research is multifaceted. It delves into the relationship between soil composition, plant chemistry, and ecological adaptation, offering valuable insights into ecosystem dynamics crucial for conservation, agriculture, and ecosystem management. Furthermore, the correlation between secondary metabolites in plants and soil types presents opportunities for optimizing medicinal plant cultivation practices, potentially increasing yields of pharmaceutically relevant compounds. Moreover, this knowledge opens avenues for biomedical research, enabling the exploration of novel therapeutic compounds influenced by soil composition. Achieving a 90%reliability in predicting soil types based on plant chemical profiles underscores the feasibility and potential of such models in informing soil classification, land use planning, and sustainable land management practices, highlighting the interdisciplinary nature of scientific inquiry in addressing environmental and biomedical challenges.

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Meta-analysis of the association of genetic variants in the NOS3 gene with the risk of prostate cancer development

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Abstract

Nitric oxide synthases (NOS) are enzymes that catalyze the oxidation of L-arginine to L-citrulline, during which nitric oxide (NO) is produced. Nitric oxide is a free radical that plays an important role in many physiological processes: regulation of blood pressure, vasodilation, immune response, neuromodulation, contraction of muscle cells, cell division and differentiation. It has been shown that gaseous molecule NO play an important role in carcinogenesis, including tumor growth, angiogenesis and vascular functions, inflammation, and immune response to tumor cells, as well as modulating responses to various therapies. Nitric oxide has a dichotomous effect on tumor growth (it promotes or inhibits tumor growth), which depends on the level of NOS activity, the concentration and time of exposure, and the sensitivity of cells to NO. Nitric oxide is the main cytotoxic mediator of activated macrophages and endothelial cells, responsible for the elimination of tumor cells that reach the bloodstream by passing through the capillary wall.

Meta analysis is a quantitative technique that involves combining the results of a large number of experiments or studies that have the same research objective. The two most used databases are MEDLINE and the Cochrane Library. Meta analysis is a discipline that critically reviews and statistically combines the results of previous studies in an attempt to summarize all the results obtained by examining a particular topic. It has been proven that polymorphism located in the seventh exon of the NOS3 gene (rs1799983) is leading to an amino acid substitution within the N-terminal oxygenase domain of the eNOS enzyme (G298E) has been shown to be associated with several pathological conditions, such as cardiovascular diseases, including atherosclerosis, essential hypertension, coronary artery disease and myocardial infarction, but also with male infertility and various malignant diseases.

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Investigating the impact of ionic liquid cosolvents on Rh(III) complexes' interactions with 5′-GMP and CT-DNA

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Abstract

The impact of different ILs as cosolvents was studied on the interaction of rhodium(III) complexes containing diene and pyridine derivatives ligands, as well as camphor-derived bis-pyrazolyl pyridine ligands with the 5-GMP and the DNA molecule. Interactions were studied using UV-Vis, fluorescent spectroscopy, and viscosity measurements. Obtained results show that the examined ILs exhibit good potential as cosolvents for the examined Rh(III) complexes and indicate a possibility of symbiotic effect.

Though only a few transition metal complexes, like cisplatin, are currently employed in cancer treatment due to toxicity, poor solubility, and resistance, there's significant promise in metals like rhodium, osmium, and ruthenium. Rhodium complexes, once disregarded for anticancer research, are now among the most potential agents, owing to their inertness. This allows for tailored designs targeting molecules like DNA or proteins, enhancing adaptability against cancer. However, their limited solubility poses a major challenge. Fortunately, cosolvents like ionic liquids (IL) offer a potential solution. Comprising ions with lower melting points, ILs are less harmful than traditional solvents, eco-friendlier, and adjustable to be non-toxic for human use. This makes them safer and more effective for cancer therapy.

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Study of the interactions between gold(III) complex containing 9,10-diaminophenanthrene and DNA

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Abstract

Since platinum medicines are often thought to target DNA and RNA, these molecules have been the primary focus of mechanistic studies for different gold complexes. Still, there are significant differences in the mechanisms underlying cisplatin and gold(III) complexes. Also, the reason why gold(III) complexes react faster with DNA than with the other biomolecules, is yet unknown (Lu, 2022). The study of the interactions between gold(III) complex containing 9,10-diaminophenanthrene (DAP) and DNA was performed by UV-Vis spectrophotometry, fluorescence spectroscopy and viscosity measurement. Based on the results of UV-Vis spectrophotometry can be concluded that complex binds to DNA. According to the results obtained by fluorescence spectroscopy and by viscosity measurement, the covalent binding mode between complex and DNA was confirmed.

DNA molecules are mainly target for the number of drugs, particularly in the case of cancer. In many previously studied instances, the drug molecules bind to DNA via electrostatic, hydrogen-bonding or π-π stacking interactions. For small compounds, like metal complexes, intercalation or minor groove binding are the main binding mechanisms. The potential for DNA damage is typically connected with the cytotoxic effect of metal complexes, which prompted thorough examination of interactions with this essential molecule. Some published results confirmed the link between the interactions of different gold(III) complexes with DNA and their cytotoxic effect, as well as the much faster interactions between DNA and gold(III) complexes than with cisplatin (Pages, 2015).

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The interactions with transport protein (BSA) of the selected 2,4-diketo ester derivative as a potential antitumor agent

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Abstract

As cancer remains a major health threat worldwide, there is a global demand for more affordable and effective therapeutic alternatives (Oostendorp, 2011). 2,4-Diketo esters have found great use in bioorganic and medicinal chemistry to obtain new potential drugs (Joksimović, 2020). Therefore, we tested a 2,4-diketo ester derivative on HeLa cell line. This compound showed very good cytotoxic activity (IC50 = 20.41 ± 0.78 μM), respectively. Also, interactions on bovine serum albumin (BSA) were performed. Examining these interactions, we concluded that our compound binds to BSA reversibly, which is of vital importance. To determine the binding site of our compound more precisely with BSA (side I/II), interactions with site markers such as eosin (side I) and ibuprofen (side II) were performed (Mihajlovic, 2022).

The synthesis of 2,4-diketo ester was performed starting from 4-(4-(isopentyloxy)-3-methoxyphenyl)but-3-en-2-one and diethyl-oxalate under basic conditions. The syntesiye compound (ethyl 2-hydroxy-6-(4-(isopentyloxy)-3-methoxyphenyl)-4-oxohexa-2,5-dienoate) was characterized by IR, NMR spectrum and elemental analysis. Cytotoxic activity on HeLa cell line was determined using MTT assy. In addition, interactions with BSA were performed using the fluorescent titration method, where the concentration of BSA was constant while the concentration of the compound increased. Site markers such as eosin and ibuprofen were used to determine the side of binding. Finally, all results indicate the great potential for application of this compound in clinical practice in the future (Mihajlovic, 2022).

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Application of immobilized proteases in the fractionation of sunflower meal

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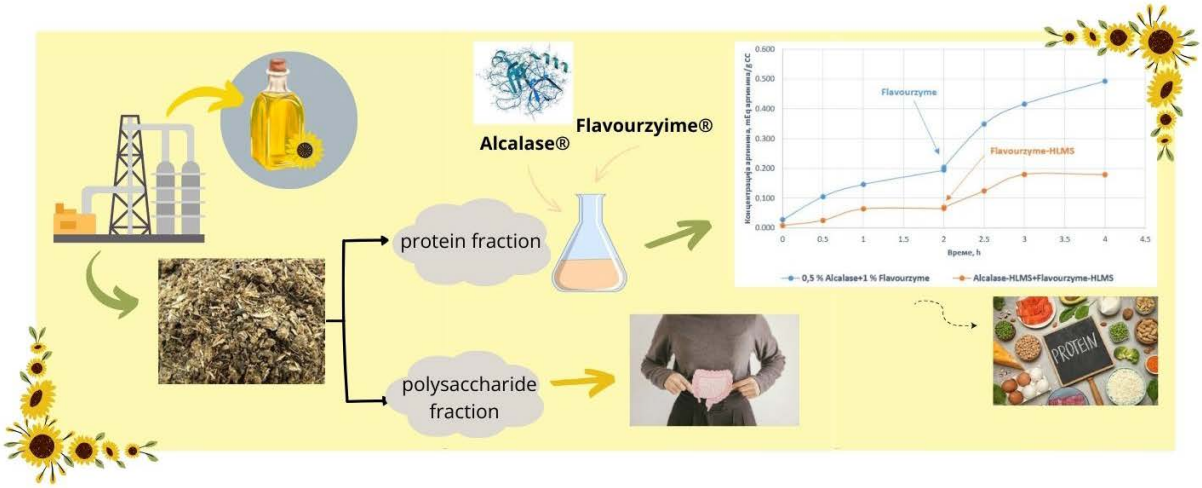
Graphical abstract



Abstract

Enzymatic hydrolysis has proven to be excellent for protein production from sunflower meal protein isolate. In this work, the separation of the carbohydrate from the protein component of sunflower meal and the two-step enzymatic hydrolysis of the protein component were performed. Two commercial protease preparations, Alcalase® with endopeptidase activity and Flavourzyme® with exopetidase activity, were used for hydrolysis, which improves the efficiency of sunflower meal fractionation by increasing the proportion of proteins in the soluble fraction. The effectiveness of immobilized proteases was analyzed, as the application of immobilized enzymes can significantly reduce process costs. Enzyme-assisted separation was followed by analysis of protein concentration - using the Lowry method and the ninhydrin method. The profiles of the obtained hydrolyzates were characterized by HPLC and electrophoresis.

Recently, there has been a growing interest in new sources of protein from unconventional raw materials. Sunflower meal is the main by-product of the industrial process of extracting oil from sunflower seeds. Currently, it is mainly used in the animal feed industry as a component of low nutritional value. However, sunflower meal represents a good source of protein for human consumption. Also, the polysaccharide components of sunflower meal (primarily xylan and pectin) are significant because they have great potential as raw materials to produce oligosaccharides that have prebiotic activity. For this reason, there is a need to separate the protein from the polysaccharide component by controlled enzymatic hydrolysis. The use of sunflower meal is important to reduce the environmental problems caused by the sunflower oil industry.

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Spectral Domain Optical Coherence Tomography (SD-OCT) in assessment and monitoring of therapeutic outcome in diabetic macular edema

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Abstract

Spectral Domain Optical Coherence Tomography (SD-OCT) in assessment and monitoring of therapeutic outcome in diabetic macular edema Spectral-domain optical coherence tomography (SD)-OCT is an advanced technology for performing high-resolution cross-sectional imaging of the retina. OCT estimates the difference in optical reflectivity of tissue microstructures of different retinal layers and provides cross-sectional images of tissue structure on the micron scale in situ and in real time with high resolution of 5-7 µm. This method utilizes light source (near-infrared wavelength), spectrometry and Fourier transformation to analyse the retina and retinal tissue interfaces, with very high scanning speed and imaging (approx. 40,000 scans in a second). With SD-OCT, we can precisely measure the thickness of the retina and get an insight into the condition of the retina i.e assessment of retinal architecture.

Diabetic Macular Edema (DME) is the main cause of decreased visual acuity (VA). Now, SD-OCT allows a much more precise analysis of morphology of edema and provides much more information about the condition of the retina. There are several OCT biomarkers that can be used to monitor the evolution of edema, as well as its response to the intravitreal application of various types of drugs: Central subfield thickness (CST), Macular volume (MV), Disorganization of retinal inner layers (DRIL), Serous retinal detachment (SRD), External limiting membrane (ELM) and ellipsoid zone (EZ) disruption, Hyperreflective foci (HF), Subfoveal choroidal thickness (SFCT), Assessment of Vitreomacular Interface: Vitreomacular interface abnormality (VMIA). The monitoring of various OCT biomarkers is essential for prognostic assessment in DME and its treatment outcomes.

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3. ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING, INCLUDING BIG DATA

Application of computer vision and deep learning techniques in improving safety at work

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Abstract

Artificial intelligence, and especially the field of deep machine learning, is increasingly present in almost all areas of industry. With the rapid development of computers and graphics processors, widely used for the training of deep neural networks, many previously manually solved problems can now be partially or fully automated. One of the numerous deep learning application examples is the automatic detection of objects in images (or video frames). By applying deep learning techniques in the field of computer vision, the video stream from the cameras can be monitored in real time. Deep learning algorithms, trained with appropriate data sets, are able to recognize the presence or absence of a desirable or undesirable object in a camera scene.

Safety at work can be significantly improved by applying computer vision algorithms supported by deep neural networks. Manual visual inspection of the use of personal protective equipment is very difficult or even impossible in specific working conditions. However, such inspection can be fully automated by developing inspection software based on the recognition of certain types of personal protective equipment. This study introduces an innovative paradigm: the deployment of artificial intelligence and computer vision algorithms for the automated monitoring of proper use, improper use or misuse of personal protective equipment in large working area covered by conventional video surveillance system.

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Efficient Generation of Diverse Instances for P||Cmax Solver Evaluation

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Abstract

The $P||C_{max}$ problem involves scheduling n independent tasks on m identical parallel machines with the goal of minimizing the execution time of the most heavily utilized machine. The existing literature lacks a standardized collection of instances to accurately evaluate solution methods. The currently used collections suffer from insufficient variety of parameter values for n and m, insufficient orders of magnitude of task execution time, and limited variability of distributions. Accessibility challenges and unclear guidelines for generation further complicate matters. Our work presents a universal instance generator tailored to $P||C_{max}$. It addresses these issues systematically and enables a versatile and reproducible framework for evaluating the performance of solvers across various instances, which represents a significant advance in overcoming the challenges of evaluating this problem.

A universal generator for $P||C_{max}$ instances unlocks scientific potential by enabling precise performance comparisons between different solver types. The inclusion of different parameter values reveals both the strengths and weaknesses of solvers, promoting robust evaluations and deeper insights into solver behavior. The standardization of instance sets simplifies collaboration and reduces ambiguities and errors. This promotes reproducibility and transparency and accelerates the dissemination of knowledge and collective progress in the field. Through clearer comparisons and higher quality measurements, researchers can advance understanding and innovation in solving the $P||C_{max}$ problem. Ultimately, this universal generator facilitates collaborative efforts, improves reproducibility and accelerates scientific discovery in this domain.

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Utilization of Lung Segmentation Algorithm to Monitor Overall Recovery in Premature Infants with Respiratory Distress Syndrome

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Abstract

Respiratory distress syndrome (RDS) frequently arises as a complication in premature infants due to inadequate surfactant synthesis. Hence, this study employed a lung segmentation algorithm to monitoring patients' recovery meticulously. The lung segmentation algorithm was developed in collaboration between the CIRPIS Center at the Faculty of Engineering and the University Clinical Center Kragujevac. The algorithm utilizes a complex sequence of steps, including image preprocessing for noise removal and contrast enhancement, followed by morphological operations for lung tissue extraction. The research results demonstrated high algorithm accuracy (0.93±0.06), precision (0.81±0.16), and F-score (0.82±0.14), offering reliable insights into lung segmentation in RDS. These findings underscore the technology's importance in enhancing diagnostics and monitoring recovery in neonates with RDS.

This study explores the practical application of a lung segmentation algorithm in monitoring the recovery of premature infants with respiratory distress syndrome (RDS). Through the analysis of chest X-rays, the algorithm enables precise determination of lung condition and assessment of therapy effectiveness. This facilitates physicians in tracking disease progression and adjusting treatment according to each patient's individual needs. Implementation of this algorithm in clinical practice is expected to enhance diagnostics and treatment of RDS in premature infants, thereby reducing the risk of complications and improving recovery outcomes.

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Evolutionary Approach for Composing a Thoroughly Optimized Ensemble of Regression Neural Networks

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Abstract

The paper introduces GeNNsem (Genetic Algorithm ANNs Ensemble), a software framework designed for optimizing individual neural networks and constructing their optimal ensembles simultaneously. Utilizing a genetic algorithm, GeNNsem searches for suitable architectures and hyperparameters for individual networks, minimizing errors for both individual networks and the ensemble model, while simultaneously ensuring prediction diversity among individual networks. To address the computational demands, distributed processing is employed, leveraging microservices and Kubernetes batching orchestration for scalability. Evaluation on regression benchmarks and comparisons with other machine learning ensemble techniques demonstrate GeNNsem's superiority in regression modeling metrics. Real-world experiments in hydroinformatics highlight GeNNsem's advantages: minimal training sessions for individual models in ensemble optimization, simplified network architectures due to initial population regularization, and significantly reduced execution times through parallelization.

Utilizing GeNNsem ensembles in industrial applications, particularly within hydroinformatics, shows significant potential. In hydroinformatics, where precise predictions are vital for water-related systems, optimized ensembles can improve predictive capabilities and streamline operations. GeNNsem's ensemble models excel in predicting dam displacements, enhancing safety and water resource management. Ensemble methods have applications in various fields like finance, healthcare, and environmental science. Ensembles are favored for their ability to enhance prediction accuracy and robustness but creating them requires proper selection of base learner hyperparameters and is computationally heavy. GeNNsem's scalability via distributed processing efficiently handles large datasets and computationally intensive tasks common in hydroinformatics. This technology promises to significantly improve decision-making processes in diverse industries, addressing complex challenges with precision and efficiency.

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Introducing Version Control and Revision History in Online Document Management System

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Abstract

This project proposes the integration of version control and revision history functionalities into the online document management system. Users will be able to track changes made to documents, view previous versions, and revert to earlier iterations. The system will allow users to leave comments or annotations on specific versions, facilitating collaboration and feedback processes. AI will advance the mentioned functions while the usage of blockchain will reduce the risk of unexpected and malicious changes. This enhancement aims to improve document integrity, collaboration, and transparency within the system. By providing a comprehensive record of document changes, users can confidently manage and track document modifications, reducing the risk of errors and ensuring accountability. This will have a significant impact on user workflow efficiency and document management capabilities.

In the private sector, version control and revision history are vital for project management, software development, legal document preparation, and any collaborative creation process. They enable businesses to manage proprietary information securely, streamline workflow, enhance team collaboration across different locations, and maintain a comprehensive record of document iterations for compliance, auditing, and intellectual property protection purposes. In the public sector, these tools support transparency, accountability, and collaboration in government document management, policy development, and legislative drafting. They facilitate the sharing of information between departments, help in maintaining public records, and allow for a more efficient public review process by tracking changes made to documents. This ensures that government operations are conducted efficiently and that citizens have access to the latest, most accurate information available.

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Artificial Intelligence Defect Detection Solutions for Small and Medium Enterprises

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Abstract

In the present era, small and medium enterprises (SMEs) often rely on human visual inspection, a method prone to unreliability. Historically, sophisticated vision systems were deemed relatively expensive, leaving SMEs with older, outdated systems capable only of basic detection tasks. Moreover, these systems require constant tuning to adapt to minor changes in the detection area. However, the advent of AI defect detection presents SMEs with a compelling opportunity for low-cost investment and rapid, high returns. This transition offers streamlined processes, heightened accuracy, and enhanced efficiency, enabling SMEs to effectively meet evolving quality standards. This research introduces a simple, versatile Python-based application for various defect detection tasks, encompassing both image and video inferencing. The utilization of AI defect detection systems promises significant cost savings.

The described approach of utilizing AI defect detection in small and medium enterprises holds immense potential for various applications. Firstly, it enables SMEs to achieve higher levels of accuracy and consistency in quality control processes, reducing the likelihood of product defects and associated costs. Additionally, the streamlined processes afforded by AI defect detection enhance operational efficiency, leading to increased productivity and competitiveness in the market. Moreover, the adaptability of the approach allows for its integration into diverse industries, ranging from manufacturing to healthcare, catering to a wide array of defect detection needs. Ultimately, the adoption of AI defect detection translates into significant cost savings for SMEs, reducing testing, claims, and pseudo scrap cost, and testing time making it a highly advantageous investment for sustainable growth.

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Physics Informed Neural Network Modeling of Oxygen Diffusion

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Abstract

Physics-Informed Neural Networks (PINNs) refers to a component of the ML model that encodes Partial Differential Equations (PDEs) through artificial neural networks. PINNs are used to solve both direct and inverse problems defined by a set of one or more PDE. The approximator network and residual network are two subnets of PINN. The approximator network gives the approximate solution of the given problem as the output. Loss function of the approximator network has the following form: L = Lr + L0 + Lb, where Lr represents residuals of governing equations, L0, initial conditions, and Lb, boundary conditions. These residuals are calculated by a non-trainable part of the PINN model called the residual network. The computation of residual Lr is achieved by automatic differentiation that requires derivatives of the outputs with respect to the inputs.

The equation describing oxygen diffusion into the soil is given by the PDE:

$\partial C(x, t)/ \partial t = D \partial 2C (x, t)/\partial x2 - \alpha$

where C(x, t) is the oxygen concentration in the soil air at depth x, t, time, D, the diffusion coefficient of oxygen in the soil, and α is the activity (the rate of oxygen consumption by within the soil mass). The following initial and boundary conditions:

$C(x, t) = C0, 0 \leq x \leq L; t = 0$

C (x, t) = C0, x = 0; t > 0

$\partial C(x, t)/\partial x = 0, x \longrightarrow \infty; t$ > 0

where C0 is the concentration of oxygen in the atmosphere.

Using PINNs to solve this problem requires constructing a neural network to approximate the concentration C (x, t). The approximate solution is differentiated with respect to their variables. Loss function consists of residuals of a given partial differential equation and the initial and boundary conditions within the domain boundary.

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The Effects of Deep Learning on the Prediction of Aneurysm Rupture

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Abstract

We propose a methodology to predict the risk of aneurysm rupture using the IntrA database, where 1694 healthy blood vessel segments and 215 aneurysm segments were collected and generated for diagnosis and 116 aneurysm segments were manually divided and labeled by medical experts. Methods that gave us the best results are 3DMedPT, SpiderCNN and PointNet++ convolutional neural networks. Results we shared are regarding to the prediction of healthy blood vessels without aneurysms, those with aneurysms, and those aneurysms with a high risk of rupture, with a 66%successful prediction rate.

Future research will focus on improving the connectivity between computational fluid dynamics with finite element and deep learning models to more accurately predict the risk of aneurysm rupture in the brain.

The reason for the lower prediction accuracy for high-risk aneurysms may be due to insufficient connectivity between finite element models and other data containing detailed geometric entities that are not directly linked. However, a 66% prediction rate is still a high percentage for risk assessment in this medical field because, for now, doctors rely solely on extensive experience when assessing the risk of aneurysm rupture in the brain. Even this prediction rate is higher than just finite element or CNN separately for calculation of aneurysm risk prediction. Future research will focus on improving the connectivity between computational fluid dynamics with finite element and deep learning models to more accurately predict the risk of aneurysm rupture in the brain.

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Assessment of mechanical properties of austenitic stainless steels using artificial neural networks

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Abstract

Knowledge of material properties is of key importance when planning the production of a product. This also applies to steel structures. Therefore, for the correct planning of a certain steel part or the production of a structure, it is necessary to get acquainted with the properties of the material, in order to make the correct decision about which material should be used. Bearing in mind that the volume of production of steel products is constantly increasing in various branches of industry and engineering, the problem of predicting the material properties needed to meet the requirements for efficient and reliable functioning of a certain part becomes imperative in the design process. In this research, a method for predicting four material characteristics (yield stress, tensile strength, elongation and hardness) for two stainless steels, using an artificial neural network (ANN), is presented.

These material properties were predicted based on the known chemical compositions of the analyzed steels and the corresponding material properties available in the Cambridge Educational System EDU PACK 2010 software, using the neural network module of the MathWorks Matlab software package. The method was verified by comparing the material property values predicted by this method with the known property values for two analyzed stainless steels: X5CrNi18-10 (AISI 304) and X5CrNiMo17-12-2 (AISI 316). The difference between the two sets of values was less than 5% and in some cases even negligible, which indicates the possibilities for the application of new technologies for predicting material properties.

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4. ADVANCED COMPUTING

Developing the procedure for damage simulation in metallic structures due to cyclic loading - DEEDS

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Abstract

In the case of engineering structures, it is necessary to control their safety, so cutting-edge tools are required to achieve safety in the design process and during the exploitation. If the loading conditions exceed the limits, structures can experience damage and failure. The prediction and prevention of damage caused by cyclic loading is obligatory. Computational modeling techniques can be used as a solution in addition to experiments. The procedure for predicting damage evolution in engineering structures under the Low Cyclic and High Cyclic fatigue loading conditions can be based on Phase Field Damage Model theory which can be implemented into an in-house Finite Element Method (FEM) software for structural analysis. This work is a presentation of DEEDS project activities – University of Kragujevac.

The developed procedure will improve the structural design process and the safety of structures. The application potential of PAK-DAM software is wide in all engineering industries (civil, mechanical, naval, biomedical, electric power) for safety and health monitoring, design reviews, and integrity and reliability assessment of structures.

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Prediction of damage evolution in engineering structures - PROMINENT

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Abstract

Nowadays, engineering structures are more complex, so advanced tools are needed to satisfy safety demands in the design process. If the loading conditions are out of the prescribed range, non-permissible deformation occurs, and structures become damaged, which can cause failure. Therefore, the prediction and prevention of damage-induced failure are mandatory. Computational modeling tools can be used as a solution for predicting the damage and failure of structures. A new PFM-based software tool, PAK-DAM, specialized for predicting damage evolution in engineering structures will be developed with the possible extension to cutting-edge materials such as Shape Memory Alloys.

The PAK-DAM software tool will improve the structural design process. It will be essential for the safety, design reviews, integrity, reliability assessment, and health monitoring of infrastructural objects such as dams, bridges, buildings, water towers, and engineering structures in automotive, aircraft, airspace, ships, biomedical, and electric power industries.

Acknowledgment: The first results presented in this research were supported by the Science Fund of the Republic of Serbia, #GRANT No 7475, Prediction of damage evolution in engineering structures - PROMINENT.

Numerical Modeling of Coupled Fluid - Solid Dynamics

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Abstract

The problem of deformable bodies motion, floating or flying in fluid flow is common in engineering practice. A variety of examples comprise: flying of aircrafts in the air, diving of submarines, bullet flight through the air or water, flying of a ball through the air in various sports (soccer, tennis, golf, etc.), transport of solids by fluids in industrial pulp processing plants, transport of mineral raw materials in mines, etc. There are also examples in biological systems: motion of aerosol particles in the respiratory tract, motion of blood cells in the cardio-vascular system, etc. The aim of this work is to explain practical implementation of the algorithm that enables the coupling of solid and fluid equations to model the fluid – solid interaction.

The potential for the application of such a software solution lies in the application of modeling of physical processes where the interaction of solid and fluid occurs. The goal of modeling is usually the simplification of the product development or deep insight into the processes that occur in complex systems with interaction of solids bodies with fluid. Examples of application in modeling of biological systems are: modeling of the stent implantation procedure in coronary arteries, modeling of experiments with blood cells where the separation of cancerous and healthy blood cells is performed, modeling of the motion of blood cells through the capillary narrowing, etc.

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The linear strain field of 4-node tetrahedral finite elements created using strain smoothing method

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Abstract

One of the goals of this research was the analysis of the strain-smoothed element method, as presented in Lee et al. (2018). The method was applied to the linear tetrahedral finite elements, with the purpose of overcoming a very stiff behavior, which is specifically expressed in bending problems. Using this method, the linear strain field is created within the element itself, considering the constant strains of the surrounding elements. Accordingly, the obtained element achieves greater precision and less stress discontinuity on the borders between the elements. The efficiency of such a method is reflected in the fact that special smoothing domains are not created and that linearity of the strain field is achieved without the introduction of additional parameters and degrees of freedom.

Additionally, we conducted a comparative analysis of performances of the linear tetrahedral finite elements implemented within the program packages PAK and Nastran, as compared to the element suggested in Lee et al. (2018). By presenting concrete examples of bending problems, it was shown that the constant strain field of a linear tetrahedral finite element requires a very dense mesh so that the approximation of linear strain field of the bending problem would be accurate enough. The element with the corrected strain field achieves a higher level of accuracy and significantly faster convergence compared to the element with constant strains. Therefore, by applying the suggested smoothing method the domain of the linear tetrahedral finite element practical application is expanded.

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Application of Altair software in structural analysis of complex geometry

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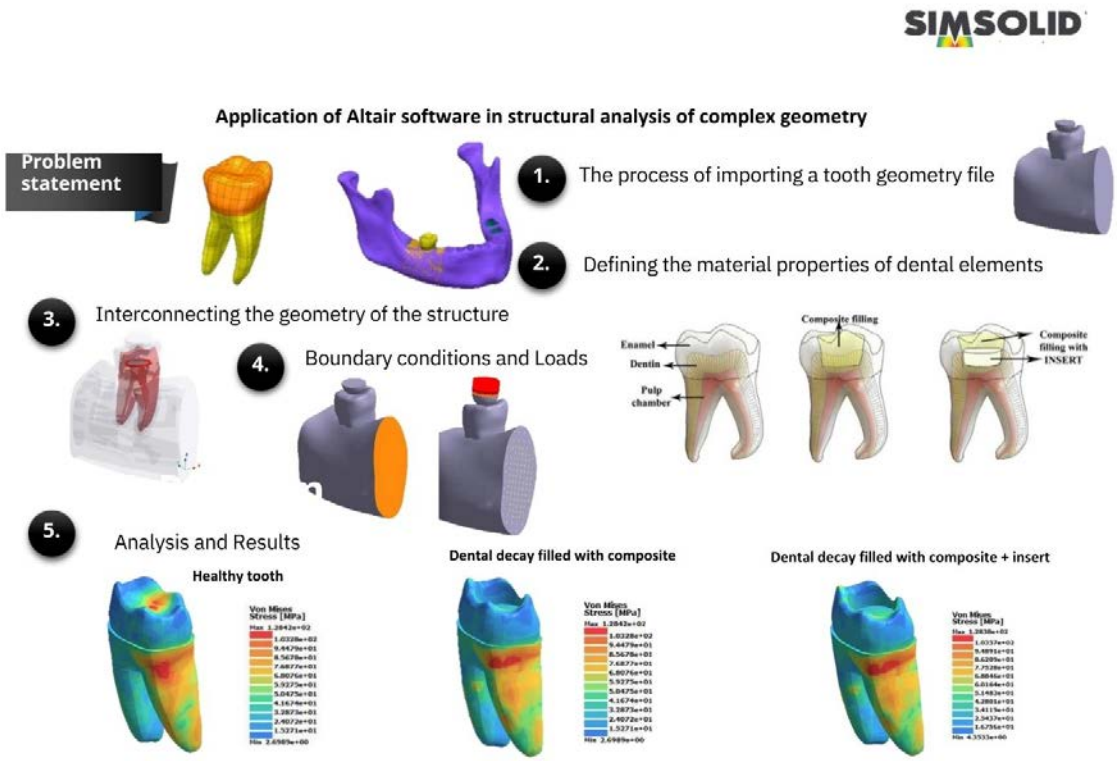
Graphical abstract



Abstract

In this paper, the application of Altair software SimSolid for the numerical analysis of the construction of complex geometry is investigated. Traditional simulation methods based on the finite element method require large computing resources, geometry preparation time, appropriate mesh modeling, and time necessary for computational problem-solving. SimSolid, a product of Altair, provides a significant acceleration of this process, making it efficient and affordable.

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In addition, the basic principles of work in the SimSolid software are explained in this paper. A special focus is placed on the process of importing geometric constructions, selecting materials, selecting the type of analysis, how to connect corresponding parts of construction, setting boundary conditions, setting loads, running analysis, and postprocessing the analysis results.

The practical application of research and innovations I present at the conference involves harnessing the scientific or technological potential of Altair's SimSolid software in analyzing the structural integrity of complex tooth geometries, with a focus on its application in dentistry. This conceptual example demonstrates the software's ability to streamline structural analysis processes in dental applications, enabling efficient assessment of the strength and durability of intricate dental structures. By utilizing SimSolid, dentists can enhance their approach to planning and designing dental solutions, improving the quality and longevity of prosthetic work, and ensuring optimal functionality and aesthetics for patients.

FEM Analysis of Hypereutectic Al-Si Piston

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Abstract

Nowadays in industry, the Finite Element Method (FEM) is used to predict the behavior of complex structures and systems in different operating conditions. In this study, FEM is applied to predict the influence of temperature and pressure on pistons made of hypereutectic Al-Si alloy. Initially, the influence of temperature on the piston is observed, followed by pressure, and finally, both temperature and pressure effects are considered. Understanding these influences is important for the optimization of piston design and material selection, improving the performance and reliability in engine applications. This study contributes to the understanding of hypereutectic Al-Si alloy behavior which is crucial for the development of more efficient and durable pistons.

FEM Analysis of pistons can accurately predict stress distribution, deformation, and failure mechanisms in pistons under different operating conditions, thus it has an important role in obtaining the optimal performance and reliability of these elements. The obtained results via FEM Analysis can help with minimizing the weight, improving efficiency and durability of pistons. Analysis of hypereutectic Al-Si pistons in conditions obtained from literature shows that stress is relatively lower than yield stress (200 MPa). FEM allows for cost-effective and efficient design iterations, reducing the need for physical prototypes and accelerating the product development cycle. Ultimately, the practical application of FEM in analyzing the hypereutectic Al-Si piston contributes to the advancement of automotive engineering by enabling the creation of more durable and efficient components.

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Advancements in Mammographic Simulation: The MAMOVOX Optimization Approach

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Abstract

In this study, we introduce an innovation in the simulation of depth dose distribution in mammography using gamma rays, achieved through the optimization of input data in the Monte Carlo-based MAMOVOX program (author R.Ilić). By focusing on a gamma ray beam of 8x6 cm^2 with an energy of 12 MeV, and conducting simulations with 100,000 gamma rays, we have significantly improved the efficiency and accuracy of dose distribution predictions. The optimization process not only involved refining the parameters and configurations within the MAMOVOX program but also enhancing the methodological approach to how simulations are executed. This innovative approach reduced the simulation time to approximately 4 minutes, substantially quicker than previous benchmarks, without compromising the quality of the results.

The optimization strategies applied in the MAMOVOX program open new horizons for application well beyond mammography, providing a framework to boost simulation efficacy across diverse sectors of medical physics and radiology. By streamlining the process of depth dose distribution analysis through refined input data and methodological enhancements, this innovation has the potential to revolutionize diagnostic imaging practices. It provides a foundation for developing more precise and less time-consuming simulation models, which could be pivotal in designing safer and more effective radiation therapies and diagnostic techniques. Furthermore, the principles of this optimization could be adapted to improve computational simulations in other scientific domains, such as nuclear medicine, radiation safety, and even environmental radiation monitoring, demonstrating a significant technological potential for wide-ranging real-world applications.

Customized user implementation of material models in PAK-S software

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Abstract

Relationships between stresses and strains are constitutive relations. The behavior of the materials depends on the material characteristics, which are contained in the constitutive relations. By defining the constitutive relations and by knowing the material characteristics, it is possible to simulate the response of the material for small and large strains by implementation into the FEM software. The aim of this work is to develop a subprogram that will represent an interface for the easy implementation of a user material models into the FEM software PAK-S for the structural analysis.

Researchers and engineers often struggle to develop and implement constitutive models for the simulation of various materials in FEM-based software. The reasons are complicated procedures and difficulties related to the features of the FEM software. The implemented interface was tested and verified for the linear elasticity, Von Mises plasticity, and shape memory alloys constitutive model. The importance of this interface is reflected in the fact that it enables easier use of already existing, but also easier implementation of new constitutive user models.

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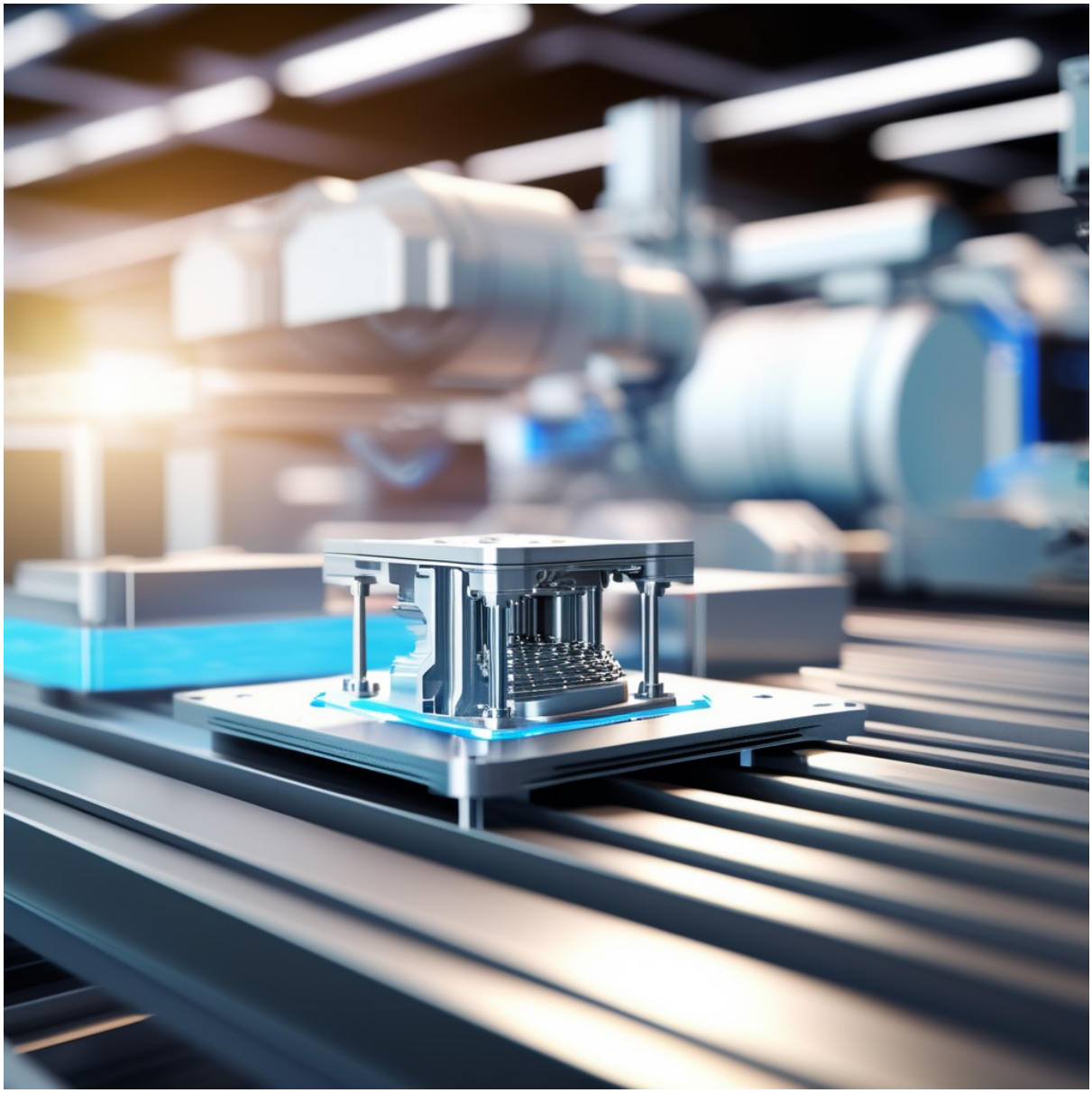
5. ADVANCED MANUFACTURING



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Design and production of a single-stage cylindrical gearbox model

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Abstract

The gearbox, as a highly complex mechanical assembly whose role is to adjust power and motion parameters of the drive machine to the needs of the corresponding working machine, is an almost indispensable element in modern mechanical systems. Within this paper, calculation, design, and production of a single-stage cylindrical gearbox with helical gears using additive technologies have been performed. Based on initial data, calculation and dimensioning of vital gearbox elements (gears, shafts, roller bearings, housing) were carried out. Subsequently, a 3D model was created in SolidWorks software. Finally, a physically functional model of the designed single-stage cylindrical gearbox was produced using 3D printing at the Faculty of Engineering Sciences in the Center for testing and calculation of mechanical elements and systems "Prof. Dr Vera Nikolić Stanojević". The created model can be used in the education of future mechanical engineers, as well as a functional model in case of lighter loads.

The functional model of a single-stage cylindrical gearbox with helical gears created by 3D printing is primarily intended for the educational process of high school students in the field of mechanical engineering, as well as for mechanical engineering students. The goal is to use the created model to familiarize students with the basic mechanical elements for power transmission and motion when the input and output shafts are parallel. Additionally, the created single-stage cylindrical gearbox can also be used as a functional model in case of lighter loads.

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Design and modeling of a single-stage conical reducer

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Abstract

The main role of the reducer is to adapt the power and movement parameters of the drive machine to the needs of the working machine (nominal power, nominal torque, number of revolutions, angular velocity). In modern engineering practice, the use of reducers is very intensive. In case when the shafts of driving and working machines intersect at an angle (most often at an angle of 90), conical reducers are used.

In this paper, the calculation, design and production of a specific single-stage conical reducer was carried out. The three-dimensional model is created in Autodesk Inventor software. The basic elements (shafts, gears,...) were made using the 3D printing method at the Center for Testing and Calculation of Machine Elements and Systems „Prof. Dr Vera Nikolić Stanojević“, while the housing was made using wooden materials. The created functional model can be used for the education of future mechanical engineers.

The created functional model of a single-stage conical reducer is primarily intended for the education process of young high school students and engineers. The goal is to familiarize students with the basic machine elements for power and motion transmitting by the created model for the case when the axes of the input and output shafts intersect at an angle of 90°. Also, the created single-stage conical reducer can be used as a functional model in the case of smaller loads.

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Four-axis FDM printing – Novel Methodology for Scaffold Fabrication

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Abstract

In this paper authors presented novel method for FDM printing of Biodegradable Vascular Stents (BVS) from Poly Lactic Acid (PLA) polymer. Method implies rearranging standard FDM printer with Cartesian coordinate system (X, Y, Z) to enable rotational printing around one rotating axis. This way, buy including rotating axis, a four-axis printing system is created, which allows printing directly on rotating drum without supporting structures. In this example, Y-axis translatory movement is translated into drum rotary movement, avoiding the need for printer reprogramming. Opposing to the standard FDM printing, CAD files for rotary printing are needed to be prepared in unfolded form. In this way, specimens surface integrity and manufacturing efficiency are both improved.

Practical implementation of this method creates novel options for printing tubular, radially loaded structures where mechanical properties are as important as surface quality. For example, shape-memory vascular stents can be produced in this way, incorporating four-dimension – four-axis printing of such structures. Combining development of new 3D printing materials and this printing method, opens wide possibilities for developing biocompatible, programmable support structures, which can be inserted into human vessels and then expanded by external stimulus (E.g., temperature), enhancing blood flow with minimal invasive effects for patient – reducing recovery time. In addition, new structure geometrical models can be developed having in mind 4-axis printing possibility.

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Investigation of dominant modes of heat transfer and thermal stability of the classic cycloid reducers concept

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Abstract

High-precision reducers are increasingly used in modern industrial systems, especially in industrial robots, navigation systems and CNC machine tools. That is why the number of installed cycloidal reducers is constantly growing year after year. One of the least researched aspects of cycloidal reducers is certainly their thermal stability, which can only be ensured if the the amount of heat dissipated should equal the amount of heat generated., that is, if the operating temperature is lower than the permitted one. This paper presents a mathematical model for determining the stationary operating temperature of a lubricant, one of the most important parameters of thermal stability. This research is very important, because elevated operating temperature affects thermal expansion, change of internal clearances, reduction of the viscosity of the lubricant, i.e. the thickness of the oil film.

For the correct operation and fulfillment of the intended work function of the cycloid reducer, its thermal stability plays an extremely important role, and it largely depends on the temperature of the lubricant. Currently, there is no methodology that systematically studies and checks the thermal stability of cycloid reducers. That is why the presented methodology is of great importance for engineering practice, as it provides the opportunity to obtain relevant data on the influence of operating temperature on the bearing capacity of the reducer in the construction phase and to make the necessary corrections in a timely manner without expensive and time-consuming prototype tests.

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Development of Components for a Water Hydraulic Axial Piston Pump - Tribological Aspects of the Research

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Abstract

The global trend to reduce oil consumption and the rising cost of traditional hydraulic fluids are spurring the development of alternative sources. Being environmentally friendly and affordable, water is considered one of the most suitable alternative working fluids.

This paper focuses on the improvement of water hydraulic axial piston pumps while searching for sustainable hydraulic solutions through detailed analyses. It gives a comprehensive study of tribological aspects of materials of the components and working fluids in water hydraulic systems and aims to improve the performance of the pump while mitigating the environmental impact. Through systematic analyses and experimental tests, it presents the development of water hydraulic technology which facilitates the transition to more environmentally friendly and more efficient hydraulic systems.

The main tribological mechanisms for the water-lubricated friction pairs are abrasive wear and indirect corrosive wear. This research will provide useful guidance for selecting materials for the key friction pairs in water hydraulic piston pumps.

In an era marked by increased environmental awareness, the imperative for sustainable technological solutions has never been greater. The development of the components for water hydraulic axial piston pumps responds to this call by pioneering research into water hydraulic technology as a sustainable alternative to conventional hydraulic systems.

This paper carefully studies the factors that affect the performance of the pump and have a significant impact on the environment and aims to chart a new course in hydraulic engineering that prioritizes efficiency, sustainability and environmental responsibility. Combining experimental research, analysis, and innovative methodologies, this paper seeks not only to advance the theoretical understanding of water hydraulic technology but also to transform the results into tangible, real-life applications. Encouraging the widespread application of water hydraulic systems in various industries, it is the aim of this paper to make a significant contribution to global efforts to mitigate climate changes and reduce dependence on fossil fuels.

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Design of Stoves for Terraces and Gardens

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Abstract

This investigation introduces a design approach for pellet stoves that are used in terraces and gardens. The presented pellet stoves are based on existing solutions, customer needs, well as production possibilities. When analyzing the existing products, the foreign and domestic markets were analyzed in order to look at all possible aspects of the design of other companies. The analysis of customer needs was carried out in the form of a survey, based on which the necessary data for the further design process is obtained. Constraints were specified, a conceptual solution was created, and the functionality of the stoves was analyzed. After the analysis, the most suitable solution was presented in the form of a 3D model. The impact of key factors in industrial design was also considered. After creating the model, a realistic view in the form of the rendered pictures of the results is shown.

The design of pellet stoves for gardens and terraces was preceded by an analysis of stove models from foreign companies. One of the methods of arriving at new ideas was benchmarking, i.e. detailed analysis of one of the competing products. The criteria for the selection of ideas were as follows: the possibility of using existing machines and tools, the expected percentage of profit from the price of prefabricated materials, the training of personnel, the existence of competition, the existence of demand, etc. In addition, the special requirements of potential customers were taken into account based on the results of the conducted survey. After all the necessary analyses, a conceptual solution was adopted and a suitable 3D model of the stove was created.

The biggest influence on the shape of the product is its function and purpose, which is expressed through the specification of limitations. Given that the stove is for terraces and gardens, care had to be taken to fit it into the space where it will be located. Ergonomics is also one of the items that need attention during the design. The digital prototype is made as the final result of the design, in order to see if the model is functional and if it meets all the production conditions.

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Stability of rectangular plates with elastic clamped edges

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Abstract

This research deals with the stability of a rectangular plate that is elastically supported along the longitudinal edges and under equally distributed compressive forces along the other edges. At the start of the paper, the general case with elastic clamps of different stiffness is analyzed, and then special and commonly known cases are considered. The Energy Method is used to determine the critical buckling force. The deflection function was chosen so as to best represent the actual deformation state of the plate. In this way, the critical stress is determined in an analytical form suitable for analysis. By analyzing the equation, it is possible to conclude how certain parameters affect the value of the critical voltage.

The paper shows how the obtained solution could be used to determine the critical stress of local buckling in significantly complex systems - pressed thin-walled beams of arbitrary length. In the case of local buckling of thin-walled prismatic beams under uniform pressure loading on the cross-sectional area, it is necessary to determine the critical buckling stress of the entire rod and of each individual rectangular assembly. The plates that make up the rod are connected along the joint lines, so when looking at the stability of each of them, the influence of the adjacent plates cannot be ignored. The influence of adjacent plates can be represented by elastic clamps that load a given plate with bending moments uniformly distributed along the mating lines. These moments are directly proportional to the slope of the slab, which was created as a result of the bending of the slabs by those edges. The proportionality coefficient C - the stiffness of elastic clamping - depends on the adjacent plates to which the plate is connected.

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Optimization of Gear Pair in Planetary Gearbox Using TOPSIS Method

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Abstract

The optimization process of the first gear pair in a planetary gearbox was conducted through the application of the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method. In this study, considered input parameters were the gear width, module, and material of the gears, while the considered outputs were factor of safety from pitting SH and factor of safety from tooth breakage SF, for implementing the TOPSIS method. Based on the selected input parameters using the design of experiments, the L18 matrix was created to obtain results for the output values. The results obtained from the TOPSIS method indicate that the optimal parameters of the first gear pair, in terms of the safety factors SH and SF, are a gear width of 20 mm, a module of 2.25 mm, and a material of gears 16MnCr5. Also, the results of this research indicated that a significant reduction in the mass of the planetary gear was achieved.

The use of the TOPSIS method in engineering, especially in planetary transmissions, is highly significant and beneficial to the industry. The aim of the TOPSIS method application is to improve the efficiency of planetary transmissions by reducing vibration, increasing component lifespan, and other. In addition, optimization can decrease production costs, particularly in the manufacturing processes of planetary transmissions. This involves selecting suitable materials, dimensions, mass, and manufacturing technology for the transmission. The TOPSIS method is also crucial for planetary transmissions designed for specific purposes and operating conditions as it helps in selecting the optimal combination of parameters to achieve maximum efficiency and reliability in those conditions.

In this study, the TOPSIS method was applied in order to optimize the first gear pair, which transmits the highest load and power and is crucial for the reliable operation of the system. It has an impact on all other elements of the transmission, including second gear pair, shafts, bearings, and other. To obtain optimal values in terms of dimensions, mass, and reliability, the first gear pair was carefully optimized. The application of the TOPSIS method showed favorable results, reducing the mass of the gear pair by 20%compared to the gear pair before optimization. This, in turn, led to the reduction of the entire planetary gearbox mass, contributing significantly to its improved performance.

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Multifunctional Device for Measuring the Kinematic Coefficient of Friction and Testing the Micro Cutting Process

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Abstract

The developed device belongs to the field of manufacturing engineering and focuses on improving the finishing process to increase the dimensional and geometrical accuracy of cylindrical workpieces. The presented device provides the capability for micro machining of cylindrical macro parts. Unlike conventional methods where the desired diameter is often achieved by adjusting the cutting depth, this method regulates the diameter by controlling the intensity of the cutting tool's penetration force into the workpiece material. This processing method minimizes the influence of all errors in the machine tool motion system. By employing this processing method, the geometric and dimensional accuracy of workpieces is enhanced, especially for those processed on older machines. Processing with the specified tool penetration force demonstrates that such systems can ensure better dimensional and geometrical accuracy, reduce surface roughness, and provide more favorable bearing profiles of the machined surface. The developed method is particularly suitable for individual and small-batch production due to its low initial investment requirements.

The developed device and proposed constant cutting force method offer the possibility of achieving exceptionally high dimensional accuracy (around 1 μm), which is not achievable with conventional machining methods. Finishing on the developed device reduces roundness deviation, surface roughness, and improves the bearing profile of the machined surface. The developed control system is industrially applicable and can be installed on both universal and CNC lathes. Depending on the size of the processed cylinders, the cutting tool holder is replaced. The sensitivity of the force penetration setting system is adjusted by selecting the appropriate springs.

In laboratory testing of the kinetic friction coefficient, a block is placed instead of the cutting element in the holder. Testing of the kinetic friction coefficient can be performed under lubricated or unlubricated conditions, without restrictions on travel distance and test duration.

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Development of a Tool for Friction Stir Processing

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Abstract

In this paper, a prototype solution of a tool for friction stir processing was developed. The prototype of the tool is made of polymer using the Fused Deposition Modeling 3D printing process. Parameters of 3D printing were: nozzle temperature 200 ° C; platform temperature 60 ° C; printing speed 60 mm/s; layer height 0.1 mm; wall thickness (shell) 0.4 mm. The tool consists of three parts, namely: Pin, Shoulder, and Shank. The dimension of the tool includes the Pin height, Pin Diameter, and the Shoulder Diameter. The dimensions of the tool are: Pin height 3 mm, Pin Diameter 5 mm, Shoulder Diameter 18m, and Shank Diameter 14 mm.

The developed CAD model of the tool prototype will be used for 3D printing of the metal tool. Additionally, based on the CAD model, a tool will be fabricated using conventional machining methods on a universal lathe.

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Prototypes of Bone Fixation Devices made from different 3D Printing Infill

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Abstract

Polymer bone fixation devices are emerging as promising alternatives to traditional metal implants in orthopedic surgeries. Their lightweight nature and biocompatibility offer potential advantages for patient recovery and long-term outcomes. In this paper, prototype solutions of bone fixation devices were developed. The prototype of the bone fixation devices is made of Polylactic acid (PLA) using the Fused Deposition Modeling 3D printing process. PLA transparent filament was used for 3D printing. Parameters of 3D printing were: nozzle temperature 200 ° C, platform temperature 60 ° C, printing speed 60 mm/s, layer height 0.1 mm; wall thickness (shell) 0.4 mm. Printing infill was 20%and 80%

Polymer bone fixation devices find widespread application in orthopedic surgeries, ranging from fracture fixation to joint replacement procedures. These devices offer advantages such as biocompatibility, reduced risk of corrosion, and tailored mechanical properties matching those of bone tissue. Their versatility allows for customization and adaptation to various anatomical structures and patient needs. Additionally, polymer fixation devices often promote faster healing and rehabilitation due to their lightweight nature, minimizing discomfort and enhancing patient mobility post-surgery. Moreover, ongoing advancements in polymer materials and manufacturing techniques continually improve the performance and applicability of these devices in clinical practice.

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Comparative study of different 3D printed PETG joining techniques

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Abstract

The most commonly used Rapid Prototyping method in recent years is 3D printing. FDM (Fused Deposition Modeling) or Material Extrusion (MEX) is currently the leader in these technologies due its affordability and material variety. One of the most commonly utilized 3D printing material, besides Poly Lactic Acid (PLA) is Polyethylene Terephthalate Glycol (PETG), a biocompatible thermoplastic polymer obtained through polycondensation reactions of CHDM, EG and TPA. Common polymer bonding techniques include different technologies and materials, including various welding and gluing techniques. Aim and objective of this study is to compare different joining techniques of 3D printed PETG with fully printed approach.

This study can provide insight in repairing techniques for 3D printed parts whether it is hobbyists or SMEs who grasp 3D printing technique in their everyday routine, or production processes. Having in mind repairing techniques for 3D printed parts can enhance productivity, provide backup plan while replacement parts can be obtained and lower overall cost of such repairs.

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Reengineering of RepRap 3D Printers

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Abstract

Daily production, based on modern technology, involves the use of software tools assisting in cost lowering, reducing production time, while keeping high product quality. This paper deals with reengineering of RepRap 3D printer, to improve the quality of the final products. The results of this study include modified 3D printing machine, to enable the improved 3D printing quality, based on the stiffer machine construction, that further enables a higher quality print, increased accuracy, reducing vibrations and deformation of the printed objects. The paper also presents some ideas for the redesign of other segments of the RepRap machines in the future.

Technological potential of this process is enabling lower cost 3D printer to fulfill higher production standards, enabling lower printing prices and less time consumption, while maintaining or improving product quality. These reengineering ideas can allow domestic companies, universities and hobbyist to improve and update 3D printers already employed in their facilities, avoiding higher costs of procuring newer printers. In addition, electronics production companies can grasp these designs and create more space for themselves in 3D printer market.

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6. ELECTRONICS AND PHOTONICS

Support of SMEs in Serbia in the Process of Manufacturing Electronic Devices

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Abstract

The production of electronic devices or printed circuit board assembly (PCBA) in Serbia and in the region, after the structural reforms that took place in the previous 30 years, was practically reduced to a minimum. PCBA is a process that consists of several stages regardless of whether it is a prototype or mass production. Production begins with the placing and soldering of electronic components for surface mounting (surface-mounted device - SMD). That phase consists of applying solder paste, placing SMD components on Pick and Place (PnP) machines, soldering in hot air (reflow) ovens, and Automated Visual Inspection (AOI). This is followed by the phase of placing the Through hole (TH) components and their soldering. If it is about embedded systems, their programming (loading the firmware) follows, and then the final control, testing and packaging.

In the last 20 years, PCBA systems suitable for SME applications have appeared on the market. The main feature of these systems is the low price compared to similar industrial systems. Their compact design and low power consumption make them suitable for placement in a smaller office space. They allow greater flexibility and speed of response in the process of making prototypes and small series. This shortens the time of appearance of new or redesigned products on the market. They lead to a significant reduction in the dependence of SMEs in Serbia engaged in the production of electronic devices on foreign service providers in this area, thus making SMEs more competitive and resistant to disruptions in the global framework that we are all witnessing.

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A Sequence of FPGA-based Digital System Design Laboratory Exercises with Simple Electronic Piano Realization as the Outcome

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Abstract

Digital electronics and the design of digital systems are an important part of every electrical engineering and computer science curriculum. A sequence of laboratory exercises in which each one builds on top of the previous is conceived to realize a digital piano. The piano is implemented on a Field-Programmable Gate Array (FPGA) platform. It exploits low-pass filtered pulse-width modulated (PWM) or pulse density modulated (PDM) signals to produce the desired frequency tones and duty cycle modulation for volume adjustment. The melody can either be stored on an FPGA memory or tones may be transferred from a computer through UART in real time. A set of laboratory tasks is targeted for Digilent's Pynq-Z1 board and employs scripts and complete build automation.

Laboratory exercises are an indispensable component in the education of digital design engineers since students there obtain mandatory hands-on experience. A series of laboratory tasks is created to guide first-time learners to grow up to an intermediate proficiency level with industry-standard hardware and electronic design automation (EDA) tools. A natural increase in problem complexity ranging from inserting simple behavioral or structural register-transfer level (RTL) Verilog code snipets up to a complete module and finite-state machine (FSM) write-up covers all aspects of combinational and sequential logic. A fully guided online tutorial requiring only relatively low-cost budget FPGA development kits can also be devised so that the proposed laboratory has the potential for much further outreach beyond the university setting.

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A Wide Tuning Range Digital Frequency-Locked Loop Synthesizable from Standard Logic Cells

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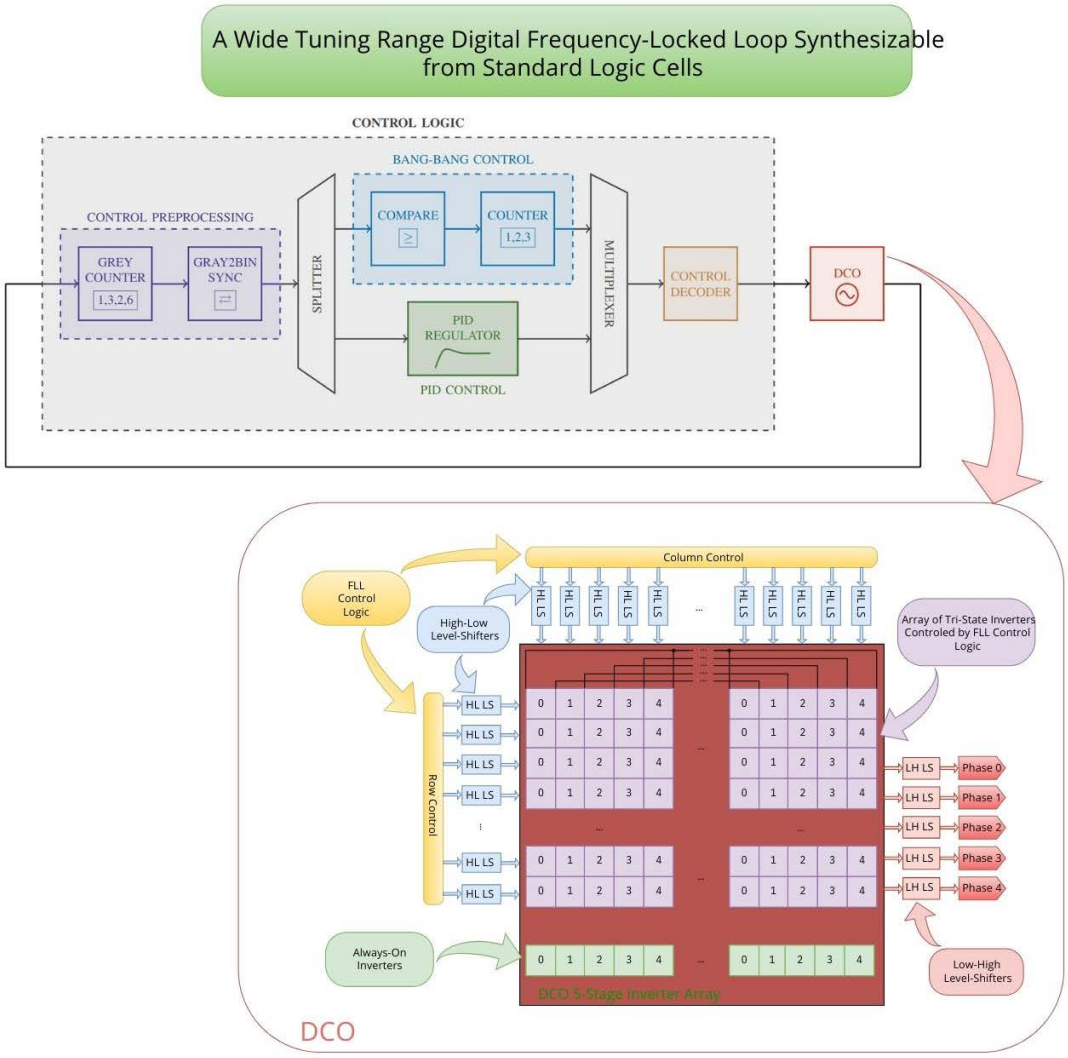
Graphical abstract



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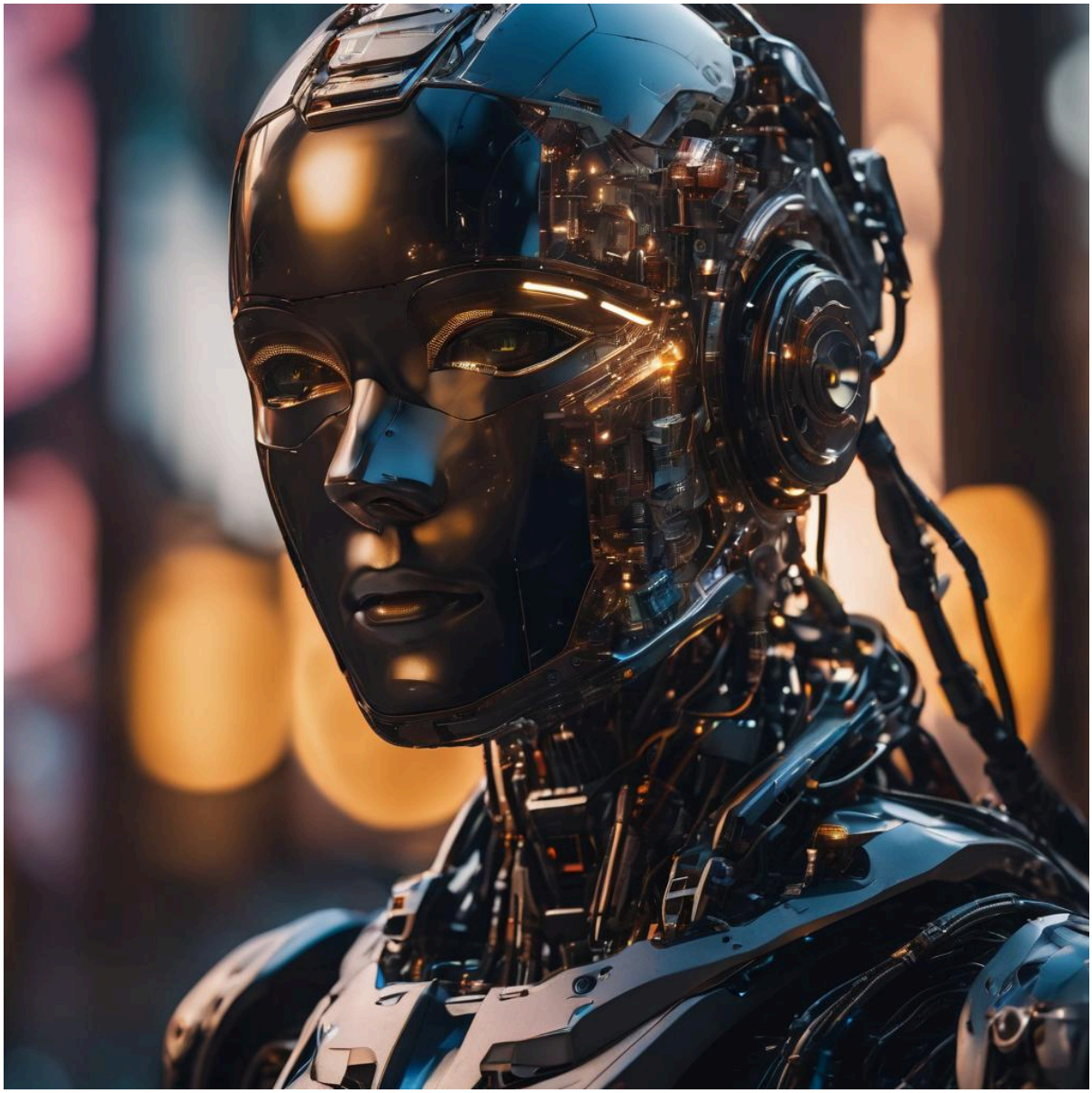
Abstract

Frequency synthesis is a technique used to generate a range of frequencies from a single reference frequency. One way to generate is by using a negative feedback electronic control system that compares the frequency of a controlled oscillator to the target frequency. If the control loop is digital in nature, such a system is using a digitally-controlled oscillator (DCO) and is called a digital frequency-locked loop (FLL). A digital FLL is designed in 130nm CMOS technology for the target frequency up to 640 MHz. It employs a wide-tuning range DCO assembled from tri-state inverters in the form of a matrix. The FLL can optionally use a bang-bang or a soft-programmable standard proportional-integral-derivative (PID) controller to regulate the feedback loop. Its design practically minimizes metastability occurrence.

Frequency synthesizers are utilized in radios and also as clock generators in every synchronous digital system. Long seen as analog electronic components, the design of synthesizers required a great deal of manual labor to optimize performance. Many systems do not require precise phase alignment to the reference, only frequency stability across PVT corners. Such systems can exploit much simpler frequency-locked loops instead of traditionally used phase-locked loops (PLLs). If a clock generator could be described in a hardware description language and then implemented in a digital tool flow, this would simplify the design process to a great extent and reduce the tedious and time-consuming porting process between different technologies. Hence, the clock generator design process could be fully automated from top-level specifications.

7. ROBOTICS



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Neurorgonomic Assessment of Mental Workload in Adaptive Industrial Human-Robot Collaboration

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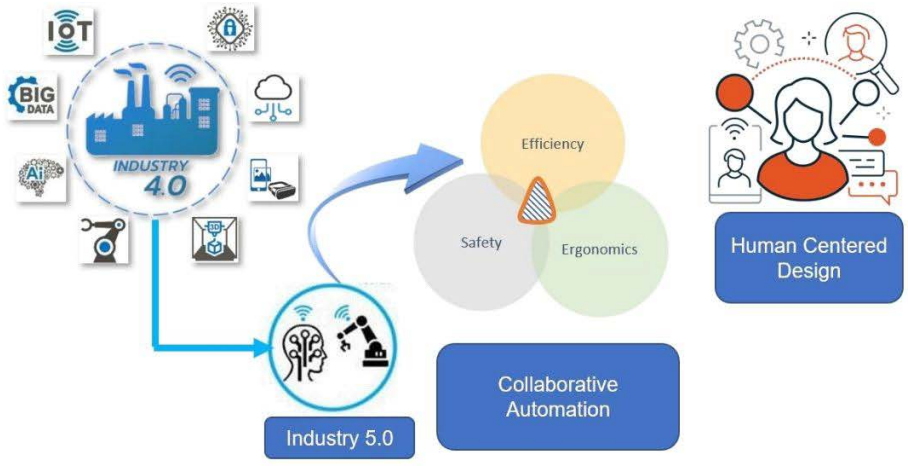
Graphical abstract



Abstract

The transformative deployment of collaborative robots, known as cobots, in Industry 5.0 has highlighted the need of safety, ergonomics, and efficiency in industrial human-robot interaction (HRI) operations. For instance, the study of the operator's mental workload (MWL) in HRI tasks has been the research focus of a new branch of ergonomics known as Neuroergonomics, which aims to increase operator well-being and system efficiency.

To explore Human-Centered Design systems in HRI, neuroergonomic evaluations are critical for monitoring operators' physiological states. This assessment is feasible with the use of electroencephalogram (EEG) instruments. In this method, an objective, real-time, analytical, and non-obtrusive investigation enables a deeper understanding of the operator's cognitive state while co-working with the robot.

In recent years, the use of cobots in production processes has increased. The increased use of cobots in fenceless industrial areas has prompted researchers to investigate the operator's mental effort while working

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with the robot. Thus, wearable sensors are used to study the human reaction in terms of cognitive workload. The developed task, which resembles wire harness assembly activities, arose from a lack of research studies on the neuroergonomic examination of mental burden with the use of robots. Furthermore, manufacturing assembly duties in Balkan countries are primarily carried out manually, without the use of robots. This research study highlights how the deployment and design of Human-Robot Collaboration tasks in manufacturing operations improves assembly efficiency.

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8. VIRTUAL REALITY, AUGMENTED REALITY, METAVERSE

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Personalized Preoperative Planning of Hip Endoprosthesis Implantation Using 3D Digital Templating

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Abstract

Surgical planning and implant selection are crucial for hip endoprosthesis surgery. This study introduces 3D digital templating as a method for precise preoperative planning, developed in collaboration between the CIRPIS Center at the Faculty of Engineering and the University Clinical Center Kragujevac. It involves parameterization, implant generation, and femur reconstruction based on manufacturer specifications. Using the parameterized femur as a reference, the patient's individual femur model is shaped from X-ray dimensions. After defining all parameters, a generic hip prosthesis implant is integrated into the virtual femur, facilitating selection of the appropriate implant instance matching the patient's anatomy and streamlining surgical procedures. Ultimately, 3D digital templating enables accurate and efficient preoperative planning of hip joint surgery.

In clinical practice, 3D digital templating is utilized for personalised planning of hip endoprosthesis implantation, resulting in more precise and efficient outcomes. Through the analysis of X-ray images and femur parameterization, an individual patient model is created, allowing for the integration of a generic hip prosthesis implant into the virtual femur. This provides orthopedic surgeons with a spatial representation of interaction, facilitating the selection of the optimal implant instance from the catalog. This advanced approach significantly improves preoperative planning and clinical outcomes of hip replacement surgeries.

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Virtual Laboratory Exercises Which Utilize Audio Signals to Enhance Understanding of Electronics Fundamentals

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Abstract

Introductory analog electronics courses are traditionally considered among the most challenging in higher education curricula. Students usually encounter several key new concepts and paradigms, including incremental analysis of nonlinear electrical circuits and devices, as well as frequency domain analysis, time- and frequency-domain duality, filters, and signal filtering in general. Laboratory exercises serve as an indispensable tool to practically reinforce these concepts and diminish abstract barriers faced by first-time learners. However, they are often limited due to resource constraints. To address this challenge, a virtual laboratory exercise has been developed. This exercise demonstrates field-effect transistor amplifier quiescent point biasing, superimposed with a small audio signal and accompanying distortion. This implementation aims to bridge the gap between theory and practice, thereby enhancing students' insight into analog electronics.

Implemented virtual laboratory exercises showcase (i) a common-source field-effect transistor (FET) amplifier with purely resistive load, and (ii) an RC-based first-order low-pass filter. These exercises enable the injection of not only generic audio signals like sine or square waves, but also samples from different music genres at the circuit input. Sound reproduction is supported for both the input and output signals. Amplitude and frequency of an input, as well as the resistor, capacitor, supply voltage, and simple switch unified MOSFET model values, are manually adjusted with the idea of observing the influence of gain, distortion and filtering. This facilitates a smoother transition between theoretical concepts, which often remain vague, and the actual, usually time-restrictive, laboratory demonstrations, thus boosting students' understanding.

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Real-time video analytics for detecting illegally parked vehicles

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Abstract

In this research, a system that helps improve traffic flow, enhance safety, and ensure fair enforcement of parking regulations by detecting illegally parked vehicles is proposed. The system is composed of fixed standardized cameras with AI video analytics. Cameras need to be strategically installed at fixed locations throughout the monitored area, such as street corners, parking lots, or key intersections, providing optimal coverage. The AI system performs real-time analysis of the video streams with the capability to identify a range of infractions, including vehicles parked in prohibited areas, obstructing traffic flow, or contravening parking rules and regulations. Once a violation is confirmed by the decision-making process, the system generates a report detailing the offense, including relevant information such as timestamp, location, and photographic evidence.

The fixed camera model provides a cost-effective and scalable solution for parking enforcement, enabling continuous monitoring of parking compliance in urban areas without the need for a mobile platform. Reports generated by the system can trigger various enforcement actions, from issuing automated citations to sending alerts to parking enforcement officers or notifying relevant authorities for further action. The authors believe that with the current AI-based video analytics & hardware technology level, a reaction time of three minutes can be achieved in urban conditions characteristic of a city as large as the City of Kragujevac.

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9. INTERNET OF THINGS, W3C, SEMANTIC WEB, WEB 3.0

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Extended SEFRA framework for e-office systems in the Serbian-speaking region

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Graphical abstract

Abstract

There is a great need for the unification and integration of several technologies and services into one product suitable for helping e-government and other public-sector services as well as private company administration to support advanced search services. For corporate operations in the Serbian-speaking region and surrounding areas (Serbian and similar languages), the authors suggest a framework that will be an extension of the previously proposed SEFRA framework. Along with updating all components that are part of the SEFRA framework, the proposed framework will also include the integration of advanced human-computer interfaces and LLM GAI models such as the GPT models GPT-3.5 & GPT-4, which will be specifically fine-tuned for the needs of the e-office of a specific enterprise from either the public or private sector. This proposed framework represents a significant advancement in leveraging AI technologies to improve the efficiency, responsiveness, and adaptability of business operations in the Serbian-speaking region and potentially beyond. Its applications could transform various aspects of corporate operations, from customer interaction to internal processes, making businesses more competitive in a rapidly evolving digital landscape.

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Advanced Technologies for Financial Information Systems in Large Companies

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Abstract

FinTech revolutionizes finance through technology, prominently featuring AI as a pivotal innovator, serving large and public sector companies alike. It encompasses everything from user-friendly banking apps to sophisticated AI-enhanced financial analysis tools. Key trends driving the sector's evolution include cloud adoption, cloud-based ERP/CRM systems, GDPR compliance for data protection, blockchain usage and AI-driven sales interfaces. At its core, AI-integrated financial information systems are indispensable for efficiently managing and analyzing financial data. These AI-enhanced systems are crucial for both large corporations and public entities, facilitating superior service delivery and informed decision-making. This synergy of cutting-edge AI technologies with traditional financial practices is transforming financial services, underscoring technology's vital role in meeting the varied needs of a broad spectrum of consumers and organizations.

FinTechs powered by AI have practical applications spanned across various sectors, streamlining financial operations and enhancing user experiences. For large companies, AI-driven analytics optimize investment strategies and forecast market trends, while cloud-based ERP systems improve operational efficiency and scalability. Public sector entities should leverage FinTech for efficient budget management and to increase transparency in financial transactions through blockchain. Additionally, GDPR compliance tools ensure data protection, fostering trust among users. Financial information systems enable real-time monitoring of 'financial health', critical for decision-making in both sectors. Consumer banking benefits from mobile apps, making transactions convenient and secure. Sales interfaces, powered by AI, offer personalized customer services, boosting engagement and satisfaction.

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10. SUSTAINABLE ENERGY AND CLEAN TECHNOLOGIES

Smarticity

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Abstract

Smarticity is a software platform designed to manage renewable energy micro-grids efficiently. It offers users a digital twin of their micro-grid, using machine learning to predict energy patterns. Smarticity optimizes energy storage through evolutionary algorithms, considering factors like efficiency, environmental impact, safety, and profit. An experiment on a virtual prosumer validates Smarticity's effectiveness, showing it outperforms other strategies in energy management.

An example application of Smarticity could be in a residential community with a mix of traditional and renewable energy sources. As households adopt solar panels and wind turbines, they become energy producers as well. By considering natural and social factors and utilizing machine learning techniques like artificial neural networks (ANN) and genetic algorithms (GA), Smarticity generates predictive models for production and consumption processes within the grid. These models enable simulation and evaluation of different operation plans, ensuring efficient energy management. Smarticity's dynamic optimization, based on meteorological forecasts and social factors, ensures reliable energy distribution at various scales, from individual households to statewide networks.

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The Hydrogen Application at IC Engine

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Abstract

The hydrogen represents the fuel of the future, because its ecological characteristics. In order to investigate the engine work with hydrogen, it was made a gas installation with two functions, the fuel delivery and fuel consumption measurement. It was used a well-known prechamber technology in order to provide direct injection into the combustion chamber. Thanks to all mentioned, were found optimal parameters, which provide a successful engine work with hydrogen. It was found that for the successful engine work, it is necessary to have two injections for each engine cycle. First injection serves to provide enough amount of fuel while the second one serves to slowdown the combustion process.

The fact that the hydrogen has a great potential is many researches on this subject. However, these researches are not always available, because in many cases are the part of commercial application in automotive industry. The hydrogen is present in almost in 99%of universe, and as such represents a great fuel, which can replace the conventional fuels, diesel and gasoline. Besides its characteristics as fuel, from the aspect of engine work, also it has a very good ecological characteristic. The prechamber technology use on the vehicles can help to the control of the hydrogen combustion process, because its high combustion speed, which is only obstacle to the hydrogen use.

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The Problem of Brake Wear and Environmental Pollution with Particles Obtained by Brake Wear - a New/Old Source of Pollution?

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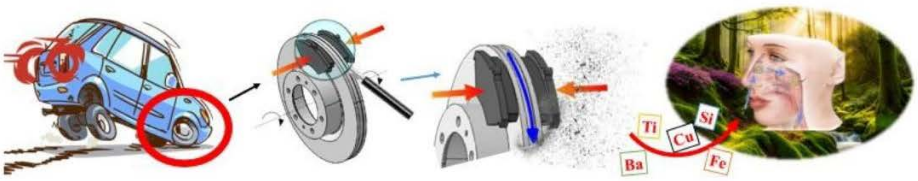
Graphical abstract



Abstract

The problem of brake wear has not been analyzed to such an extent from the point of view of ecology. One of the systems on the vehicle that emit particles, which often contain substances harmful to the environment and human life, is the braking system. Particles in this case are formed as a result of wear of friction pairs (brake pads and discs) due to vehicle braking. Analysis and research of the formation of particles of different sizes (PM10 and PM2.5) due to brake wear is very relevant today, so different systems and regulations are being developed that are related to this topic.

By researching the influence of various factors on the resulting particle emission, as well as the mechanism of particle release, the answer can be found as to how much and what influences the resulting particle concentration. Thus, it is possible to develop new systems on the vehicle that would collect particles or optimize braking, development of new materials for friction materials, development of technologies for the production and processing of friction pairs, introduction of new legal regulations in the field of motor vehicles and the environment.

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Construction Waste Calculator - a Software Solution for Calculating Waste Quantities During the Demolition of Buildings

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Abstract

This study addresses waste management in the construction sector, emphasizing analysis and recycling opportunities to improve waste handling. A novel demolition waste calculator was developed from analysing 23 construction projects, to estimate the volume of waste per square meter, categorize waste types by area and floor, and identify recoverable secondary raw materials. This information supports effective waste management strategies, contributing to the reduction of construction waste volumes. The approach is underpinned by circular economy principles, aligning with the Green Agenda and Serbia's industrial strategy, demonstrating a commitment to sustainable construction practices.

Calculating potential construction waste volumes for buildings of known size before demolition aims to understand material behaviour as waste, its flow, and presence in various construction phases, ultimately estimating produced waste and recoverable secondary raw materials. Utilising software solutions, incorporating artificial intelligence and optimisations, facilitates quick, straightforward waste management predictions. This indirectly reveals the economic and ecological value of waste as a potential resource for further production, paving the way for strategic investment planning and the development of new recycling markets. High-confidence recycled products emerge from precise waste management based on accurately determined waste quantities and types generated from demolitions, advocating for sustainable development and resource utilisation.

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Sustainable Urban Waste Management System: Implementing Smart Solutions for Efficient Collection

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Abstract

The current infrastructure in the Republic of Serbia in the field of municipal waste collection is not sufficient to meet the requirements of the EU Waste Directive, so it is necessary to improve collection processes through the application of innovative digital technologies. This research aims to develop a comprehensive methodology for optimising the municipal waste collection process. Furthermore, the aim is to assess the efficiency of integrating smart sensors into waste collection bins to improve the overall waste management system. By using such smart solutions, the goal is not only improving operational efficiency, but also enhance user services, thereby advancing sustainable waste management practices at the local level in Serbia.

This research investigates the concept of a smart municipal waste management system, focusing on the implementation of innovative solutions to improve waste management efficiency. The waste management system creates more efficient conditions from the aspect of environmental protection by integrating technologies such as GIS, robotics, AI, IoT, neural networks, cloud computing and data analytics. The primary scientific objective of this research is to establish a methodology for optimising the municipal waste collection process in urban areas using smart solutions. Furthermore, research assesses the technological potential by examining innovative solutions such as smart sensors for waste collection bins. These advanced tools in waste management systems enable precise mapping and analysis of waste generation patterns, allowing the development of more efficient waste collection strategies.

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Improving Energy Efficiency in Buildings Using Wastewater Heat Recovery System - a Review of Available Cases

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Abstract

Implementation of wastewater heat recovery systems significantly contributes to enhancing the energy performance of buildings, thereby reducing heating demands and advancing sustainability goals. This study provides a comprehensive overview of heat recovery from wastewater in buildings and the opportunities to reduce energy consumption and greenhouse gas emissions through the use of wastewater heat recovery technologies. The study outlines the methodology for assessing the impacts of potential wastewater heat recovery in buildings and provides an analysis of the primary factors influencing the wastewater heat recovery potential, incorporating specific research methods and criteria for assessment. Considering the consistent potential of heat recovery and its widespread accessibility at the source, the study indicates the need for further research on the possibilities of heat recovery from wastewater at the building level. It is particularly crucial as future strategies for fostering sustainable development may rely on heat recovery from wastewater.

The practical application of wastewater heat recovery systems in buildings is of immense importance. To successfully implement wastewater heat recovery systems in residential, commercial, and industrial environments, it is necessary to design, install, and optimize them. The aim of implementing such systems is to reduce heating demands and decrease energy consumption and greenhouse gas emissions, thus advancing sustainability and effective environmental management. Through case studies, researchers can demonstrate the effectiveness and feasibility of implementing wastewater heat recovery technologies in diverse environments.

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Sustainable Development and Environmental Protection with Water Hydraulic Systems - Experimental Research and Development of the System Components

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Abstract

This paper presents a detailed study of the components of water hydraulic systems. The aim of the paper is to encourage sustainable development and strengthen efforts to protect the environment by improving the performance of the system components.

The performance and environmental friendliness of each component is analysed systematically and thoroughly- The key role of the axial piston pump as the main component of a water hydraulic system is pointed out, emphasizing its importance in increasing efficiency, performance and sustainability. The axial piston pump is the heart of water hydraulic systems because it facilities production and transmission of hydraulic power for various industrial applications. Through experimental investigation, this paper provides a valuable insight into the complex interaction between hydraulic technology, environmental management and industrial efficiency.

The study of the design principles, performance characteristics and operation of axial piston pumps in water hydraulics contributes to the advancement of environmentally friendly hydraulic solutions which promote sustainable development and environmental protection.

The practical application of the research presented in this paper offers benefits in various industries, promotes environmentally friendly practices while increasing operational efficiency and reducing environmental impact.

An important application lies in the area of production and industrial automation. When water hydraulic systems developed through experimental research and component development are implemented into manufacturing facilities, significant reductions in energy consumption and carbon emissions will be achieved.

Using water as a hydraulic fluid eliminates the risk of oil spills and contamination of the environment, which protects both the environment and the workers. In addition, optimized system components, such as axial piston pumps, ensure reliable and efficient operation and contribute to increased productivity and cost savings for industrial companies.

In conclusion, research on sustainable development and environmental protection with water hydraulic systems has a number of possible applications in various industries. The insights and innovations achieved in the field of experimental research and development of components can help companies embrace

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environmentally friendly hydraulic technologies to achieve sustainable growth, improve operational efficiency and contribute to global efforts to protect the environment and mitigate climate changes.

Increasing Biogas Yield by Optimizing the Co-Digestion Process

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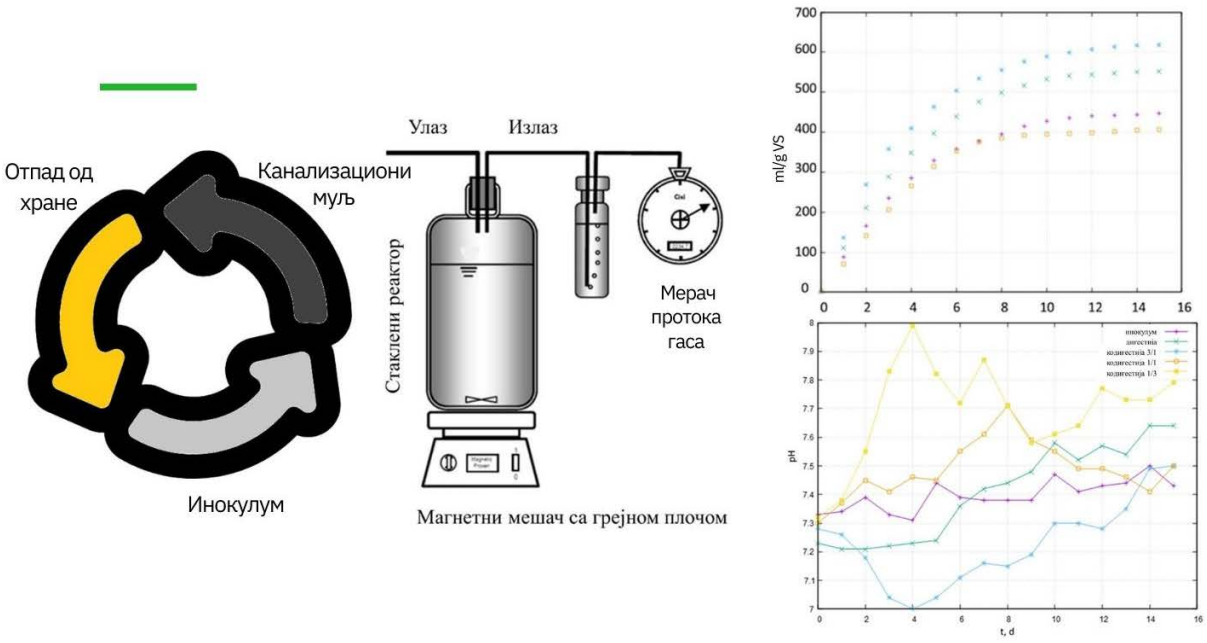
Graphical abstract



Abstract

The implementation of co-digestion in wastewater treatment plant would reduce the production of waste and would increase the yield of biogas. This research determined the increase in biogas yield and the synergistic effects of co-digestion were evaluated through batch tests and chemical oxygen demand balance of each co-/substrate in the feedstock. Anaerobic mono-digestion of primary sludge and co-digestions of primary sludge and food waste were performed in three volume basis ratios (3/1, 1/1, 1/3) with small inclusions of FW: 3.375% 4.675%and 5.35% respectively. The maximal performance was demonstrated by the mixing ratio of 1/3, which produced the most biogas (618.7 ml/g VS added) and had the highest organic reduction with COD elimination of 52.8%

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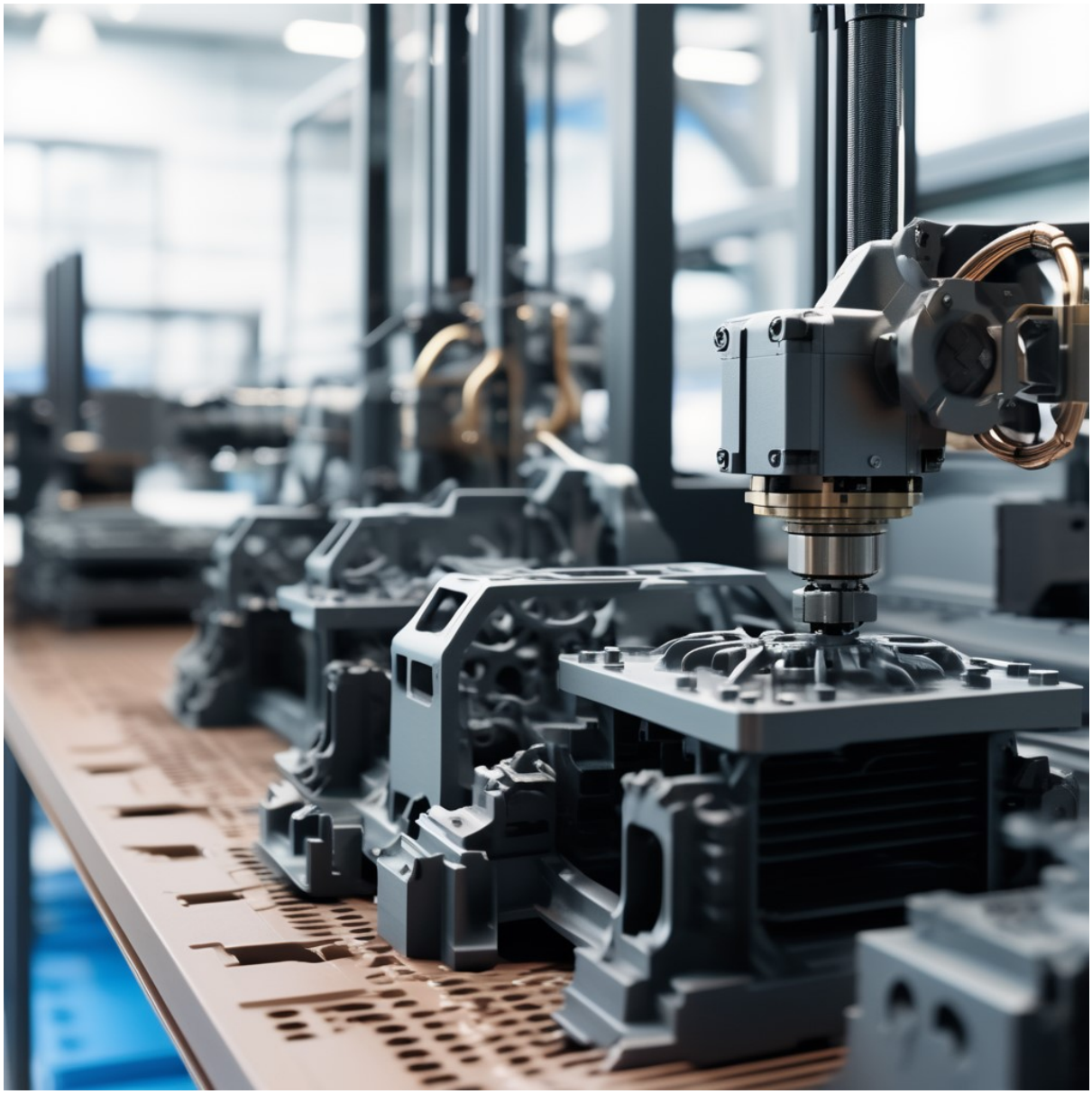
The practical application of the research is reflected in the supplementation of sewage sludge digester with food waste, which improves the yield of biogas and achieves a synergistic reaction of the process. In this way, co-digestion operations are made economically profitable and practical, while at the same time more stable operation can be ensured throughout the year. Also, the test results, if properly conducted and of good quality, can be used to obtain additional information about the studied substrate, such as hydrolysis rate and biomethane production potential.

11. AEROSPACE, AUTOMOTIVE AND REMOTE SENSING



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Structural Analysis of the Nose Landing Gear Support of Utva 75A41M "Sova" Aircraft

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Abstract

A new solution for the nose landing gear support has been designed in the process of modification of Utva 75A41M "Sova". Structural analysis relied on FEM approach employing surface and volume elements for defining nose landing gear support, as well as beams and rods for approximating engine mount and struts. Besides numerical calculation carried out in software Femap, an analytical evaluations of several landing gear components were also performed. Prescribed loads utilized throughout the analysis were adopted from articles CS 23.493, CS 23.479 and CS 23.499. The results concluded that new design of the structure complies with allowed maximum stresses and that it stands as permanent solution of sufficient strength for the nose landing gear support of Utva 75A41M "Sova".

Utva 75A41M "Sova" is a single engine, low wing airplane, with metallic semi – monocoque airframe, four seats in side – by – side arrangement and fixed landing gear. It is intended for initial training and selection , taxi, sport flying, tourism, aerial photography and more. "Sova" had completed its testing phase, received type certificate (TC) in 2023 and is expected to enter serial production in the next period. Given its favorable commercial potential, it has to be a resilient, durable and reliable mean of aerial transport, hence it is necessary to keep a critical approach to existing design. The process of constant improvement and optimization never truly stops as various airplane elements may be enhanced. The present project represents a permanent solution for landing gear structural integrity.

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The Test Rig for the Investigation of Thermal Stresses of Disc Brakes - BRAKE DYNO2020

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Abstract

One of the basic systems on vehicles is disc brakes. The main purpose of brakes on vehicles is to adjust speed to traffic conditions, stop the vehicle, and maintain a constant speed during long downhill drives. In order to investigate the reliability and efficiency of the brake system, the test rig was developed for the investigation of disc brakes. The disc brakes that can be tested are those used on passenger cars. With the aim of determining the efficiency of the brakes, testing procedures were defined that are characteristic of everyday driving as well as some extreme driving conditions.

The practical application of the test rig of the disc brakes is that it can be used for the testing of brake discs and brake pads (that is, for the testing of braking performances, thermal stresses, frictional characteristics, emission of wear products and braking noise) which installs on passenger cars and light duty vehicles. Additionally, it has the ability to be used for teaching in laboratories. It can also be utilized for industry-related projects that involve the development and investigation of disc brakes.

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Real-Time Radar Signal Visualizer with Temporal Interframe Target Smoothening

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Abstract

Millimeter-wave radars are going to be the key enabling technology for future autonomous vehicles. Observing radar signals in real time before and after each processing stage is a highly desirable step in radar data processing chain optimization. More than just displaying the numerical signal values, it is important to alleviate the influence of clutter and noise on the obtained radar detections. To address these needs, a real-time radar signal visualizer was developed. It receives radar data through Ethernet and plots range-Doppler and range-azimuth/elevation two-dimensional spectral heatmaps. To filter out substantial temporal variations between consecutive frames, a DBSCAN clustering algorithm is applied. Even though it is implemented in Python, it can still handle up to one hundred frames per second.

A typical frequency-modulated continuous-wave (FMCW) radar signal processing involves a two-dimensional (2D) fast Fourier transform (FFT) associated with range followed by Doppler or angle dimension, after which range-velocity or range-azimuth/elevation magnitude matrices are obtained. Targets associated with peaks are usually extracted with an adaptive thresholding algorithm and, by the rule, involve using constant false alarm rate (CFAR) detectors. The visualizer can be paired with radar hardware accelerators of 2D-FFT and CFAR implemented on an FPGA prototype to facilitate an attractive and easy-to-manipulate development tool. Furthermore, in the future, it can potentially also be glued to the camera and other sensor streams to allow radar dataset generation or even for automatic object annotations between camera and radar videos.

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12.MATHEMATICS

Polynomials Orthogonal on the Semicircle

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Abstract

Orthogonal polynomials throughout the history of scientific works had alternate periods of popularity and weak interest in them – until interest in orthogonal polynomials began to grow rapidly. The reason was the increasing application in different areas. That is the reason that we started to observe polynomials orthogonal on the semicircle introduced by W. Gautschi, H. Landau and G. Milovanović. It turns out that these polynomials, although at first sight completely different because of complex plane, have convenient properties very similar to real orthogonal polynomials. The properties of the polynomials we consider are recurrence relations, location of zeros and the corresponding Gaussian and anti-Gaussian quadrature rules.

It had to pass about 20 years before orthogonal polynomials found application in areas as numerical integration, number theory and probability theory and statistics. In the age of technological innovations, one might think that the mentioned applications are no longer significant. However, papers from the last few years show that these polynomials do not lose race with time and show their application with artificial neural networks, in new models of food engineering, as well as they greatly help Markov's chains in predicting events. That's why it is very likely that our polynomials orthogonal on the semicircle will also find application in some fields of machine learning, so we don't want to wait another 20 years to give them a chance.

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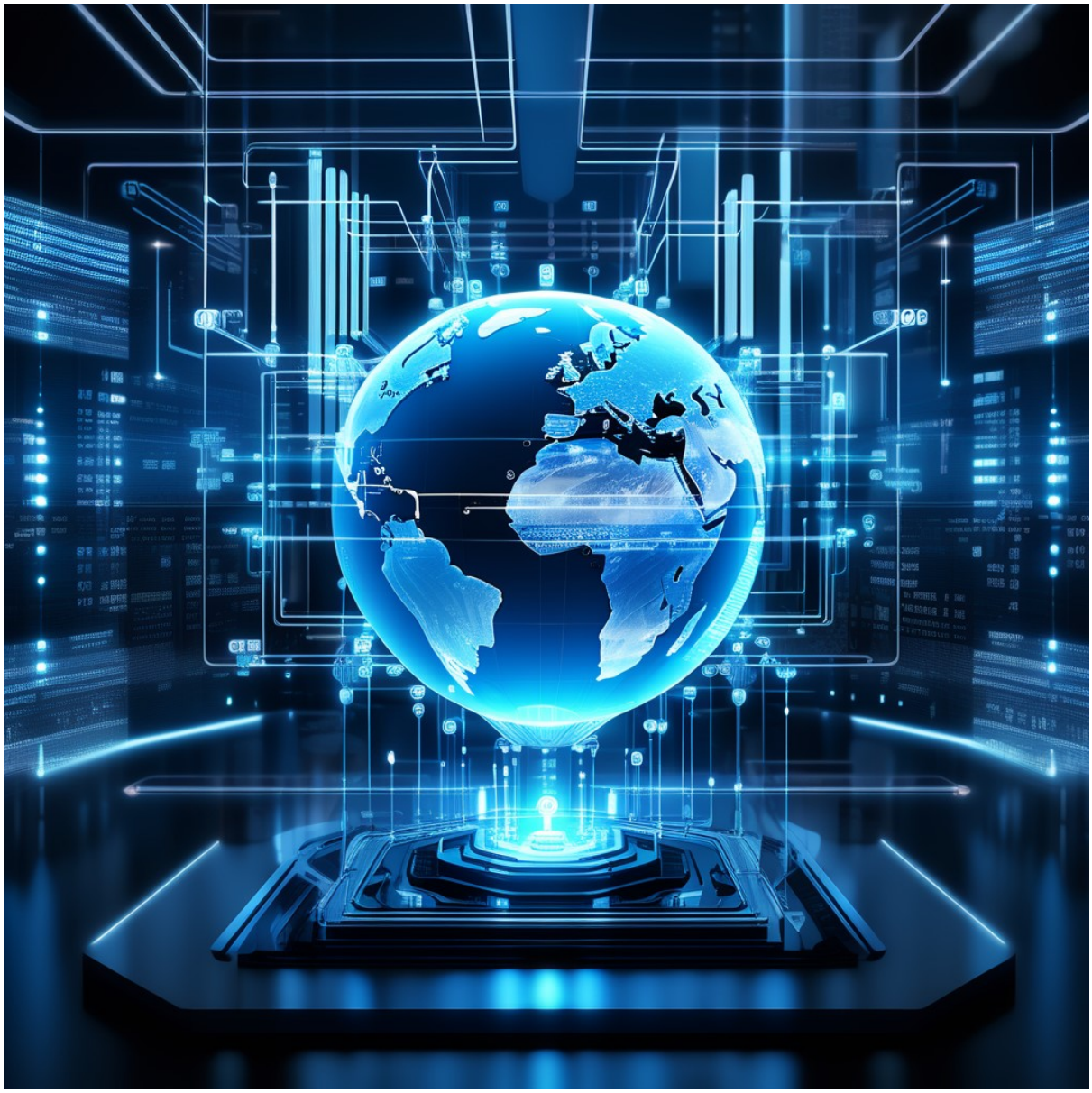
13. LINGUISTICS



Non-Standard Patterns of Noun Modification in Serbian

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Abstract

The study explores a marginal set of novel noun modification patterns in the Serbian language. These structures of questionable grammaticality present a Serbian reflection of the syntactic matrices characteristic for the English language. Several hundred examples of calqued English modification patterns were collected from Serbian Twitter, classified and consequently analyzed according to the modifying element identified in the adjectival position. The analysis shows that the modifiers comprise nouns (monarhija fazon), noun phrases (život na ivici rešenja) and clauses (Ne podnosim ove jesam ti rek'o ljude). Our findings suggest that the need to explore the limits of the native tongue is the main motivating force behind these linguistic escapades of the Serbian speakers who disregard the systemic syntactic differences between the two languages.

Apart from the obvious contribution to syntactic explorations of Serbian and contrastive analysis, the fact that the results of the study pertain to natural language usage makes them applicable in LLM training. Used as guidelines, the detailed descriptions of inappropriate noun modifiers can channel the choice of training material which AI will perceive, interpret and learn. The exclusion of the language uses observed in this analysis from the data set in unsupervised machine learning will harness the LLM's language production and improve its translation training. Raising developers' awareness of such ungrammatical patterns is important for data mining in unsupervised machine learning, while labelling such training data is recommendable in semi-supervised learning. The material can also be used when formulating explicit instructions to discourage an LLM from using structures that follow such patterns, as well as when training LLMs to detect anomalies in translation tasks.

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14. ORGANISATIONAL RESILIENCE AND SMES

Crowdfunding as Alternative Way of Projects Financing

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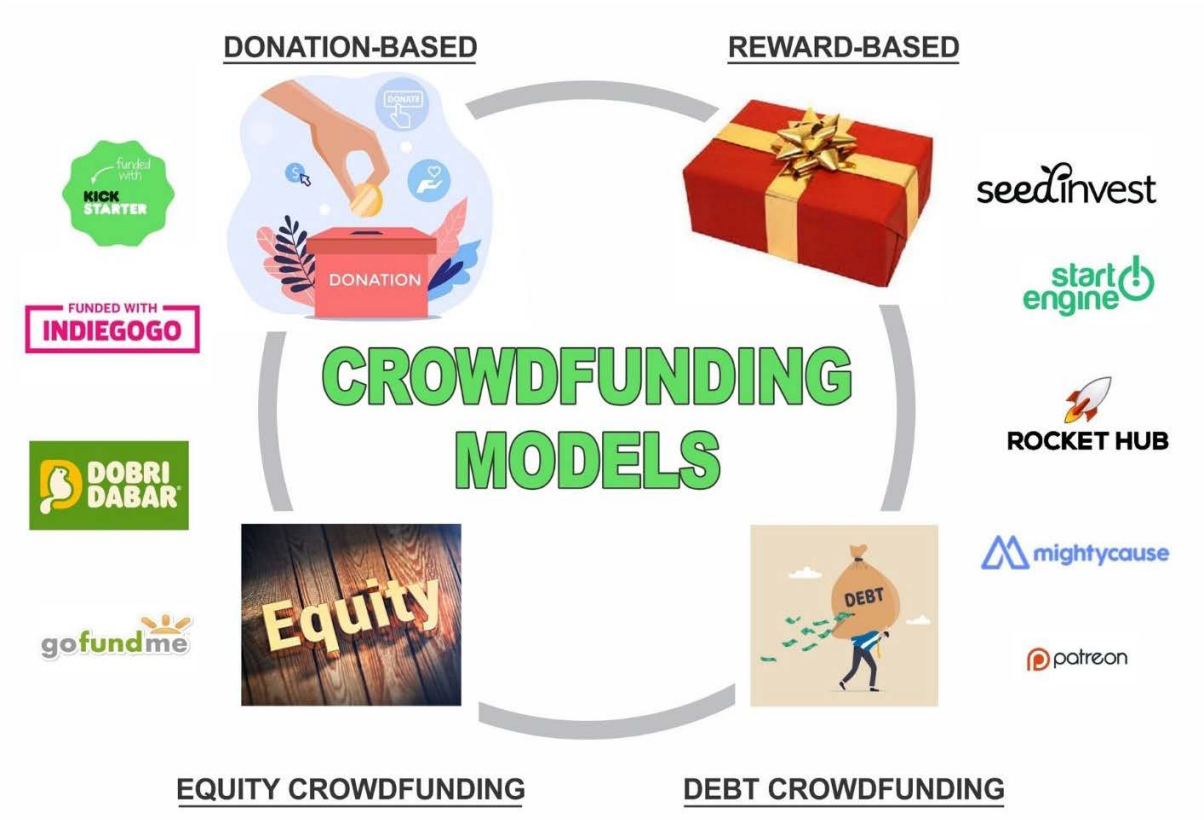
Graphical abstract



Abstract

Crowdfunding enables projects creators to invite numerous minor investors using online platforms unlike the traditional ways of financing that assumes minor professional investors financing. Accelerated and sustainable crowdfunding development may become an indicator of crowdfunding resistance to external shocks impacts of the global financial market. Initiating and leading of crowdfunded platforms requires serious preparation and well-organized team. The relationship between financier (community) and project creator makes the differentiation between four basic crowdfunding models: donation-based, rewards-based, debt-

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based and equity-based. These mentioned crowdfunding models are applied in many countries mainly in entertainment industry specialized in the video game industry.

The global financial crisis in 2008, the coronavirus pandemic, Russia-Ukraine war significantly affected numerous projects financing, that is start-ups as well as small and medium-sized enterprises. That may be considered as a reason for alternative financing sources development which has resulted in crowdfunding expansion.

Realization of the Scientific-Research Project of Young Researchers and Artists of the University of Kragujevac: "Overcoming Disruptions in the Field of Engineering Management - Improving Organizational Resilience: CODEMO"

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Abstract

The project was implemented during 2022 and 2023. The topic of the project arose from the analysis of current business activities of companies that have to continuously adapt to market conditions. Sometimes, market conditions can be shaped by significant disruptions (the COVID 19 pandemic, geopolitical instability, inflation, etc.). In such uncertain conditions, adaptation is often not enough, so organizations must demonstrate the ability to be resilient. It allows them to overcome the current bad state and continue to function as before or with improved performance. The goal of the project was to propose a model for assessing organizational resilience at the level of one business process by establishing mutual connections between key process performance indicators and resilience factors using fuzzy sets and multi-criteria decision-making techniques. For the purpose of verifying the results of the project, two papers were published in the journal category M21A.

During the implementation of the project, two young researchers were directly involved and participated in the development of the methodology, data collection and model testing. The results of these activities were verified through two papers at international conferences in 2022 and 2023.

Based on the developed models and collected data, the relationships between organizational resilience factors that affect key performance indicators and the time needed to recover the value of each key performance indicator were analyzed. It was established that there is a correlation between the analyzed variables.

An optimization model was determined for improving the value of the resilience factors. As an area of business that needs to be improved, the improvement of customer satisfaction was chosen. A model for evaluating customer satisfaction based on an adaptive neuro-fuzzy inference system was developed.

As part of the realization of project activities, the used scientific methodology was adapted for the preparation of the scientific project proposal of the PRIZMA program, which was announced by the Science Fund of the Republic of Serbia.

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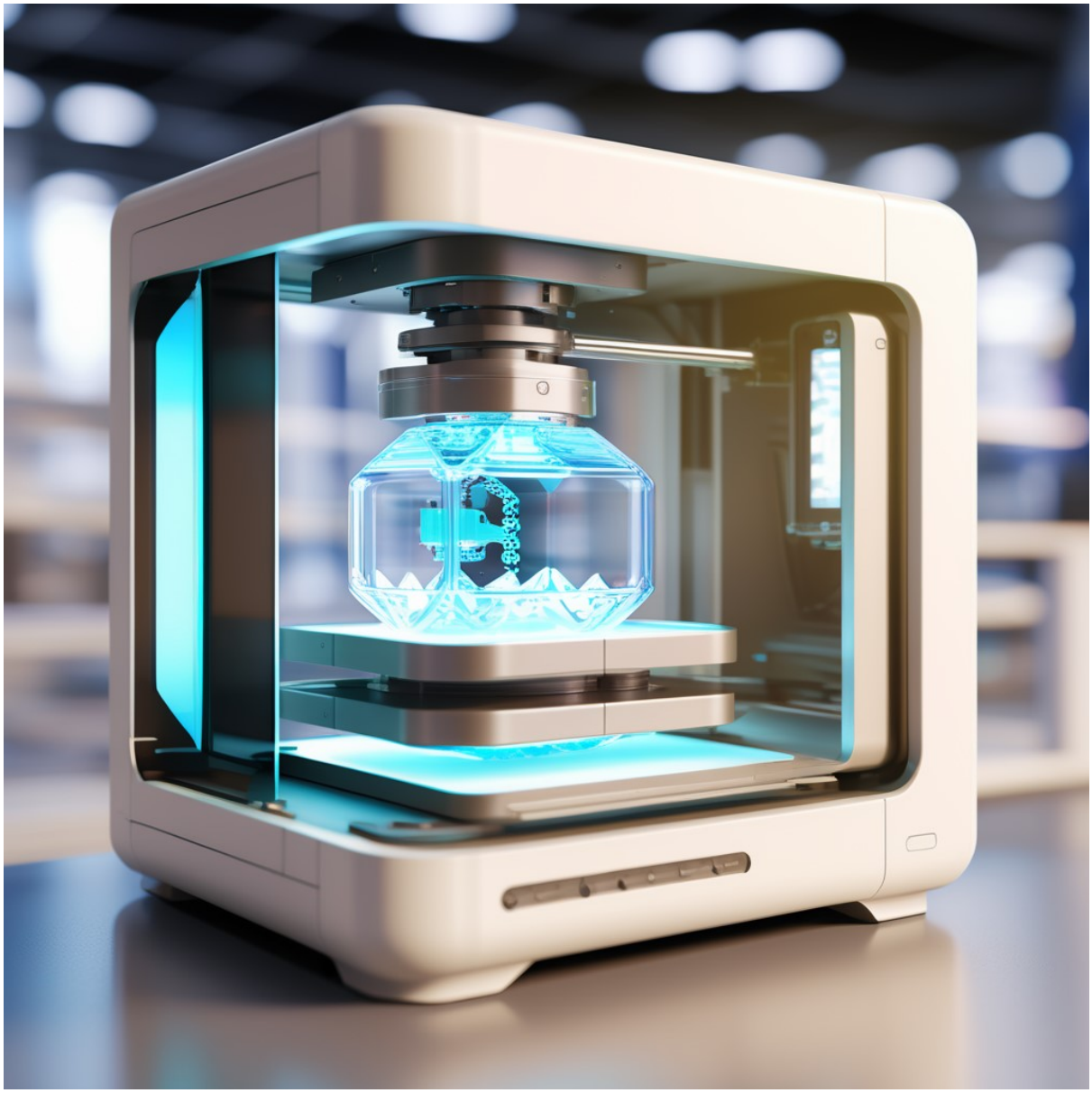
15. STUDENT PROJECTS



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The Dance Pad for Folk Dance

Katarina Veljković*, Ana Stanković, Todor Stanković, Natalija Đoković, Hristina Novaković, Rastko Andrejević, Katarina Vesković, Bogdan Dunjić, Đurđa Jevtić, Pavle Novaković, Lena Stanković, Marko Bogićević

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Abstract

Based on the survey results, through which we identified whether respondents have experience with dancing the kolo and recognize the challenges they face when learning new steps, as well as the fact that our kolo was added to the UNESCO's Intangible Cultural Heritage list in 2017, an innovative solution has been developed in the form of a specially designed dance floor pad. This pad serves as a tool for learning the basic steps of the Moravac dance and other authentic folk steps. The dance pad combines music and light panels. Each panel lights up with the appropriate color when the user needs to place their left or right foot on a specific panel, following the rhythm of the music - kolo dance. This dance pad will help users adopt step by step our traditional dance with visual feedback during practice.

The dance floor pad is an innovative product developed during preparations for the First Lego League competition. This mat combines fitness and fun with technology in a unique way. With the potential to become a favorite tool for exercising and learning traditional dances (folk dances), this innovative pad can transform the way people experience physical activity and entertainment. The combination of physical activity, rhythmic skills, and visual stimulation attracts a wide range of users, including people of all ages and fitness levels. Additionally, the opportunities to customize music and difficulty levels make this product accessible and useful for various user groups, even individuals with hearing impairments and color blindness. The primary goal of the dance pad is to preserve cultural heritage and tradition.

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Starting circulation pumps and lighting in thermal substations

Danko Andrijanić, Milica Miladinović*, Nikola Vuletić, Viktor Jeličić, Mihajlo Antić, Branislav Karajović
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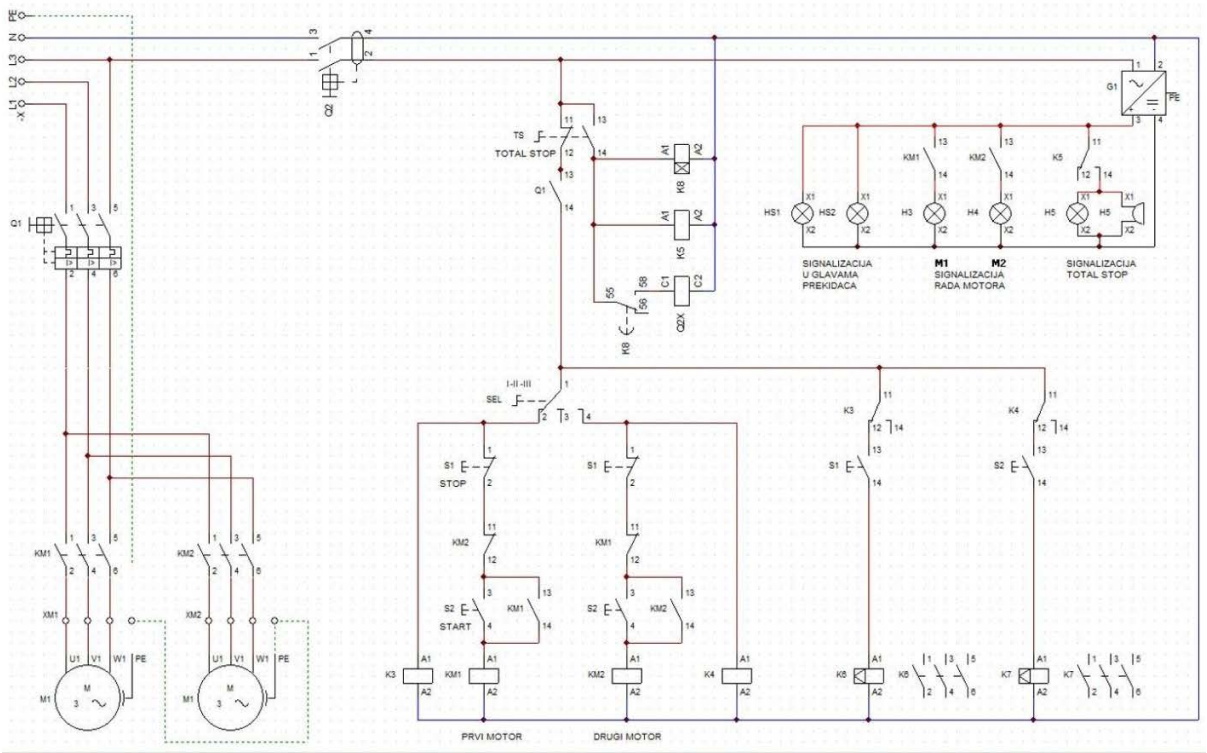
Abstract

Non-typical solutions, starting circulation pumps and lighting in thermal substations.

This paper (electrical cabinet) presents an unusual solution for starting circulation pumps in thermal substations. Only one START/STOP button combination is used to start the main and backup pumps as well as the lighting. Integrated audible and visual signaling of emergency situations, locally and remotely.

Graphical abstract



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Triple Pendulum

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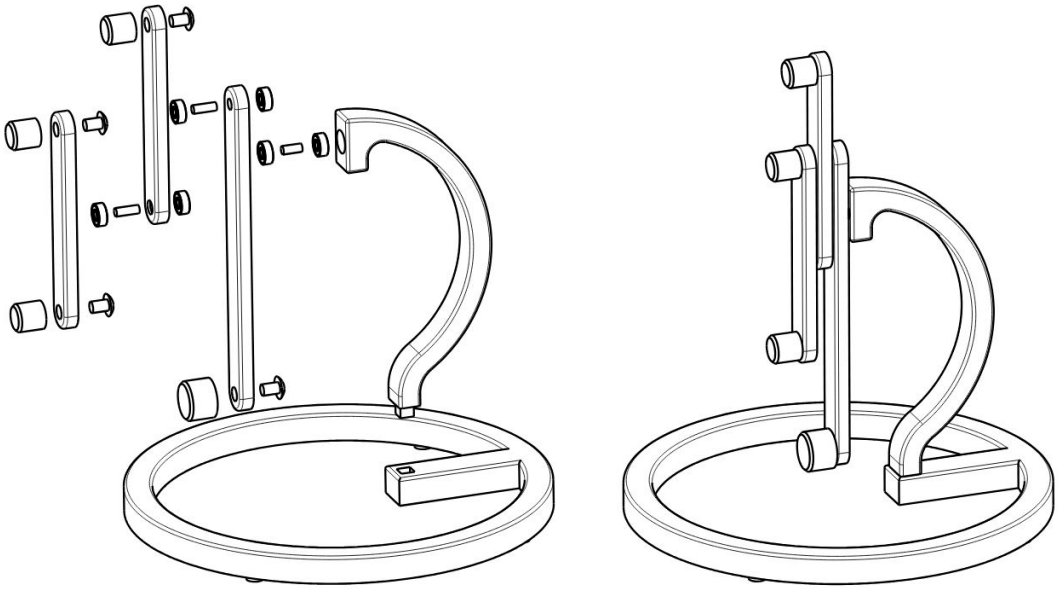
Graphical abstract



Abstract

The research topic is the triple pendulum and the study of its operation and capabilities. First and foremost, it is important to familiarize oneself with the subject of investigation. The triple pendulum is a complex mechanical device consisting of three interconnected rods or strings that have the ability to move freely around their pivot points. When set in motion, each of the rods can move independently of the other two. This system can exhibit extremely complex behavior, including unpredictable oscillations and chaotic movements. Knowing all the aforementioned aspects, it became evident that the construction of such a device would contribute to the clarification of the above-mentioned phenomenon. The studies that led to its construction

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were indeed complex and had to encompass equations of motion, system stability phenomena, knowledge of oscillation theories, material characteristics, etc.

Triple pendulums essentially have various applications, including demonstrations in physics, where one aims to prove that small changes in initial conditions can lead to significant differences in the system's subsequent behavior. Besides that, this pendulum also finds application in art, as well as in robotics, where they are used as models for studying dynamic systems and developing control algorithms. Their complexity makes them challenging but fascinating objects for research and application in various disciplines.

Studying this device not only provides insight into the fundamental principles of mechanics and dynamics but also opens the door to the development of new technologies and innovations in various industrial and academic fields. Given their complexity and interest, triple pendulums remain the subject of interest and research worldwide.

Gyro Turtle

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Abstract

We have studied the design and fabrication of the Gyro Turtle that can be easily deconstructed. Gyro Turtle is a spiral looking wheel that can find wide application in engineering. It can transmit torque and transform translational motion into planar motion, which is crucial for the efficient operation of many systems. For example, in the automotive industry, the same principles are applied in transferring power between the engine and the wheels, allowing the vehicle to move with desired speed and efficiency. Similarly, in the field of mechanical engineering, these principles are essential in the development of metal processing systems, enabling precise rotation of tools for shaping materials. Through the consistent application of these principles, engineers achieve advanced technological solutions that transform the way the modern world operates.

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Wave Automata - Development of a Prototype Solution

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Abstract

In this paper, a prototype solution for "Wave automata" was developed. The dimensions are calculated based on the laws of mathematics and kinematics. The parts are made of plexiglass and wood. Laser cutting and engraving were used to process the material. "Wave automata" consists of a base, back support panel, left and right support, two shafts, handle, and cube cams. This prototype has two rows of cube cams, which are of different lengths. The lengths of the cube cams are 80 mm and 120 mm. Each of the cube cams has a hole with a diameter of 8 mm. The length of the shafts is 250 mm.

"Wave automata" can be used in art and design to generate different patterns and shapes. "Wave automata" open doors to creativity in art through their ability to generate dynamic and fluid shapes. By using these automata, artists can create hypnotic visual effects that continuously transform and evolve. Their application enables the creation of interactive installations that react to the presence of viewers, thus creating a unique spatial experience. Additionally, kinetic wave automata can be utilized to generate complex patterns and textures applicable in digital graphics, textile design, or animation.

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Rotation Kinetic Sculpture - Development of a Prototype Solution

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Abstract

The project called "Rotation kinetic sculpture" represents a type of sculpture in which the rotational movement of the basic element shows the mechanical principles. It consists of a stand made of steel on which a pole is welded, also made of steel to make the sculpture durable. In the middle of the column there is a shaft that is stationary and connects two ball bearings that rotate and are also made of steel. Two rotors are placed on the bearings, which are made of plexiglas by laser cutting, and the bearings enable the rotor to turn.

Our sculpture resembles a windmill, a wind generator due to the appearance and movement of the rotor. Our project is driven by the work of observers. One rotor spin to one side while the other spins in the opposite direction creating the illusion of movement.

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Chaos Pendulum

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Abstract

A chaos pendulum, also known as a pendulum with two points of support, is a dynamic system that illustrates the basic concepts of the chaotic behavior. It consists of two or more connected pendulums that are movable in different dimensions. This interaction generates complex, non-equilibrium oscillations that cannot be predicted in the long run. While the initial movement can be identified, small changes in conditions or position can result in completely different trajectories. The chaos pendulum illustrates the basic idea of chaos in dynamical systems, where small variations in initial conditions can cause large changes in system behavior.

The Chaos Pendulum, known for its unpredictable dynamics, is being explored as a potential source of energy. The concept is based on converting chaotic oscillations into useful energy. This technology has possibilities for use in situations where natural oscillations are present, such as waves or vibrations. The integration of chaos pendulums into devices for the conversion of kinetic energy to electricity can provide an alternative source of energy, especially in remote locations or in conditions where traditional sources are limited. Research on this innovation can contribute to the development of sustainable and efficient systems for generating energy from chaotic processes, promising a new approach in renewable energy sources.

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