AGH

Akademia Górniczo-Hutnicza
im. Stanisława Staszica w Krakowie

Studenckie Koła Naukowe AGH

Book of Abstracts

62nd HKSKN

Conference of the AGH University of Science and Technology

May 8th, 2025

ArcelorMittal Huta Warszawa

OPTO-LAB

MTU Aero Engines

Studenckie Towarzystwo Naukowe Rok zał. 1997

CELSA HUTA OSTROWIEC

HASTAL

ACADEMICA

Struers Ensuring Certainty

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Kraków

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Kerma

Non-Obvious Applications of Eyeglass Lenses: The Use of Lenses in Retrospective Dosimetry

According to data from the World Health Organization (WHO), nearly 2.2 billion people worldwide suffer from visual impairments such as myopia and hyperopia. It is estimated that by 2050, half of the global population will experience vision-related problems [1]. As a result, corrective glasses, classified as medical devices, have become a ubiquitous element of daily life.

The number of applications involving ionizing radiation in various scientific and technological fields is is constantly growing [2]. In accordance with current atomic law regulations, monitoring of radiological exposure levels among individuals present in hazardous zones is mandatory [3]. Such measurements are conducted within the frameworks of both individual and environmental dosimetry. Despite strict supervision, the risk of dosimetry system failure cannot be entirely ruled out, particularly under emergency conditions. Furthermore, radiological incidents may occur in locations where no contamination monitoring systems are installed. To address these problems, retrospective dosimetry has been rapidly developing in recent years, enabling the assessment of absorbed radiation doses through the analysis of thermoluminescent signals emitted by everyday objects [4].

The aim of this study was to evaluate the feasibility of using eyeglass lenses as potential detectors of ionizing radiation in retrospective dosimetry. A total of three mineral and three organic lens types were tested. Initially, residual signals were examined, followed by exposure to ionizing radiation. The lenses were irradiated using X-ray, gamma, and neutron sources. Signal registration and analysis were conducted at the Laboratory of Environmental and Individual Dosimetry, Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, using RA'94 and RA'04 thermoluminescent readers.

The results confirmed the suitability of three organic lens types for retrospective dosimetry applications involving neutron, gamma, and X-ray radiation. Among the mineral lenses, thermoluminescent signals were observed in only one type, after exposure to a dose of 11 Gy using a medical accelerator.

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BioMetr

Analysis of biosignals in augmented reality

The present study conduct a gait biosignals analysis of individuals suffering from Parkinson's disease and healthy subjects to parameterize gait dynamics and analyze the differences between the indicated groups. For this purpose, measurements were carried out using mixed reality goggles equipped with sets of sensors such as: accelerometer, gyroscope, magnetometer. In particular, two sensors were used in this study: an accelerometer and a gyroscope. As part of the work, signals were recorded in 26 healthy people. 14 sick people were registered in cooperation with the Andrzej Frycz Modrzewski Krakow University. To verify the correctness of the recorded results from the mixed reality goggles, the same measurements were performed using a reference device. Signals from the goggles were analyzed using the Python programming language. The study presents methods of signal preprocessing, their parameterization and statistical analysis of the obtained results. Based on the mentioned factors of the experiment, the following parameters were found: average step time, average cadency, time during rotation, speed during rotation, time during sitting, speed during sitting, average rotation time, average rotation speed, number of steps during rotation and number of steps when sitting down. Parameters allowed to the detection of differences in the gait of healthy and sick people.

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Mat4Future

Bioinspired implant from the stem of parsley for peripheral nerve regeneration

Peripheral nerve injuries lead to severe impairments in motor and sensory functions and, in extreme cases, can result in permanent dysfunction. One of the promising approaches in peripheral nerve reconstruction is the use of biomaterial scaffolds developed through tissue engineering. However, designing and manufacturing scaffolds intended for peripheral nerve surgery remains a significant challenge, mainly due to the high structural and functional requirements they must meet. One method that helps avoid some of these issues is the decellularization process, which enables the desired form to be obtained by removing cells from the selected tissue while preserving its extracellular matrix.

The aim of this study was to develop an implant intended for the reconstruction and support of peripheral nerve regeneration using chemically decellularized stems of common parsley. The choice of this plant was based on demonstrated microstructural similarities between the cross-section of plant tissue and that of a peripheral nerve, aligning with the principles of biomimicry. The decellularization process was carried out using less toxic alternatives to traditional chemical reagents, which reduces the risk of cytotoxicity, tissue irritation at the implantation site, and also contributes to environmental protection by minimizing the use of harmful substances.

The obtained scaffolds were analyzed in terms of their microstructure under simulated physiological fluid conditions (in phosphate-buffered saline (PBS) and simulated body fluid (SBF)), physicochemical characterization, and thermal stability, thus assessing their suitability for sterilization—a necessary step in preparing the implant for potential clinical use.

The results allowed the conclusion that the designed and fabricated scaffolds possess a microstructure and macrostructure suitable for peripheral nerve regeneration. Degradation studies indicated that the tested precursors need to undergo prior modification (e.g., surface coating with polyurethane) so that the scaffolds degrade after an appropriate period. Thermal analysis results showed that the implant can be sterilized using low-temperature plasma before being introduced into the body.

Further studies on the samples should be conducted, including investigations after scaffold modifications, such as surface coating with polyurethane.

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Komfort

Environmental Monitoring and Control System for a Reverberation Room Complex

The presentation outlines the design and implementation of a system for monitoring and controlling environmental conditions in the Reverberation Room Complex (ZKP). This laboratory is used for a variety of acoustic measurements in diffuse sound fields, including airborne sound insulation testing, sound absorption coefficient measurements, and sound power level determination of noise sources.

Environmental parameters such as humidity, temperature, and atmospheric pressure are of great importance, as they influence the properties of tested materials. In some cases, it is essential to stabilize or reproduce these conditions to ensure the comparability of measurement results.

The developed system is based on a Raspberry Pi minicomputer connected to BME sensors installed in both the source and receiving rooms. It enables real-time monitoring of environmental parameters and automatic humidity control using relays that activate air humidifiers. The user can set a target humidity value via a touchscreen interface. Tests demonstrated effective humidity increase from 20% to 40%.

The implemented system now serves as a permanent part of the laboratory's infrastructure, contributing to improved repeatability and reliability of acoustic measurements, while offering intuitive operation and potential for further development.

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Artificial Intelligence in Medicine

Automation in Service of Oncology: A 3D Slicer Module for Radiotherapy Plan Verification

Verification of radiotherapy treatment plans is a crucial component in ensuring both patient safety and treatment effectiveness. In response to the need for streamlining and automating this process, the Dosimetry extension has been developed for the 3D Slicer environment. This tool enables semi-automatic calibration of dosimetric films and analysis of radiation dose distribution using optical scans. The module can be utilized in both scientific research and routine quality assurance of treatment plans performed with linear accelerators.

The Dosimetry extension serves as a free, open-source alternative to expensive commercial solutions available on the market. The project is being developed in collaboration with the Świętokrzyskie Oncology Center in Kielce, which has allowed its functionality to be tailored to the real-world needs of clinical professionals.

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Komfort

Transmission of Vibrations in a Reverberation Room System under Acoustic Excitation Conditions

During research on airborne sound insulation in a system of reverberation rooms, unexpected disturbances were observed in the vibration measurement results of the test sample, conducted using a laser vibrometer and harmonic signals. Contrary to the assumptions of the pressure method adopted in standard procedures, the measurements revealed the presence of vibrations in the receiving room, caused by the sound source located in the source room. This phenomenon led to distorted results: instead of remaining stationary relative to the sample, the laser vibrometer itself moved due to vibrations transmitted through the building structure.
To assess the extent of the problem, vibration measurements were conducted along three axes in both the source and receiving rooms for various excitation frequencies and sound source locations. The tests employed both tonal signals and broadband noise. The presentation will discuss the measurement results, identification of dominant frequencies and potential vibration transmission paths, as well as proposed technical solutions aimed at reducing vibration transmission between the rooms. The goal is to improve measurement conditions and ensure compliance of the results with the methodological assumptions.

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Hexa

Modeling of the mechanical properties of trabecular bone fragments

The aim of the study was to determine the Young's moduli of trabecular bone fragments derived from bovine femurs. Trabecular bone is a highly anisotropic structure, which means that its mechanical properties can vary significantly depending on the direction. Based on experimental and microtomographic measurements, and using the finite element method (FEM), the Young's moduli of solid bone tissue and the effective Young's moduli of cubic samples in three orthogonal directions were determined for several samples extracted from the trabecular structure. The same parameters were also calculated using a mathematical averaging model known as the Curnier-Zysset (C-Z) model. The results obtained using both methods were compared with experimental measurements. One of the aims of the study was to evaluate the applicability of the C-Z model to trabecular bone, as well as to expand knowledge about the mechanical properties of this structure.

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AGH Rapid Prototyping

Speaker biometrics for biomedical applications: Extending CNN-based voice recognition to physiological state estimation and assistive technologies

In this study, we build upon a previously developed convolutional neural network (CNN)-based system for speaker recognition using acoustic signals. The primary work focused on classifying individual speakers based on voice spectrograms and MFCC features. This extension introduces additional analysis to explore how voice features can be linked to physiological parameters such as age and potential markers of health status. We propose a refined experimental setup with a larger and more diverse speaker database, including biometric metadata. Furthermore, we discuss the potential of such systems in assistive communication technologies for the elderly or individuals with impaired motor function. Our results suggest that speaker-specific acoustic features may also serve as indicators of physical condition, opening new avenues in biomedical signal processing.

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BIO-LOGIKA

Alternative chitosan sources: extraction and characterization

Chitin can be found in many living organisms, such as insects, crustaceans or fungi. It is the main material from which chitosan, a biopolymer with a wide range of applications, is derived. It can be used in hydrogel wound dressings, bioplastics, food packaging, heavy metal filters and antifungal soil additives. Currently, chitosan is mainly produced from the shells of crustaceans, particularly shrimp.
Its natural sources are much more varied, which prompted us to attempt to obtain chitosan from a variety of materials - besides shrimp, we used the carapaces of mealworms, crickets, grasshoppers, as well as Fomitopsis pinicola. We analyzed the efficiency of the process of producing the biopolymer from these sources and parameters related to the quality of chitosan, such as the degree of deacetylation.

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Nucleus

OncoHydrogel – Intelligent Hydrogel in Cancer Diagnostics

The OncoHydrogel project aims to develop an innovative diagnostic system for early detection of skin cancers using a hydrogel that responds to biological changes in tissue. The research will test various hydrogel matrices, such as sodium alginate, PEGDA, PHEMA, and Gelma, for detecting cancerous skin lesions. The key detection mechanism involves L-Dopy, which reacts with the enzyme tyrosinase present in cancerous cells, causing a color change in the hydrogel. The project will also investigate pH changes within the cancerous tissue, which could serve as an additional diagnostic parameter. Additionally, trials will focus on detecting markers specific to skin melanoma, such as S100 proteins, gp100, and MIA. OncoHydrogel aims to develop a method accessible to a wide range of patients, including the elderly and children, providing fast, stress-free, and effective diagnostics. The visible color change of the hydrogel will offer a simple, non-invasive alternative to traditional methods like biopsies or imaging tests.

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AGH Marines

Sound Source Localization Using TDOA Methods for an Underwater Robot

An Autonomous Underwater Vehicle (AUV) is a multi-module vehicle that enables research exploration of areas inaccessible to humans. Due to the conditions present in dark and deep environments, radio waves are ineffective for determining location, unlike acoustic waves. The foundation of localization systems in AUVs consists of arrays of underwater microphones, which allow the vehicle to position itself relative to other objects in the water column. As part of the project, measurements were conducted in an anechoic chamber to select the method that will be used for measurements in a real water reservoir. The research results, including a comparison of the effectiveness of selected weighting functions for the GCC algorithm, will be applied in the implementation of a real system.

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Akustyki Architektonicznej

Koło Naukowe Akustyki Architektonicznej

ICP Conditioner with Adjustable Gain

One of the most popular standards for powering preamplifiers used with measurement microphones and piezoelectric accelerometers is the IEPE (Integrated Electronics Piezo-Electric) current loop. This standard uses a constant supply current, allowing a single wire to function both as a power supply line for the preamplifier and as the carrier of the signal generated by the microphone or accelerometer.
The goal of the project is to develop a signal conditioner that provides a constant current power supply in compliance with this standard and conditions the received signals to match the specifications of measurement cards. A key design requirement is to implement adjustable gain, which the user will be able to set in predefined discrete steps.

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AGH Eko-Energia

Determining the optimal steering wheel and screen positions in the cockpit of the Perła solar vehicle

The aim of the paper is to conduct an ergonomic analysis of the cockpit of the solar vehicle Perła, designed by the AGH Eko-Energia Scientific Club.
The study will be conducted by the author of the paper.
The paper will present ergonomic assumptions that will enable further development of the project in the area of construction. Measurements will be performed on a 1:1 scale model of the cockpit.
The analysis will consist of a series of measurements with the participation of a research group with various anthropometric parameters (selected).
The ranges of steering wheel and main screen settings will be compared, which will ensure their functional and safe position.
Conclusions will also be presented regarding the introduction of adjustments to elements, taking into account their angle of inclination, height and distance from the edge of the driver's seat.

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mHealth SpaceMed

Smartphone-based intelligent digital stethoscope

As part of the project, a mobile application is being developed that is to provide the ability to listen to one's own heart without using additional devices. Only the microphone built into the phone is used to record sounds. The obtained signal is filtered and processed, after which we obtain parameters regarding the heart's rhythm, such as pulse or rhythm variability. Additionally, the application is to verify whether there are any unwanted sounds, e.g. heart murmurs - for this purpose, AI algorithms will be used, among others. In order to verify such a solution, a series of tests is carried out, in which its results are compared with a simultaneously recorded ECG. Another part of the project is to collect a dataset consisting of anonymous recordings of heart sounds, in order to further verify the solution, as well as to introduce automatic differentiation of correctly performed recordings.

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AGH Marines

Prototype of an Acoustic Communication Protocol for an Underwater Robot

The Autonomous Underwater Vehicle (AUV) serves as a research platform enabling the exploration of environments inaccessible to humans. In conditions of limited visibility and significant depth, traditional communication methods such as electromagnetic waves face numerous limitations. One proposed solution for data exchange in underwater environments is the use of acoustic waves, which offer greater range in water. The aim of this project was to develop an initial communication protocol that enables bidirectional data transmission while taking into account the specific characteristics of the underwater environment, such as signal attenuation, propagation delays, and interference. As part of the work, a prototype of a transceiver module was designed and tested, with its operation based on sound modulation and binary encoding. The results of the conducted tests provide a foundation for further system development and its future implementation in an autonomous underwater vehicle.

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Akustyki Architektonicznej

Koło Naukowe Akustyki Architektonicznej

Acoustic metamaterial with a flexible structure for enhancing sound insulation

Flexible acoustic metamaterials are engineered structures designed to attenuate sound waves through geometry-driven effects, such as local resonances. Unlike traditional rigid metamaterials, flexible variants are made from resilient materials, allowing their use in applications requiring both sound insulation and structural adaptability. Some designs include perforations that enable airflow while maintaining acoustic performance, making them suitable for use in, for example, machine housing. This project focused on developing a numerical model of a single unit cell of an elastic metamaterial using COMSOL Multiphysics. Simulations were carried out to evaluate the structure's transmission loss and to study the influence of different material and geometric parameters on acoustic performance. A prototype of the optimized configuration was then fabricated and tested in an impedance tube according to ASTM E2611-09.

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Mat4Future

An Integrated Approach to Designing a Scaffold for Corneal Regeneration: A Plant-Based Biomaterial Modified with Polyvinyl Alcohol

Modern biomedical engineering increasingly embraces nature-inspired solutions, utilizing biological structures as scaffolds supporting tissue regeneration.
In the field of ophthalmology, one of the main challenges remains the development of biocompatible and biofunctional materials to replace damaged corneal tissue. The aim of this study was to design and evaluate a biomimetic composite scaffold based on a decellularized plant structure modified with a synthetic polymer.
Carrot root was selected for scaffold preparation due to its natural porosity, which morphologically resembles the microstructure of the human cornea. The decellularization process was carried out using reagents such as L-ascorbic acid, NaCl, and $CaCl_2$, allowing effective removal of cellular components without compromising the integrity of the structural materials. The resulting matrix was then impregnated with polyvinyl alcohol (PVA), which enhanced its physicochemical stability and mechanical properties.
Material characterization included microstructural analysis (scanning electron microscopy – SEM), thermal stability assessment (thermogravimetric analysis – TG), and in vitro degradation studies in three different fluids simulating physiological conditions (Phosphate-Buffered Saline – PBS, Simulated Body Fluid – SBF, Simulated Tear Fluid – STF). SEM observations confirmed the presence of a uniform, porous structure. Thermal analysis indicated material stability up to approximately 90°C, exceeding both human body temperature and that
of selected sterilization techniques. The modified degradation tests showed a gradual, controlled mass loss and no significant changes in pH, confirming a mild degradation process and good biocompatibility.
The developed biomaterial combines the microstructural advantages of a natural biological matrix with the functionality of a well-characterized synthetic polymer. The results indicate strong potential for further research toward applications in corneal tissue engineering
as a scaffold for regenerative cell culture.

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BioMetr

Multimodal analysis of human behavior in relation to disease detection

The project: “Multimodal analysis of human behavior in relation to disease detection” presents a novel approach to the use of mixed reality technology and machine learning algorithms in the diagnosis of one of the most common neurodegenerative diseases - Parkinson's disease. Methods were designed and presented to enable integrated analysis of data from different modalities: body movement, voice and eye movement trajectory. Data were collected using Hololens 2 augmented reality glasses and a dedicated DiagNeuro application, enabling the recording of seventeen different diagnostic tasks. Data from dozens of healthy and sick patients were subjected to advanced processing. Analyses were performed using classification algorithms and state-of-the-art boost-based models. In addition, an anomaly detection algorithm was used, which proved to be extremely effective in identifying patients with Parkinson's disease.

The research undertaken and the results indicate the potential of integrating mixed reality and machine learning technologies in medical evaluation. The project is an important contribution to the development of engineering focused on early diagnosis of patients with neurodegenerative diseases.

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Automation and Robotics

Analysis of the radio frequency spectrum utilizing the USB-SA44B spectrum analyzer.

The analysis of the radio frequency spectrum plays a critical role in telecommunications, security systems, and studying the radio frequency environment. The use of spectrum analyzers, such as the USB-SA44B, provides the ability to conduct accurate and detailed spectrum analysis, identify sources of interference, measure signal power levels, and determine the frequency bands in use.

The work explores the processes of collecting and analyzing data from the radio frequency spectrum, identifying signals and interference, measuring signal characteristics, visualizing the results, and evaluating the radio frequency environment.

A series of experiments were conducted to analyze radiation. Research on spectral characteristics conducted with a transceiver antenna and a mobile radio signal generator revealed that improving the transceiver antenna equipment is essential for achieving more precise spectral radiation measurements. This is due to significant differences in the maximum signal values when using a transceiver antenna versus a mobile radio.

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AGH Solar Boat

Implementation and challenges of SLAM algorithms in Autonomous Surface Vehicles

SLAM (Simultaneous Localization and Mapping) algorithms play a crucial role in autonomous navigation, enabling the simultaneous localization of the vehicle and mapping of an unknown environment. In the case of autonomous surface vehicles, implementing SLAM presents a number of specific challenges. These include platform instability caused by wave motion, a limited number of detectable environmental features (e.g., LiDAR, GPS, camera), and sensor data disturbances resulting from atmospheric and hydrodynamic factors. Additionally, signal reflections and the lack of permanent structures in open marine environments make stable position tracking more difficult.

This paper presents a comparison of selected SLAM algorithms in the context of their application on water. Tests were conducted in the Gazebo simulation environment using the ROS2 framework, with various environmental scenarios. The aim of this study is to evaluate the suitability of selected SLAM algorithms for autonomous maritime navigation, identify their limitations, and highlight potential directions for future development.

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AGH Solar Boat

Design and Implementation of Educational Miniature Models of the Solar Boat Celka for the Expo 2025 Osaka Exhibition

The paper presents the design and implementation process of educational miniature models of the solar-powered boat Celka, developed for the Expo 2025 exhibition in Osaka. The project covers both conceptual design and practical aspects – including the selection of components such as the motor and photovoltaic panel, as well as 3D printing and post-processing techniques. Innovative construction solutions, such as using neodymium magnets to attach the parts to the hull, will also be discussed. The presentation will be accompanied by photographs of the models and reference material related to the Expo. Additionally, a remotely controlled version of the boat will be showcased as an extended, interactive variant of the original educational concept.

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Sensor

Predictive Maintenance

As part of the activities of the Sensor Student Research Group, a concept of a predictive maintenance (PdM) system is being developed. Its core is based on real-time monitoring of the technical condition of rotating machinery. The main objective of the project is to design a test stand that enables continuous observation of machine operating parameters and early detection of potential irregularities during operation.
The system includes an accelerometer that records vibration signals generated by an electric motor operating under variable load, simulating real-world working conditions. The collected data is processed by a computing unit built on a Raspberry Pi and visualized in real time using the Grafana platform. This approach enables continuous supervision of the machine's condition and dynamic analysis of the system's behavior. Preliminary observations indicate a clear correlation between load variations and the characteristics of the vibration signal, confirming the potential of the proposed solution as a basis for further work on diagnostic systems. The project offers applications in both educational environments and as a foundation for the development of more advanced solutions within the framework of Industry 4.0.

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Sensor

Noise-Driven Challenges in Feature Selection Strategies for PdM Systems

In industrial environments, vibration signals and other measured quantities are frequently affected by complex and overlapping sources of noise and disturbance. These conditions can significantly impair the reliability of machine learning (ML) models used in predictive maintenance (PdM) systems. This study investigates the robustness of scalar condition indicators derived from both time and frequency domains when exposed to varying levels of noise. To identify features that remain informative despite substantial signal contamination, we apply feature selection techniques, including Random Forest-based methods and L1 regularization. To simulate industrial conditions, we generate multiple noisy datasets by systematically introducing controlled disturbances. The aim of this work is to compare effectiveness of PdM systems operating on diagnostic indicators versus those relying on raw time-series data in the presence of noise. The effectiveness of ML models, is analysed under both clean and noisy conditions, using accuracy score and statistical Friedman Test. By emphasizing the challenges of feature selection in noisy environments, the findings of this study aim to support the development of more robust and noise-tolerant strategies for PdM applications in industrial settings.

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Sensor

Design of a Vibration Sensor Based on MEMS Technology for Diagnostic Applications in Predictive Maintenance (PdM)

The aim of this work is to design a complete vibration sensing system based on MEMS technology, including both the electronic hardware and the software for data acquisition and processing. The developed prototype is intended to provide a low-cost alternative to traditional piezoelectric sensors used in Predictive Maintenance (PdM) systems.

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Creative

Position determination and navigation system for autonomous boat based on heterogeneous data

The main of the project is to design and implement a positioning and navigation system for an autonomous boat by extending an engineering project I have previously completed. The developed solution will allow the boat to navigate autonomously along a route determined in the client application, as well as view the current measurements in real time and collect them for further analysis. One of the main aspects of the project was the creation of an optimal filtering algorithm that guaranteed accurate determination of the current state of the model without the need for high-tech sensors. The implemented algorithm improved the performance of the basic sensors determining the position of the boat in space and provides the basis for the aforementioned main objective of partial autonomy of the boat.
In addition to manual control via a radio controller or client application, the user will have the option of autonomously controlling the boat. Four methods were developed to estimate the state of the model, with the output being the input to the autonomous control algorithm. This allowed the performance of the implemented filtering algorithm to be compared with the other methods. In order to guarantee a modular design, two PCBs were designed and fabricated to integrate all the components of the boat, the microcontroller, the location module and the IMU consisting of the accelerometer, gyroscope and magnetometer. In addition, a design was created and then a 3D printed enclosure for the aforementioned IMU was made to ensure its isolation from the other components. The client application including state estimation methods was written in the Java programming language using the JavaFX framework, and the microcontroller software was implemented in C.

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AGH Avader

Threat detection in a known urban area using a swarm of unmanned aerial vehicles

This paper presents an autonomous drone swarm system developed for the ICUAS'25 UAV Competition. The system is implemented in the Gazebo simulator using the ROS 2 Humble environment, which enables communication among agents within a distributed system. The solution to the task of localizing and identifying an unknown number of hazards or targets in a known urban environment will be showcased, utilizing Bitcraze Crazyflie unmanned aerial vehicles operating in SITL (Software-In-The-Loop) mode via the CrazySim extension. Additionally, a method for communication between drones based on the ROS 2 architecture will be demonstrated, taking into account limitations such as maintaining line-of-sight between units, ensuring continuous connectivity with the base in every configuration, and the limited mission duration.

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Sensor

Design of a multidimensional control system test stand for studying neural controllers

The paper presents the design of a multidimensional control system for testing neural controllers. The project involves constructing a laboratory crane based on the Raspberry Pi platform, including both mechanical and electronic components, as well as developing the control software. The main goal is to develop control methods that allow the trolley to move in such a way as to minimize the oscillations of the cable with a suspended load. The test stand enables the evaluation of various control algorithms, particularly neural controllers, and comparison of their effectiveness with classical solutions. The project provides a practical platform for verifying modern control methods in a laboratory environment.

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AGH Avader

Autonomous Drone with an Intelligent Line Detection System

Line following is a popular challenge among mobile-robotics enthusiasts, where the task is to program a robot to follow a specified path. One example of this type of challenge is the task posed in the MathWorks Minidrone 2025 competition.

The first stage of the competition was conducted in a simulated environment, utilizing image-processing algorithms such as binarization and segmentation to detect the red line and determine its parameters. The developed detection algorithm analyzes selected points laid out along an ellipse extracted from the camera image. Once the red line is identified at those points, the drone's flight parameters are updated, enabling dynamic responses to changing course conditions. At the ellipse points, binarization is applied—by thresholding pixels—to unambiguously distinguish regions of interest (e.g., the start, end, or branches of the line) from the background. Based on the resulting binary image, the system identifies these key points and passes them to the control module, which dynamically corrects the drone's trajectory. Thanks to binarization, control becomes more robust against variable lighting conditions and contrast differences in the environment. Landing-zone detection is performed by counting pixels within the target area and computing the average distance from the centroid to the boundary pixels.

The solution employs PID controllers and the defined image regions of interest, similarly to algorithms used in mobile line-following robots.

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Sensor

Design of a device for scanning underwater surfaces

The aim of the project is to design and build a modern split-beam sonar system that enables three-dimensional imaging of the bottom structures of water reservoirs with high precision. As part of the work to date, the design of load-bearing elements has been developed and manufactured, optimized for physical phenomena such as acoustic wave aliasing, and an acoustic lens has been designed to focus the signal. Advanced tests are currently being conducted on the emission and reception of the ultrasonic signal, using dedicated transducers. The next stage will be the implementation of the acquisition module and the development of data processing algorithms that enable spatial reconstruction and analysis of underwater topography.

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AGH Solar Plane

Evaluation of Open-Source tools for UAV systems in the context of mapping and object recognition

In the rapidly evolving world of autonomous technologies, an increasing number of open-source tools for image analysis and object detection are becoming available. As part of this project, a detailed analysis of existing solutions was conducted to select the most promising and effective ones in the context of developing a system for fixed-wing unmanned aerial vehicles (UAVs). The system's task will be autonomous terrain mapping, identification of selected targets, and precise determination of their coordinates. A wide range of tools was tested in the course of the work, including OpenCV, PIL, and advanced AI models such as YOLO.

The project also initiated the process of preparing dedicated datasets containing aerial images, intended for training advanced machine learning models.

Unlike an approach based on developing everything from scratch, this project focuses on maximizing the use of available, proven technologies and adapting them to specific, demanding applications such as the international Student Unmanned Aerial Systems Competition 2025. It is at this competition that the developed system will undergo a practical evaluation.

The paper presents the results of the conducted technological review, the design decisions made, and the initial stages of system implementation.

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AGH Avader

Object tracking utilizing fusion of vision and thermal imaging implemented in an SoC FPGA using the Vitis AI tool

This paper presents a vision system combining images from a visual and a thermal camera. The calibration process of these cameras is described, along with a system implemented in Python for object detection using the YOLOv3 detector and object tracking using the SORT algorithm. The YOLO convolutional neural network model was trained and tested on the PST900 image dataset. The Vitis AI 2.0 tool was used to implement the detector on an SoC FPGA platform. The vision pipeline was tested on both an eGPU (Nvidia Jetson Xavier NX) and an SoC FPGA (Xilinx Kria KV260). The computation time and detection quality were evaluated. Furthermore, the advantages and disadvantages of both platforms are discussed, along with the complexity level of implementing the vision system.

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AGH Avader

Locating and counting objects using data fusion from unmanned aerial vehicle sensors

This paper presents an object localization system developed for the detection and tracking of apples using an unmanned aerial vehicle (UAV). The system employs sensor data fusion, integrating inputs from a GPS RTK module and onboard sensors, and is implemented on a drone platform equipped with an Nvidia Jetson computing unit to enable real-time processing. Advanced object detection and tracking methods are applied, including YOLO (versions v8 and v11), SORT, Deep-SORT, as well as single-object (SOT) and multi-object tracking (MOT) techniques. The system was developed in the Robot Operating System (ROS) environment using Python and C++, and adapted to the UAV hardware, incorporating the Pixhawk The Cube Orange flight controller and custom communication schemes. The paper also presents performance evaluations and test results of different tracking approaches, including OpenCV Tracker, MOT Tracker, and SOT Tracker with GPS integration.

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AGH Drone Engineering

Transport and Deployment System for Autonomous Unmanned Aerial Vehicles

The aim of this paper is to present a system for the autonomous operation of unmanned aerial vehicles functioning as a drone swarm, transported by a larger carrier drone. During the flight, individual autonomous drones are released and begin executing their assigned tasks. After deployment, the carrier drone continues to carry out its own mission. We present a case study in which we achieved high effectiveness with our developed system, as well as outline future development perspectives for this technology.

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Elektrotermia

Analysis of control systems design using model based approach

Microcontrollers play a key role in many areas of engineering, serving as the foundation of modern control systems. Their growing popularity drives the development of advanced programming tools that enable the efficient creation and implementation of a wide range of applications. This paper describes and compares two popular development environments that support programming of the STM32 microcontroller: STM32CubeIDE and Matlab Simulink with the “Embedded Coder Support for STMicroelectronics STM32 Microprocessors” add-on. The STM32CubeIDE environment represents a traditional, text-based approach widely used in software engineering. Simulink Embedded Coder, on the other hand, utilizes a visual methodology based on Model-Based Design, which is gaining increasing recognition in projects involving advanced control systems. The paper presents the implementation process of an inverted pendulum control system using the Embedded Coder package and compares it with the traditional approach.

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AGH Avader

Perception and control system for a transport drone

This paper presents a perception and control system for a transport drone, which tackles GNSS-denied environments. The topic was inspired by one of the Droniada competitions, in which the AVADER students research group is participating this year. Basic perception sensors of drones, such as the IMU, magnetometer and pressure sensor, were extended by an RGB camera. Its image was processed by vision algorithms. Their purpose was to extract data necessary for positioning based on detected objects from the competition map. The position estimation problem was solved using the Perspective-n-Points (PnP) based method. The simulation evaluation of the implemented perception module showed its high effectiveness. Furthermore, the system achieved sufficient results, which proved designed drone system accuracy.

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AGH Focus

"Advanced Remote Management System for Industrial Robots"

The paper will present a system that allows remote control of industrial robots in a safe and efficient manner, without the need for the physical presence of an operator. A key element of the solution is the use of digital twin technology, ultimately allowing simulation and analysis of robot operation in a virtual environment.
The implementation of the system is based on the use of a web application, designed for mobile devices, which provides users with an intuitive tool for managing and monitoring the work of robots. The system will enable real-time analysis of the workspace, which will translate into greater control and safety of operations.
Potential applications for the solution include a wide range of fields, such as education, industry and scientific research. The system can be used, among others, in technical universities to teach programming and operation of robots, in industrial plants - to remotely supervise and optimize production processes, and in research laboratories - to test innovative technological solutions.

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Efficiency of Lambda Functions in C++: Data Processing and Performance Analysis

This paper explores the application of lambda functions in C++ as a method of optimizing data processing performance. Using sorting algorithms and financial calculations as test cases, we compare lambda-based implementations with traditional approaches. The experiments involve sorting a dataset of product prices using a recursive QuickSort algorithm and calculating interest for bank accounts. Execution time was measured for various data sizes. The results show that lambda functions improve performance in sorting tasks, particularly with large datasets, but may be less efficient for floating-point mathematical operations. Overall, the study highlights when and how lambda functions can contribute to code readability, maintainability, and computational efficiency. The findings support selective usage of lambda expressions in high-performance applications.

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PP-32

Bioinspired Soft Robotic gripper with Logarithmic Spiral Architecture for Adaptive Multiscale Manipulation

This project introduces a robotic system inspired by the logarithmic spiral, a natural design pattern found in various biological structures. By integrating bioinspired principles with advanced fabrication techniques such as 3D printing and cable-actuation mechanisms, the system demonstrates versatile grasping capabilities across different scales. The design leverages the simplicity and cost-effectiveness of the manufacturing process while ensuring robust performance and adaptive handling of objects with varied sizes, shapes, and weights.

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Automation and Robotics

Smart gripper for manipulator

Modern robotics requires precise adaptation to various objects, especially in tasks involving controlled gripping force. The integration of pressure sensors and intelligent algorithms enables the development of advanced manipulators capable of handling delicate and heavy items with equal reliability.

The smart gripper for robotic manipulators, based on the ESP32 microcontroller, ensures accurate and adaptive object handling using FSR402 force-sensitive resistors. By analyzing real-time sensor data, the system dynamically adjusts gripping force to prevent damage to fragile items while maintaining a secure hold on heavier objects. Bluetooth connectivity allows for remote control and monitoring, improving operational flexibility. Built on the ESP-IDF framework, the solution optimizes hardware efficiency while offering scalability and seamless integration with broader robotic and automation systems. This makes the gripper a versatile tool for robotics research, industrial applications, and advanced manufacturing.

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Automation and Robotics

3D MODELING, MANUFACTURING AND CONTROL OF UAV

Modern warfare demands rapid and cost-effective production of unmanned aerial vehicles (UAVs), especially in Ukraine. The integration of 3D modeling in CAD systems with CNC manufacturing technologies enables the fast development of high-quality, low-cost UAVs. This approach allows quick prototyping, easy design modifications, and full local production, minimizing logistics costs. The use of composite materials such as Airex-based structures and carbon fiber ensures lightweight, durable airframes. Practical application has demonstrated success, with an F-15-based UAV achieving a weight of only 2.4 kg while maintaining flight stability and maneuverability. Additionally, OpenCV-based laser targeting systems enhance operational accuracy. Combining modern design, manufacturing methods, and innovative materials creates an optimal solution for efficient, scalable UAV production under the urgent needs of national defense.

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RedoX

Adsorption of pharmaceuticals on the surface of microplastics

Pharmaceuticals and their metabolites are an increasingly serious source of environmental pollution, especially in aquatic and soil ecosystems. Their presence is the result of the increasing use of drugs by humans and animals, as well as the fact that the sewage treatment system is often insufficient. In recent years, increasing attention has been paid to the role of microplastics as a carrier of biologically active substances, including drugs. Microplastics, due to their porous structure and adsorption properties, can bind pharmaceutical compounds, changing their mobility, durability and toxicity in the environment. An example of a substance that can be sorpted on microplastics is lamotrigine - an antiepileptic drug that is sometimes detected in sewage and aquatic environments. This paper aims to discuss the potential threats associated with the presence of pharmaceuticals in the environment and the interaction of these substances with microplastics, as well as to emphasize the need to counteract their negative effects.

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Zgarek

ZGAREK
AGH Koło Naukowe

Electrolytic copper plating as an additive manufacturing technology combined with 3D printing.

Electrolytic copper plating technology is widely used in industry for the production of printed circuit boards (PCBs). Due to the large scale of industrial production and the limited interest in the technology for small-scale or individual manufacturing, there are few commercial solutions available for personal use. However, thanks to its additive nature and the ability to control copper deposition to achieve directional growth, the technology is well-suited for small-scale manufacturing of parts with complex geometries using 3D printing.

The combination of 3D printing and electrophoretic copper deposition offers the potential to produce mechanically durable and geometrically complex components that are difficult to manufacture using CNC machines.

The first part of this work will cover the topic of electroplating non-metallic surfaces with copper, including the setup and construction of the workstation, as well as the electroplating process. The second part will present a hypothetical application of electrolytic copper plating as an additive manufacturing method for creating complex copper components based on a 3D-printed skeleton.

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Hydrogenium

Development of new Mn-based double perovskites Sm0.9Ba0.9Mn1.8-xFex(Ni/Co)0.2O6−δ with in situ exsolved nanocatalysts for Solid Oxide Cells

World energy management is mainly based on traditional fuel sources such as coal and gas. However, with their rapid depletion and the introduction of regulations limiting greenhouse gas emissions, maintaining a high standard of living will be impossible without developing renewable energy sources. Technologies like symmetrical Solid Oxide Cells (s-SOCs) offer a potential solution to this issue. s-SOCs are efficient electrochemical devices capable of storing and converting energy depending on demand. However, electrode materials for s-SOCs must fulfil several requirements, including high catalytic activity for hydrogen oxidation and oxygen reduction, as well as structural stability in both hydrogen and oxygen atmospheres in operating temperature (600 — 800 °C).

In this work, perovskites Sm0.9Ba0.9Mn1.8-xFex(Ni/Co)0.2O6-δ with in situ exsolved nanocatalysts were developed as potential electrode materials. Electrospinning was used to fabricate nanofiber electrodes with enhanced catalytic activity and porosity. X-ray diffraction, electron microscopy, and dilatometry were applied for the preliminary evaluation of the materials.

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CarbON

Rosa pulchra est, synthesis of carbon nanodots from rose petals

In this work, the rose, a symbol of beauty for centuries, has been used as a natural raw material to obtain modern nanomaterials. Carbon nanodots (CNDs) are a new class of fluorescent nanomaterials with applications in sensors, electronics and modern energy technologies. CNDs were synthesised using two methods: microwave and hydrothermal, under mild temperature-pressure conditions and without the use of toxic reagents.

The materials obtained were characterised by UV-Vis spectroscopy, confirming the presence of characteristic absorption bands related to the optical properties of the nanodots.

The use of plant biomass highlights the potential of green chemistry to create advanced materials in an environmentally friendly manner. The CNDs exhibit intense fluorescence and favourable physicochemical properties, which may predispose them to future applications in optoelectronics, diagnostics and energy technologies.

Acknowledgements

The research was carried out within the framework of the 'Initiative of Excellence - Research University' (IDUB) programme, Action D12, Edition V 2024/25, proposal no. 12607.

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Inspired Science (InScience)

Synthesis of XY-type catalysts based on platinum group metals in a microreactor flow

Synthesis of XY-type catalysts based on platinum group metals in a flow microreactor. This innovative continuous synthesis method ensures precise control over reaction conditions, which is crucial for obtaining nanoparticles with desired properties. The morphological and structural characterization of the obtained materials was performed using advanced analytical techniques such as UV-Vis spectroscopy, transmission electron microscopy (TEM), and X-ray diffraction (XRD). UV-Vis analysis confirmed the presence of noble metal nanoparticles, TEM revealed their size and dispersion on the support, and XRD provided information about the crystal structure. The catalytic tests were carried out to evaluate the activity and selectivity of the obtained catalysts in a selected model reaction, demonstrating the potential of flow microreactors in the efficient production of advanced catalytic materials.

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CarbON

The influence of applying materials with a negative thermal expansion coefficient on the improvement of electrochemical parameters of a solid oxide fuel cell

Solid oxide fuel cells (SOFCs) represent a key technology in supporting the development of low-emission energy systems, particularly in the context of the transition towards a hydrogen-based economy. However, their commercial application is limited by material degradation caused by the mismatch of thermal expansion coefficients (TEC) between the cathode and electrolyte layers, leading to internal stresses and structural cracking. To improve thermomechanical compatibility, composite cathodes were developed with the addition of negative thermal expansion (NTE) materials, synthesized using the sol-gel method, with the general formula Sm_1-x A_x MnO_3-δ (where A = Zn, Cu, Fe, Co; x < 0.2). The main cathode material was a double perovskite, SmBa_0.5 Sr_0.5 CoCuO_5+δ, offering high electronic and ionic conductivity. The use of composite cathodes in SOFCs reduced polarization resistance to 1.4 Ω·cm^2 (800 °C) and enabled a power density of 680 mW/cm^2 (850 °C), demonstrating improved electrochemical performance, thermomechanical compatibility, and long-term stability, which supports the development of low-emission fuel cell technologies.

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Era Inżyniera

Influence of oral hygiene in the corrosion resistance of 3D-printed Co-Cr dental prostheses

The development of the prosthetic sector creates opportunities for the reconstruction of the patient's stomatognathic system. Such dental-prosthetic assistance not only improves functionality, but also aesthetics, with an unequivocal increase in the quality of life of patients. The task of prosthetic technicians is to properly fit prosthetic components so that they are functional, do not interfere with basic activities such as chewing or speaking, and do not cause undesirable reactions with oral tissues. In recent years, as a result of advances in technology and digitalization, 3D printing techniques using Co-Cr alloy powders have become increasingly popular. One such method is Direct Metal Laser Sintering (DMLS) selective powder remelting, which allows the fabrication of complex parts while maintaining high accuracy and favorable metallic material properties. The purpose of this in-house research was to analyze the effect of a variable corrosion medium on the properties of CoCr alloy with W and Mo micro-additives produced by the incremental DMLS method. Corrosion tests were conducted in various physiological solutions - from artificial saliva to solutions simulating the oral environment, also taking into account elements related to oral hygiene (Eludril Care and Classic liquid). In-house studies were supplemented with microscopic observations using light microscopy and scanning electron microscopy.

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Nucleus

Possibilities of using Cu2Se as thermoelectric material in air atmosphere

Copper(I) selenide is a promising thermoelectric material that can be used in thermoelectric generators (TEG) in purpose of converting heat energy into electric energy. The best transport properties of this material are observed in 400-700°C. However, in those temperatures Cu2Se oxidizes which worsens its transport properties and lowers efficiency of energy conversion. The aim of this work is to determine the behaviour and stability of Cu2Se at temperatures above 400°C in air atmosphere. Diffraction studies (XRD) were conducted in order to determine phase composition of oxidation's products. SEM-EDS analysis was used to determine chemical composition of the resulting scale. Thermogravimetric studies in 300-700°C showed in which temperatures rapid degradation of Cu2Se begins. Thermal analysis TPO was also conducted in order to define in which temperature oxidation begins.

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Hydrogenium

Prussian white analogues as cathode materials for Na-ion cells

The progressive development of portable electronics over the past decades, the growth of the electric car market and the need for stable and reliable energy storages results in a growing demand for Li-ion cells. However, Li-ion cells, despite having many advantages, have some serious drawbacks: the low availability of lithium and the associated high price of lithium have prompted the search for alternatives to Li-ion cells [1].

Increased growth of interest for Li-ion cell alternatives is being observed. Alternatives, such as Na-ion cells, whose working mechanism is similar to that of Li-ion cells and which, compared to Li-ion cells, have a much lower price and greater availability of raw materials for production [2].

One of the most promising groups of materials are those with a regular or rhombohedral structure, including in particular Prussian Blue (PB) and Prussian White (PW). These materials are of particular interest due to their high operating voltages, theoretical capacity, lack of heavy metal content and wide, three-dimensional diffusion channels, enabling efficient and long-lasting cell operation [3].

This paper presents the results of a study on Prussian white structured materials. A method developed in our Team to synthesise a material with a composition similar to Na2Fe[Fe(CN)6] is presented. The crystallographic structure and morphology of the materials obtained were analysed, as well as their chemical composition (Raman, FTIR and ICP spectroscopy). In addition, measurements of capacity and transport properties were studied in cells constructed from obtained material.

Bibliography:

[1] M. A. Yanuar, Jongsik Kim, Carbon 149 (2019) 483-491 https://doi.org/10.1016/j.carbon.2019.04.081

[2] G. Wazny et al., Energy Technol. 2023, 2300139, https://doi.org/10.1002/ente.202300139

[3] X. Liu et al., Adv. Energy Mater. 2022, 2202532, https://doi.org/10.1002/aenm.202202532

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Mechaniki Stosowanej "SIMCAD"

Introduction to the study of the impact of atmospheric conditions on the mechanical properties of composites

The presentation will outline the plan and preliminary results of comparative studies on epoxy-glass laminates used in the aerospace industry. The aim of the research is to analyze and evaluate the mechanical properties of composites produced using three different types of epoxy resins, with particular emphasis on the impact of prolonged exposure to atmospheric conditions. The research is conducted in three stages: immediately after the samples are produced and after 10% and 20% of the expected service life has elapsed.

The technology for sample preparation will be described, with particular emphasis on the technological difficulties encountered during lamination and cutting. The results of mechanical properties tests, including bending and tensile tests, conducted on samples immediately after their production, will be presented.

In the following section, the research plan related to the impact of atmospheric conditions on mechanical properties will be presented. Preparation for the research included an analysis of the atmospheric conditions in which the material operates and the degradation of glass fiber-reinforced composite materials resulting from the effects of individual environmental interactions. Based on the model scenario of the airframe's operation and the available meteorological data, a plan for accelerated aging of the samples was prepared. This procedure involves the cyclical interaction of temperature, ultraviolet radiation, and increased relative humidity, aiming to replicate real operational conditions.

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AGH Eko-Energia

Comparison of properties and enviromental impact of bazalt and carbon fibers.

The paper will present the properties of carbon fiber-based composites and their wide application in modern industry, including aerospace, automotive, and high-performance sports. The methods of manufacturing and disposal of carbon fiber laminates will also be discussed, along with their impact on the natural environment and climate—particularly due to the high energy consumption during production and the challenges associated with recycling these materials. In the following part, an alternative in the form of basalt fibers will be introduced, which are getting popular as a more environmentally friendly option. The factors contributing to their lower environmental impact, such as reduced CO_2 emissions during production and greater biodegradability, will be explained. The mechanical properties of basalt fibers will also be presented and compared with those of carbon fibers, along with examples of potential applications in solar car PERŁA.

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RedoX

Theory of the adsorption and desorption processes

Adsorption and desorption are processes used in many areas of chemical engineering and environmental protection, including substance recovery technology and separation processes. The aim of the paper is to present and discuss the physiochemical mechanisms concerning these phenomena and their industrial applications. Moreover, in this paper, different types of adsorption (physical and chemical) were compared and factors influencing the efficiency of the process, such as temperature, pressure, type of adsorbent and properties of the adsorbed component was presented. What is more, the importance of the desorption process, as a reverse process to adsorption, enabling the regeneration of adsorption materials and the recovery of adsorbed substances, was emphasized. Desorption methods, including thermal, vacuum and chemical, as well as their importance in the context of the efficiency and economics of sorption processes used on an industrial scale were also presented in this paper.

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CarbON

In vivo Synthesis of Metal–Organic Frameworks (MOFs) in Plants

Metal-organic frameworks (MOFs) are crystalline materials characterized by an ordered structure, high degree of functionalization and selective sorption capabilities. Integration of MOFs with plants in vivo enables the creation of functional biohybrids, opening new perspectives in the field of pathogen detection, nitrogen fixation and CO2 capture. The aim of the work was to synthesize MOF HKUST-1 directly in plant conducting tissues (e.g. celery) and to evaluate the sorption properties of the obtained materials. The synthesis was carried out by incubating plant fragments in precursor solutions, using natural transport processes in the plant. After the process was completed, the samples were dried and freeze-dried, and then powdered. The obtained material was characterized by X-ray diffraction (XRD) and analysis of CO2 adsorption isotherms. The results confirm the effectiveness of MOF synthesis in vivo in plants and their potential in gas capture and development of modern and functional biomaterials.

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Hexa

Application of Metal Nanomaterials in Surface Engineering of Passive Radiation Detectors

The study presented the application of passive thermoluminescent detectors (TLD) in ionizing radiation dosimetry, with surface modified using nanoparticles and nanolayers of metals. MCP-N detectors (lithium fluoride doped with magnesium, copper, and phosphorus) were utilized, onto which silver (Ag) and titanium dioxide (TiO2) nanoparticles were deposited using the wet deposition method, and thin layers of copper (Cu) and silver (Ag) were applied using magnetron sputtering. The quality of the magnetron-deposited layers was analyzed using atomic force microscopy (AFM). Thermoluminescent analyses showed that Cu and Ag reduce the sensitivity of the detectors, while TiO2 provides responses comparable to the control. The obtained results suggest that the deposition technique significantly affects the sensitivity of the detectors, which may serve as a basis for further research on optimizing their parameters and exploring the application of other types of nanocoatings.

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Laboratorium Twórczości

Laboratorium Twórczości

Innovative nanostructure-based composite materials for industrial applications – synthesis, properties, and development prospects

This presentation discusses innovative composite materials based on nanostructures, which are increasingly important in industrial applications. The synthesis methods of nanocomposites, including chemical, physical, and mechanical techniques, are reviewed, emphasizing control over particle size, distribution, and interfacial interactions. The unique properties of these materials, such as high mechanical strength, lightweight nature, corrosion resistance, and excellent thermal and electrical conductivity, are highlighted. Their potential applications span various industries, from automotive to electronics and medicine. Challenges related to scalability, production costs, and material stability are also addressed. The presentation explores future development prospects of nanocomposites, emphasizing their potential to revolutionize industries by offering enhanced performance and multifunctionality. Overall, nanostructure-based composite materials represent a promising frontier in material science, with significant implications for sustainable and advanced technological solutions.

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Hefajstos

Anodic oxidation of titanium as a method for controlled surface modification using electrochemical phenomena

The aim of this study was to analyse the parameters of the electrochemical process of anodising titanium in the context of obtaining oxide coatings with high colour intensity and increased corrosion resistance. The anodising process was carried out in an electrochemical system in which titanium acted as an anode and a TiO_2 oxide layer was formed on its surface as a result of controlled electrochemical oxidation. The influence of technological variables such as the type and concentration of electrolyte, voltage value and current, thickness and colour of the layers obtained were analysed. The functional properties of the coatings were also evaluated, with particular emphasis on their resistance to electrochemical corrosion in solutions simulating a physiological environment. Recycled titanium components were used as substrates, adding an environmentally sustainable dimension to the process. The results obtained indicate the possibility of precise control of the properties of the anodic layers through the selection of appropriate process parameters, which may find applications in biomaterials and surface engineering, among others.

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Udział w grancie „Zastosowanie inżynierii defektów i inżynierii stanów elektronowych w opracowaniu analogów błękitu pruskiego, materiału katodowego dla nowej generacji ogniw Na-ion o wysokiej gęstości energii i bezpieczeństwie użytkowania"

development of alternatywę small-scalę energy storage systemy Prussian blue

Prussian blue, originally known as a pigment, has recently gained attention from researchers as a promising material for energy storage applications. Its open framework structure, based on transition metal hexacyanoferrates, allows for rapid insertion and extraction of ions, making it an attractive cathode material for sodium-ion and potassium-ion batteries. Compared to conventional lithium-ion batteries, these technologies offer greater resource availability and lower production costs. Studies have shown that by modifying the structure of Prussian blue—such as through defect control or doping—its capacity, cycling stability, and ionic conductivity can be significantly improved. Developing such solutions could lead to the creation of low-cost, eco-friendly, and efficient energy storage systems, particularly suitable for local. As a result, Prussian blue emerges as a promising alternative to traditional battery materials, paving the way for more sustainable energy technologies.

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Indygo

Synthesis and hydrothermal stability od metal-organic framework HKUST-1 modified with Fe(III), Ce(III) and Ni(II) ions

MOFs (metal-organic frameworks), are class of a crystalline materials composed of metal clusters and organic ligands acting as so-called “bridges” connecting these clusters with each other via coordination bonds. MOFs have found many applications, such as: gas adsorption, heterogeneous catalysis, or drug delivery systems. HKUST-1 (Hong Kong University of Science and Technology-1) is a common MOF structure, composed of copper(II) ions connected with an organic linker - 1,3,5-benzenetricarboxylic acid (H_3BTC). It is characterized by a large specific surface area (>1000m^2·g−1) and pores with a diameter of about 0.9nm. HKUST-1, due to its high hydrophilicity, is unstable in water, which limits its use as an adsorbent. After only 2 weeks of water exposure, its structure undergoes irreversible changes.
In the conducted studies, the HKUST-1 type MOF was modified with Fe(III), cerium Ce(III) and Ni(II) ions at the stage of solvothermal synthesis. The stability of the HKUST-1 crystalline structure was studied after 7 and 14 days of exposure to water, by means of XRD analysis.

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AGH Space Systems

Design of a bioreactor to study the effects of microgravity on bone tissue on the International Space Station

GraviTE (Gravity-free Tissue Engineering) is a project aimed at designing a bioreactor for studying cell cultures on the ISS and exploring the effects of microgravity on a bone tissue model. The bioreactor's role is to sustain an in vitro cell culture, which includes automatically exchanging medium in the cell culture chambers with the use of peristaltic pumps, valves and tubing, and maintaining the temperature at 37 °C using the electronic heating system. Bone tissue model consists of MG-63 cells seeded on a porous polymeric scaffold. By directly comparing Earth's gravity, real microgravity, and microgravity simulated on Earth, the project seeks to validate the use of microgravity-simulating devices and contribute to the standardization of tissue microgravity research. The project was recommended for a flight to the ISS as the laureate of the Direction: Space contest.

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AGH Space Systems

AGH Space Systems Rocket Software - Mission Control Infrastructure: Overview and system architecture

AGH Space Systems Rocket Mission Control Infrastructure is currently undergoing comprehensive transformation. One of key development directions is to increase the performance of core internal libraries used by our team, through a gradual rewriting of python modules in Rust programming language.
In addition, our team is expanding the infrastructure with new tools, including an introduction of custom communication proxy server built with Rust and Tokio, serving as a centralized point of communication management between software and rocket hardware.
Moreover, we are introducing a new mission control solution built using web technologies, making use of the knowledge we have gained throughout years of work.
The presentation will provide an overview of functionalities and describe the system architecture of our Rocket Mission Control Infrastructure.

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AGH Space Systems

Smart battery project with custom battery management system and wireless telemetry

During the presentation, the design of new intelligent batteries for powering the projects developed by the Planetary Rover team of AGH Space Systems will be presented. The project was developed in response to specific problems and limitations identified in the existing solution, such as lack of monitoring of operating parameters, difficult diagnostics, and limited protection mechanisms. The talk will present the design assumptions and architecture of the custom battery management system (BMS), which allows continuous monitoring of voltage, current, temperature, number of cycles worked, and cell state of charge. Special emphasis will be placed on reliability and safety aspects, which are critical in the context of mobile system operation in field conditions. The integration of Bluetooth Low Energy wireless communication will also be explored, enabling remote access to diagnostic data and streamlining the testing and operation process.

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Nucleus

Bio Print Life – Printing Life in Space

The BioPrint Life project aimed to develop two types of hydrogels—one based on sodium alginate and the other on GelMA (methacrylated gelatin). These materials were used to test bioprinting with Escherichia coli and Staphylococcus aureus bacteria. Experiments confirmed the feasibility of successfully printing three-dimensional structures containing living bacteria, as well as the potential of this technology for creating biological materials, including tissue printing.

In the context of space exploration, bioprinting could be applied to the production of biomaterials, fertilizers for space farming, and drug synthesis. The ability to print tissues in space conditions could support astronaut medical treatment during long-term missions. Additionally, bacteria could be utilized for waste biodegradation and the creation of self-healing structures, potentially increasing the durability of space habitats. The development of this technology could play a key role in the future colonization of the Moon and Mars, although further research is needed on the stability of these processes in microgravity and the effects of cosmic radiation on living cells.

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AGH Space Systems

Development of electric drive controllers and their implementation in the Kalman planetary rover

The paper presents the development process of electric drive controllers and their implementation in the planetary rover Kalman – a mobile robotic platform designed for extraterrestrial terrain exploration.
The architecture of the control system for both DC (direct current) and BLDC (brushless direct current) motors, used in the rover's drivetrain and manipulator, is discussed.
The development of the system was carried out iteratively, allowing for systematic improvement of both hardware and software solutions.
The paper outlines the evolution of the approach to the design and integration of controllers as the rover's construction progressed, along with the increasing demands for precision and reliability.
Special attention is given to practical aspects and the experience gained, which may be valuable for similar projects in the fields of mobile robotics and embedded systems.

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Wydział Zarządzania

AGH Lunar Technologies

Project management based on the space industry standards

Today's reality is characterised by the dynamics of change and high risk levels, which can be challenging for managers responsible for project management processes. The distinguishing factor of the space technology field, on the other hand, is the high degree of innovation combined with the need to implement management processes in a particularly coordinated and standardised manner at the same time. Taking these aspects into consideration, the space industry can be a valuable reference point and a source of inspiration for other market sectors. This lecture aims to introduce good project management practices used by global leaders in the space industry, as well as specific project management standards, such as the ECSS used by the European Space Agency (ESA), or the National Aeronautics and Space Administration's (NASA) procedures. The presentation will also cover the practical aspect of space project management on the example of the management scheme of the student's organization AGH Lunar-Technologies, implementing the first Polish lunar mission 'Lunaris'.

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AGH Space Systems

Temperature Controller as a Component of the KALMAN Rover's Mobile Laboratory

The presentation focuses on the development of a temperature controller used in the KALMAN rover's mobile laboratory, built by AGH Space Systems. The system is responsible for controlling the temperature in cuvettes containing chemical samples. The key functions of the controller, its integration with the rover's other systems, as well as the device's design and testing process, will be discussed

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AGH Lunar Technologies

Opportunities and Challenges in the Exploitation of Resources from Asteroids, the Moon, and Mars

The aim of this paper is to present the current state of knowledge and development prospects of space mining as a key component of future exploration and commercialization of outer space. In the face of increasing demand for natural resources and the limitations associated with their availability on Earth, extracting raw materials from asteroids, the Moon, and Mars emerges as a significant alternative for ensuring long-term technological and economic progress.

The paper discusses methods for identifying and exploiting deposits on celestial bodies, such as asteroid capture, surface and subsurface mining, as well as the use of advanced robots like LEMUR for exploring hard-to-reach terrains. It also presents potential applications of the extracted materials — ranging from fuel production and construction components to supporting planetary colonization and building an interplanetary trade system.

Space mining involves numerous technological challenges that currently prevent the economical utilization of extraterrestrial deposits. However, the advancement of space technologies may lead to a breakthrough in the use of natural resources.

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AGH Lunar Technologies

Vacuum test bench for simulating selected lunar conditions.

As part of the activities of the AGH Lunar Technologies, a test rig equipped with a vacuum chamber for achieving high vacuum was developed and built by members of our student club, including the control electronics. A liquid nitrogen cooling system, intended to support the high vacuum generation process, is currently under development.

The aim of the paper is to present the bench and its potential applications in research related to the lunar surface environment. Particular attention has been given to the potential for investigating issues such as the outgassing phenomenon, the behaviour of regolith in vacuum, mechanical friction in non-atmospheric conditions and heat transfer processes with limited convection. The work resulted in a comprehensive experimental platform dedicated to the simulation of the lunar environment for future scientific research.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

Calculation of surface strength of bushing and support insulators using 3D electromagnetic simulations. Method verification and comparative analysis with test results.

The work will present a method for calculating the inception voltage of surface discharges. Electromagnetic simulation of two insulator models will be performed. The insulator models will be modeled as 3D geometries, representing real objects. Based on the electric field distribution, the effective air ionization coefficient and the streamer constant, the streamer criterion formula will be determined. The results will be compared with laboratory tests for different lengths of insulators and different atmospheric pressures.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

The influence of temperature on the application of the reflectometric method for locating faults in power cables.

The report concerns the reflectometric method used for locating faults in cables. This method is based on the analysis of signals reflected from discontinuities in the cable, which allows for determining the location of the fault. The principle of operation of this technique is discussed, along with the types of detectable defects and the influence of temperature on the propagation speed of voltage impulses, which affects the accuracy of fault location. The impact of temperature on the relative permittivity of XLPE (cross-linked polyethylene) is also presented. A comparison of the accuracy of fault location using various portable reflectometers is included.

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Maszyn i Napędów Elektrycznych proMOTOR

Construction of a prototype of a high-speed switched reluctance motor (SRM) and an asymmetric bridge converter for powering the motor

The paper will present a theoretical design of a high-speed switched reluctance motor (SRM), based on which a physical prototype is currently being built. The paper will be divided into two main parts: a theoretical part and a simulation part. The theoretical part will discuss the operating principle of the SRM motor and the asymmetric bridge converter used to power the motor. The simulation part will present simulation results obtained using the finite element method (FEM) in Ansys Maxwell software. As a result of the FEM simulation, an average torque map was obtained, based on which the optimization process of the motor by the phase current turn-on and turn-off angles will be presented. The summary of the paper will discuss the current work on the construction of the motor and further possibilities offered by the creation of a physical prototype of the machine based on previous analytical calculations and computer simulations.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

Voltage Regulation of a Large Photovoltaic Power Plant

The paper discusses issues related to the response of a photovoltaic power plant to voltage level variations at the point of common coupling with the power grid, in accordance with the requirements of the NC RfG network code. An analysis of the impact of voltage deviations on the magnitude and direction of reactive power flow is presented, along with the identification of installation components that play a key role in this process. The study was conducted using the specialized engineering software DIgSILENT PowerFactory.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

Hand gesture classification based on surface EMG signals from the forearm using convolutional neural networks and spectrogram fusion.

Hand gesture recognition based on surface electromyographic (sEMG) signals constitutes a key component of modern human–computer interface systems, particularly in the context of upper-limb prosthetics.

This study presents a classification process for six selected hand gestures, based on sEMG data acquired from three forearm muscles. The signals were digitally filtered, and an automatic signal segmentation algorithm was developed to extract individual gesture repetitions from continuous muscle activity recordings. Subsequently, the signal segments corresponding to muscle activation were transformed into spectrograms using the Short-Time Fourier Transform (STFT). These spectrograms served as input data for various convolutional neural network (CNN) models used to classify gesture types.

Two input processing strategies were compared in the study: the first employed CNN architectures that analyzed each of the three channels independently, while the second utilized a fusion approach that combined the three channels into a single three-channel image, processed as a unified input to the model (spectrogram fusion). The goal was to determine which method better captures the complex dependencies between the activities of different forearm muscles.

All models were subjected to training, validation, and testing using a cross-validation procedure. The best-performing model achieved an accuracy exceeding 90%. The results indicate that the spectrogram fusion approach can yield better outcomes when classifying more complex muscle activity patterns, especially in scenarios with limited training data.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

Methods of sharing the total reactive power in the group of parallel connected passive harmonic filters

Nowadays, many electrical devices connected to the network are built with nonlinear components. They are also the source of reactive power in the electrical system. The can cause problem in the electrical system. For consumer, they involve additional charges from the energy supplier. In this paper, the group of three passive filters were designed in such a way as to achieve the lowest possible distortion of voltage and current, thus reducing the higher harmonics of current and voltage of the electric grid. The filters were applied to compensate the load for inductive reactive power. The work concerned the distribution of reactive power in a group of passive filters connected in parallel. The design of the filter group was used to reduce characteristic harmonics, which were the fifth, seventh and eleventh. Five methods (A to E) of dividing the total reactive power were presented. All the methods were compared in terms of voltage and current waveforms and spectrum with their THD coefficient. The reactive power and impedance versus frequency characteristics of the filters were also used as comparison criterion. The studied power system consisted of a thyristor rectifier load with resistance at the DC side and a choke at the AC side. The model was simulated in MATLAB/Simulink environment. After conducting the analysis, method A was found to be the best method, and method E to be the worst.

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Elektrotermia

Electric vehicles as a mobile energy storage

The rapid advancement of electromobility is unlocking new opportunities to use electric vehicles as mobile energy storage systems. The implementation of bidirectional energy flow technologies - such as V2L, V2H, V2G, and V2X - enables vehicles to consume energy from the grid, as well as supply it back, actively supporting intelligent energy management within buildings. When integrated with renewable energy sources and building automation systems, this approach enables optimized energy usage and greater self-consumption. In light of fluctuating electricity prices on the SPOT market, vehicles can be charged during low-price periods and export energy when prices peak, offering tangible financial savings. These concepts are brought to life through a demonstration platform that illustrates energy flows and highlights the potential of smart, flexible control in future-oriented energy systems.

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Elektrotermia

ESP32-based smart air quality sesnor

The lecture presents a prototype of a compact air quality sensor that allows intuitive monitoring of the state of the indoor environment in real time. The device was built on ESP32 microcontroller, VOC sensor (SGP40) and MPU6050 for motion detection. Measurement results are presented via an 8x8 LED matrix with the MAX7219 chip in the form of simplified emoticons, depending on the level of pollution. The module is distinguished by its simplicity of use and low manufacturing cost, which makes it an ideal educational tool and an element of popularization of knowledge about air quality and its impact on health. The speech will present the development process of the device, the principle of operation and possible applications. As part of the implementation of the project titled “Using digital twin technology to improve indoor air quality in buildings,” the integration of the module in a demonstration installation in a living AutBudNet laboratory equipped with a building automation system, HVAC with air purification and humidification will be discussed.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

Diagnostics of medium voltage cable lines using DAC/VLF technology

The presentation will cover a modern method for diagnosing medium voltage cables using the portable diagnostic module DAC/VLF MM3640 manufactured by ONSITEHV. Commissioning and in-service testing of cables with extruded XLPE insulation require the use of test voltages other than direct current (DC), which had been used for many decades in the testing of paper-insulated lead-covered (PILC) cables. This necessity arises from adverse physical phenomena related to the accumulation of space charge in XLPE insulation, which can lead to insulation breakdown or initiate accelerated aging processes. The presentation will showcase the capabilities of VLF (Very Low Frequency) and DAC (Damped AC) voltage testing methods, along with the results of partial discharge and dielectric loss measurements obtained during the testing of actual, installed medium voltage cables.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

Analysis of ferroresonance in medium-voltage networks with an isolated neutral point

The presentation covers an analysis of the phenomenon of ferroresonance in a model medium-voltage network system with an isolated neutral point. For the purpose of the analysis, the impact of voltage and network capacitance on the forms of ferroresonance occurrence was examined, as well as the effectiveness of mitigation measures in the form of damping resistors. The physics of the mentioned phenomenon is presented, and the consequences of its occurrence are also discussed.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

Analysis of the impact of changes in selected RF applicator parameters on the thermal ablation zone of liver tumors

The study analyzed the process of thermal ablation of liver tumors with a fixed, spherical shape and a radius of 15 mm (currently considered the maximum size for which this treatment method is applicable). A constant voltage of 25 V was applied, enabling controlled execution of the ablation procedure. The aim was to examine both the qualitative and quantitative characteristics of the resulting ablation zones. Computer simulations were conducted using COMSOL Multiphysics software, which allowed for the analysis of temperature distribution and prediction of thermal necrosis areas. The obtained results were visualized and evaluated in terms of the shape and symmetry of the ablation zone. The analysis showed that this zone had a nearly ellipsoidal shape, with a distinct extension in the direction of the electrode. For the quantitative assessment of these zones, Python programming language was used in the Google Colab environment. This made it possible to determine the volume and dimensions of the necrotic regions. Data analysis enabled a comparison between the simulation results and expected clinical outcomes. It was found that, under the given conditions, effective tumor ablation with an appropriate safety margin could be achieved. The applied methodology may serve as a basis for further optimization of treatment parameters. The results confirm the relevance of computer modeling in planning thermal therapy of liver tumors.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

Analysis of the cost of electricity supply depending on the use of energy storage

The paper will present an analysis of the cost of electricity supply by a prosumer with simulated energy storage. The actual measurement data comes from a power quality analyzer connected to the inverter of the PV system and an electricity meter. For the purpose of the simulation, an iterative algorithm was developed to calculate the energy generated, consumed and stored of a given hour. The paper will present three strategies for energy storage operation: maximum self-consumption, minimization of consumption during peak hours and hybrid mode controlled by the level of charge. The results of economic calculations will be compiled for the G12 tariff in net-metering and net-billing systems.

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Elektrotermia

A model of a three-pulse buck DC-DC converter

Aim:
Building a physical model of a three phase interleaved DC-DC buck converter and comparing real world results with a virtual model.
Zawartość:
Theory:
Interlaved three phase buck converter vs classic design. Controll strategies.
The pros and cons of interlaved technology
Problems and challanges of interlaved design approach:
- non-simetrical phase leg current distribition
- complications of controll circuit
Different ways of dealing with non simetrical current distribution
- pros
- cons
Interleaved buck converter with variable number of active phases - maximum efficiency cryterion
Simulations:
- dynamic states (enabling and disabling a phase leg – Spice simulation)
- current equalisation (Spice simulation)
- efficiency simulations (Spice simulation)
- automatic phase number selection - is inductor saturation limit based a good strategy a optimal one ?
PCB Project
FPGA based controll circuit
Conclusions
Further work directions

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Elektrotermia

Integration of smart street lighting installation for the parking area within the AGH university campus

In the face of rising energy prices and the need for sustainability, smart lighting systems are becoming a key component of modern cities. The aim of this paper is to present the results of a designed and implemented smart street lighting system for the parking area within the AGH university campus. The modernisation aimed to increase energy efficiency, reduce operating costs and improve safety. The implementation identified the shortcomings of traditional sodium lamps and replaced them with modern LED luminaires, controlled by a LoRaWAN® gateway and wireless controllers. The system offers four operating modes: manual, schedule, astronomical calendar and event mode, allowing the lighting to be dynamically adapted to the environment. The implementation has brought measurable benefits, such as reduced energy consumption, extended infrastructure life and flexible system management. Suggestions for further development have also been made, including integration of sensors, expansion of user interface functionality and the use of analytical algorithms.

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Elektrotermia

Control system for the autonomous mowing robot

Technological progress is constantly moving towards the automation of everyday tasks, including those related to the care of the surroundings of buildings. Lawn mowing robots are gaining popularity, but current solutions are often ineffective - they move randomly, which leads to inefficient mowing and excessive energy consumption. The subject of the paper is to present the work undertaken to develop an improved control system for an autonomous lawn mowing robot. The project was based on the modernization of the cheap Yard Force Classic 500 robot model, using the open source OpenMower system. The aim was to increase the precision of the robot's work, improve the quality of mowing and optimize battery consumption. Both the hardware and software were modernized, implementing new navigation and work management algorithms. The system was based on available open-source technologies, which ensures flexibility, expandability and low implementation cost. The result is a functional, cheap and easy to modify mowing robot, adapted for home use. The project emphasizes the potential of open-source solutions in improving the work of autonomous devices.

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AGH Eko-Energia

The control system for the "Perła" electric vehicle

The presentation concerns an advanced electronic board project, which serves as a critical component of an electric vehicle's control system. It directly transmits signals via the CAN bus from the driver to the onboard computer, which uses algorithms to calculate the appropriate torque to apply to the vehicle's wheels or the intensity of regenerative braking to recover energy.

The system operates by continuously receiving signals from the accelerator pedal, converting them into a digital format, and transmitting them to the onboard computer. These signals are processed and analyzed, enabling precise control of the vehicle's motor operation. Similarly, the brake pedal signal is digitized—depending on the degree of pedal depression, the system automatically adjusts the level of regenerative braking while ensuring efficient energy recovery.

Additionally, the project incorporates steering wheel angle measurement. This data is used by the onboard computer to dynamically adjust torque distribution to the wheels via a torque vectoring system. Communication between the board and the onboard computer occurs via the CAN bus, ensuring reliable and fast data exchange, thereby enhancing vehicle control efficiency and safety.

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Piorun

Harmonics in Power Systems – Sources and Reduction Methods

The presentation discusses the issue of harmonics in power systems, which arise from the operation of nonlinear loads. This phenomenon negatively affects the technical parameters of electrical energy, leading to disturbances and reduced device efficiency. The most common sources of harmonics are analyzed, along with methods of mitigation using modern technologies and filtering solutions. The importance of proper selection and configuration of system components in minimizing these undesirable effects is emphasized.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

Modern Digital Relays as Protection in the Power System

The paper discusses the crucial role of protection systems in the power system, which safeguard against faults and their consequences. Using the Schneider MiCOM relay as an example, the operation of susceptance, motor thermal, and overcurrent protection is presented. The work highlights the advantages and capabilities of modern digital relays in ensuring the safe and reliable operation of the power system.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

Nuclear power plant cable exposures and methods of investigation

This presentation will include a classification of the types of stresses of power and signal cables occurring in nuclear power plants, the effects of these stresses (including those related to increased levels of ionizing radiation) on cables, methods used in practice to test cables and the degree of degradation of their insulation systems, and methods to prevent accelerated degradation of insulation. The listed technical aspects of cables are related to high requirements for the reliability and safety of nuclear power plant operation. They are ensured by appropriate selection of cables and their proper operation and maintenance.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

Lithium-ion and hydrogen energy storage systems.

The presentation compares two modern and widely developed technologies: lithium-ion energy storage systems and hydrogen-based storage systems. It discusses the operating principles of both types — lithium-ion systems rely on reversible chemical reactions between electrodes, while hydrogen systems store energy through electrolysis and fuel cells. The presentation outlines the advantages, limitations, and specific applications of these technologies in the energy sector, both for residential and industrial use. It concludes with a comparison of the pros and cons of each technology, along with insights into their role in the context of the energy transition.

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AGH Eko-Energia

Onboard residual-current protection system of an electric car

This paper presents the design of a differential current protection system in the form of a PCB, developed for the electric solar vehicle PERŁA — a four-person car equipped with 5 m^2 of solar panels, designed by members of the AGH Eko-Energia student research group. The system is responsible for detecting AC and DC leakage currents and managing the charging process in compliance with the TYPE 2 mode 2 standard. The control unit is based on an STM32 microcontroller, which handles Control Pilot (CP) signal analysis, fault detection, and charge management. Communication with the vehicle's onboard systems is carried out via the CAN bus, enabling full system integration. Automotive-grade contactors are used for disconnecting the power path, offering both reliability and compactness. The PCB has been optimized for miniaturization, ease of integration, and environmental resilience. The presentation will cover key design assumptions, implementation of protection functionalities, and the operation of the embedded control algorithms.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

Analysis of earth faults in a medium-voltage grid with a directly non-earthed neutral point.

This thesis presents methods of neutral point operation in medium-voltage power grid and the potential hazards arising from single-phase earth faults. A simulation model replicating a selected medium-voltage network structure was developed, allowing for multi-variant analysis of fault current distribution and electric shock risks. Based on the simulation results, the influence of selected grid component parameters on expected earth fault current values and the corresponding electric shock hazards was analyzed.

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Track robot for debris removal: challenges of power supply in the new energy paradigm

Nowadays, introduction of robots in the field of emergency response with electric mobility, where autonomy, flexibility and energy efficiency are key factors is extremely relevant. A tracked debris removal robot operating in emergency situations is an example of an engineering system that requires a stable and efficient power supply even in hard field conditions.

Given the need for significant power and energy consumption of this robot storage device and also short-term use during its service life, the rest of the time it can be the part of a smart system within the framework of the Smart Grids concept.

Thus, the electric tracked robot is not only an engineering achievement, but also an example of how new energy solutions are integrated into real-world scenarios, increasing the efficiency of emergency services in critical situations.

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Analysis of the impact of the DST on electricity consumption in modern conditions

Daylight saving time was introduced in the last century to save electricity in lighting systems. Currently, according to the European Union Directive 2000/84/EC, the observance of summer time is mandatory for EU member states. However, modern studies by scientists from different countries indicate that the transition from standard to summer time leads to a change in electricity consumption near ±1%. This is due to a significant change in the structure of electricity consumption.

At the same time, a small percentage of efficiency calculated for one country does not mean that it is necessary to cancel the daylight saving time, since each individual country has its own specifics of the structure of energy consumption and geographical location.

Therefore, the task of studying the feasibility of switching to daylight saving time requires the formation of a set of significant factors and their unification for further adaptation of use in other countries.

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ANALYSIS OF DISTRIBUTION POWER NETWORKS STRUCTURAL INTERCONNECTIONS AS A PREREQUISITE OF ENERGY ISLANDS FORMING

The isolated (island) mode - independent operation of a part of the power network that is isolated due to disconnection from the utility grid, and has at least one generating or energy storage unit. This research is directed on structural interconnections in the low voltage distribution power networks. The study covered both rural and urban power networks with two or three transformer substations in island mode. A statistical analysis was conducted on the number of external connections.

The results of the study allow us to assess the needs for the number of modern switching devices, such as reclosers, to ensure the formation of energy islands and the restoration of system connections. The introduction of island modes as one of the components of the smart grid concept will contribute to increasing the energy security not only of Ukraine, but also of Europe as a whole.

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Caloria

Effect of NACA 6409 blade plane deflection on wind turbine performance characteristics.

In order to analyze the performance of the wind turbine, two sets of aerodynamic blades with NACA 6409 profile were used, provided by the manufacturer of the AE1005V test stand. Both sets were made of “hard tough” resin using 3D printing technology. Although to the naked eye there were no geometric differences, one of the kits was characterized by a slight deviation of the blades from the plane, which could affect their aerodynamic properties.

Experiments were conducted in an open wind tunnel, comparing the reference configuration (blades without deviation) with a modified variant (blades with deviation from the plane). The tests included measurement of the generated power of the turbine in depending on wind speed and blade angle of attack.

In order to accurately represent geometric differences, 3D scanning was performed at using the GOM Scan 1 device available at the DigiLab AGH laboratory. The obtained digital models were used in the ANSYS Fluent environment to perform numerical simulations.

It was observed that the deviation of the blade from the plane with respect to its geometric center of attachment led to a change in the local angle of attack, which in turn affected the distribution of aerodynamic forces along the entire length of the blade. The results clearly indicate that even small design deviations can significantly affect the power generated by the turbine and the stability of its performance. This underscores the need for high-precision manufacturing of blades in the production process.

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AGH Eko-Energia

Cooling system for the battery and motor of an electric vehicle

The paper presents a cooling system that is part of the PERŁA electric vehicle project. Its main purpose is to ensure effective heat dissipation from both the battery and the motor. The cooling system is designed to maintain the temperature of the battery cells and motor below 55 °C and 85 °C, respectively.

The control board, based on an STM32 microcontroller, communicates with other systems via the CAN bus and controls the operation of the battery cooling fans. A similar board is used for motor cooling. An optocoupler is implemented to provide galvanic isolation and protect the electronics in situations where the fan motors operate as generators. This voltage generation can occur when the vehicle is moving and airflow enters the cooling system from outside. The system also includes a voltage converter to supply power to the PCB and DC motors.

The control logic includes functionality to verify proper fan operation. The entire cooling system ensures an airflow rate of 130 m^3/h, which enables effective thermal management of the battery cells, particularly during vehicle stops and battery charging.

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Green Energy

Analysis of the current state and development directions of heating systems in single-family buildings in Polish conditions

The paper presents a multi-aspect analysis of the current state and directions of development of heating systems in single-family buildings in Polish conditions. The analysis takes into account, among other things, the changing national and EU law over recent years regulating the departure from solid fuels in favor of the widespread use of renewable energy, as well as changing building standards specifying standards for ensuring thermal comfort in residential buildings. Examples of non-European legal regulations, where solid fuels are used for heating to a greater extent, as well as examples of positive effects of the mass implementation of EU standards in selected European countries, have also been analyzed. As part of the conducted analyses, various scenarios of the directions of development of heating systems in single-family buildings in Poland have been proposed, taking into account the fuel market in Poland, directions of development of the energy sector, and taking into account technical, ecological and social aspects.

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Caloria

Aerodynamics in the service of energy: Turbine blade optimisation

Modern wind turbines are technologically advanced devices whose efficiency depends on a number of design and aerodynamic factors. One of the key aspects affecting airflow characteristics and system efficiency is the angle of attack of the blades and their geometry. For years, research has been carried out to optimise these parameters in order to maximise energy efficiency. In the past, numerous attempts have also been made by amateur designers who intuitively recognised the importance of blade orientation relative to the wind direction. This paper presents an analysis of the effects of angle of attack and varying blade shapes on the airflow through the turbine, as well as on the amount of energy generated. Particular attention is given to the effect of blade geometry on pressure distribution and turbulence in the turbine operating area. The paper also presents directions for further development of wind turbine technology in the context of improving their efficiency and adapting to changing environmental conditions.

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Caloria

Research on the Application of Thermoelectric Modules for Waste Heat Recovery from Moving Heat Sources

The analysis focuses on the possibility of recovering waste heat from moving heat sources used in the processing of semi-finished steel products. As part of the project, a modern and innovative test stand was developed to enable the investigation of thermal energy recovery from moving sources using thermoelectric generators (TEGs). TEG modules generate electrical energy based on a temperature difference, allowing for the conversion of waste heat into usable electrical power. In the case of moving heat sources, a portion of the thermal energy emitted by hot semi-finished products can be effectively recovered.

The student-led research includes tests of the energy efficiency of TEG modules under laboratory conditions, as well as an analysis of the potential for large-scale implementation. The results may contribute to increased energy efficiency and the reduction of heat losses in industrial processes.

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Section VII Renewable Energy, Nuclear Energy and Alternative Fuels

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AGH Solar Boat

Design and Optimization of a Propeller to Enhance the Propulsion Performance of a Solar-Powered Boat

The presentation will showcase a propeller designed specifically for a solar-powered boat, aimed at improving its efficiency. It will cover the various stages of the design process, the materials used, and innovative structural solutions that contributed to enhancing the effectiveness of the propulsion system.

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Energetyków Jądrowych Uranium

Analysis of the cooling system of the cloud chamber

The paper presents a numerical analysis of the heat dissipation system for Peltier cells powering a cloud chamber built by the Uranium Nuclear Power Engineering Student Research Group. The cloud chamber, also known as a Wilson chamber, is a detector that allows for the visualization of ionizing radiation particle tracks. To ensure proper operation of the chamber, it is necessary to maintain sufficiently low temperatures, which requires an efficient cooling system. The heat dissipation analysis involved designing the system geometry using Autodesk Inventor and performing numerical simulations in ANSYS Fluent, a tool used for analyzing heat and fluid flow. Calculations were carried out for various fan rotational speeds to investigate the influence of this parameter on cooling efficiency. Based on the obtained results, the optimal fan speed was determined to ensure effective heat removal from the Peltier cells and stable operating conditions for the chamber.

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AGH Eko-Energia

Laminating PV cells in fiberglass for the PERŁA solar car.

Vehicle-integrated photovoltaics (VIPV) enhance the range and energy efficiency of electric vehicles, contributing to greenhouse gas emission reduction. However, current PV modules are often too heavy and inflexible, limiting their use in vehicles. To address this, lightweight and flexible crystalline silicon (c-Si) modules laminated in glass fiber composites were developed for the solar car "Perła" by the AGH EkoEnergia research group. The modules, produced using a vacuum infusion process, underwent optical transmittance, current-voltage, electroluminescence, and accelerated degradation tests. They demonstrated high transmittance (losses <6% compared to laboratory glass) and excellent resistance to mechanical and environmental damage. Despite being prototypes, the best modules achieved a cell efficiency of 19.3%, indicating minimal losses compared to non-laminated cells. This glass fiber lamination technology enables the production of lightweight, durable modules tailored for solar vehicles and has potential applications in aviation and construction, opening new opportunities for commercializing flexible PV modules.

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FENEC

Use of a hydrogen fuel cell stack for underwater vehicle propulsion

The paper presents the results of an engineering project focused on the development of an unmanned underwater vehicle powered by an electric propulsion system. The vehicle uses a hybrid energy source combining a hydrogen-fueled fuel cell stack with a lithium-ion battery. The paper outlines the complete design process—from the 3D model created in SolidWorks and the hydraulic system schematic to the control and power supply systems. Particular attention is given to the power architecture: the unit is powered by a Li-Ion battery supported by a hydrogen fuel cell, which increases operational autonomy while ensuring a fully eco-friendly source of electrical energy. The control system is also discussed, based on a custom solution using Raspberry Pi to manage both propulsion and ballast systems, with remote operation enabled via a dedicated mobile application. The project integrates both technical and functional aspects, serving as an example of a modern, integrated approach to propulsion in underwater vehicles.

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Zrównoważonego Rozwoju Energetycznego Solaris

Scenario-Based Cost Analysis of Providing 24/7 CO_2-Free Energy Supply to Industry in the Netherlands Using the TIMES Model

In the context of increasing climate ambitions and the rapid development of weather-dependent renewable energy sources ensuring a continuous supply of carbon-free electricity (CFE) becomes a major challenge, especially for energy-intensive industrial consumers. The aim of this study was to assess how the costs of supplying carbon-free electricity to the industrial sector change depending on the share of CFE in total electricity consumption, ranging from 50% up to full hourly coverage throughout the year (the so-called 24/7 CFE approach). Within the scope of the study, an optimization model was created using the TIMES generator. The model captures the hourly variability of electricity demand and supply and considers a planning horizon up to the year 2030. The analysis was geographically limited to the Netherlands, where the industrial sector accounts for approximately 33% of national electricity consumption, making it a key area for energy system transformation. The model includes both existing and emerging generation technologies, as well as various forms of energy storage. Calibration was based on data from the ENTSO-E platform.

The results show that achieving 100% hourly coverage of electricity demand with CFE leads to a steep increase in system costs, primarily due to the need for extensive energy storage deployment and large-scale investments in renewable energy technologies. Nevertheless, the implementation of 24/7 CFE strategies may serve as a significant driver for the development and earlier deployment of advanced clean energy technologies, supporting the broader decarbonization of the economy.

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Feniks

Analysis of the properties of paper and mixed waste and coffee brewing waste for use as components of formed solid fuels

Non-recyclable waste fractions are increasingly considered as alternative fuel sources within sustainable waste and energy management strategies. The aim of the study was to evaluate the physicochemical properties of selected paper and mixed waste fractions in the context of their potential use as components of densified alternative fuels. Elemental analysis (C, H, S, Cl, Hg), proximate analysis (moisture, ash, volatile matter, calorific value), XRF analysis, bulk density, and particle size distribution were performed. The results indicate that all tested fractions are characterized by a high volatile matter content. Despite higher ash content, mixed waste exhibited low moisture and favorable energy properties. Paper waste was distinguished by low sulfur and chlorine contents. The analysis of fuel parameters enabled preliminary classification of the samples into appropriate SRF (Solid Recovered Fuel) classes according to PN-EN ISO 21640:2021. The results confirm their suitability for low-emission fuel production aligned with circular economy goals.

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Feniks i TD Fuels (współpraca)

Analysis of the properties of distilled glycerine production waste for its use as a component of formed solid fuels

Non-glycerol organic matter (MONG), a by-product of crude glycerol distillation, is a complex mixture of fatty acids, triglycerides, polymeric glycerol, and other organic compounds. Due to its chemical and physical properties, MONG has potential for use as both an energy-rich additive and a natural binder in the production of densified solid fuels based on biomass and/or waste. In this study, MONG was subjected to detailed physicochemical characterization, including elemental analysis (CHS), FT-IR spectroscopy, and heavy metal content assessment, as well as determination of ash content, moisture, calorific value, specific density, and viscosity. The results indicate high density and viscosity, low moisture and ash content, moderate calorific value, and low sulfur content. No heavy metals were detected. These properties suggest that MONG can positively affect the energy and mechanical characteristics of solid fuels by reducing undesirable components and improving the cohesion of pellets or briquettes, making it a promising component in sustainable alternative fuel technologies.

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Feniks

Characterization of the physicochemical properties of selected waste biomass in terms of fuel production

Waste biomass is a valuable renewable energy source, particularly in the context of sustainable technologies and organic waste management. The aim of this study was to assess the physicochemical properties of selected types of waste biomass—maple and horse chestnut leaves, larch needles, brewery spent grain, and coffee grounds—for their potential use as components of densified solid fuels. Technical analysis (moisture, ash, volatile matter, calorific value) and elemental analysis (C, H, S, Cl, Hg) were performed, along with XRF measurements. The results show that brewery spent grain exhibits high calorific value, low ash content, and trace levels of sulfur and mercury. Leaf- and needle-based biomass demonstrated moderate calorific value and low sulfur content, with slightly higher ash levels. Coffee grounds showed favorable energy properties and high bulk density. The obtained results provide a basis for further optimization of biomass fuel formulations incorporating these waste-derived components.

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AGH Eko-Energia

Aerodynamics of electric vehicles

The paper will discuss the importance of aerodynamics in the context of electric vehicles and present an aerodynamic analysis of the solar electric car "Perła," designed by the AGH Eko-Energia student research group with the aim of participating in international competitions. The study was carried out using CFD methods with the k–ω SST turbulence model in Ansys Fluent. The drag coefficient (0.33082) and lift coefficient (0.28818) were evaluated. Additionally, flow recirculation zones were identified, which could be reduced in future iterations of the project. The analysis confirmed the importance of accurate flow modeling in optimizing the design of electric vehicles, highlighting the potential for further geometric improvements and the application of more advanced unsteady simulations.

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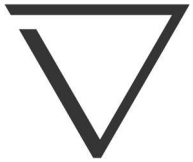
Nabla



Design and Construction of a Closed-Circuit Wind Tunnel

Experimental research, particularly that conducted in a wind tunnel, is a key method for studying the aerodynamic properties of various objects. A wind tunnel enables precise measurement of airflow parameters and their distribution under different boundary conditions. Due to its high measurement accuracy, it serves as a fundamental tool for verifying the results obtained from computer simulations.

This work presents the design and construction of a closed-circuit wind tunnel, developed for educational and research purposes in the field of flow analysis using the PIV (Particle Image Velocimetry) method. The tunnel features a test section with dimensions of 80×80 cm, and the theoretical maximum airspeed reaches 16 m/s. The size and operational parameters of the tunnel allow for experiments on relatively large-scale models, while its construction ensures favorable conditions for observing flow phenomena.

The wind tunnel was entirely designed in a CAD environment, and its key components were subjected to numerical analysis using CFD simulations. This allowed for optimization of the channel geometry to minimize pressure losses and select an appropriate fan. Unlike typical educational solutions, this tunnel is based on a closed-loop system, providing better control over test conditions and improved energy efficiency.

Although the device is currently undergoing operational testing, its design parameters and readiness for integration with a PIV system make it a valuable educational tool and a potential platform for conducting experimental research in aerodynamics.

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Green Energy

Analysis of the current state and different scenarios of approaching the problem of global warming

The paper analyses the problem of global warming propagation and anthropogenic gas emissions into the atmosphere and presents various scenarios of approaching the aforementioned problem and the resulting consequences in the near and long term. In particular, it presents the existing main approaches to the above topic, which are mutually exclusive, i.e. those assuming that humanity has a significant impact on the propagation of global warming and the opposite ones, negating the impact of human activity on the aforementioned phenomenon. It also critically analyses selected initiatives aimed at reducing carbon dioxide emissions and presents selected technologies for capturing, storing and using captured carbon dioxide. It also draws attention to the controversies related to the development of renewable energy and electric vehicle infrastructure, which are to play a significant role in the fight against global warming.

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TD Fuels

The energy potential of brewer's spent grains

Due to the geographical limitations of Poland, the development of renewable energy sources such as wind and solar power faces numerous challenges. Therefore, it is essential to seek alternative solutions that can enable an efficient energy transition while aligning with the principles of a circular economy. This presentation will discuss the energy potential of brewer's spent grain – a by-product of the brewing industry – as a feedstock suitable for thermochemical and biochemical conversion processes. The possibilities of its transformation into energy products such as trophic pellets, carbonizate (a pyrolysis product), and bioethanol produced through fermentation will be presented. The aim of the presentation is to highlight brewer's spent grain as an example of effective utilization of organic waste in the context of sustainable energy transformation.

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Fluid Flow

Fluid Flow

Modeling the membrane separation process in CHEMCAD for obtaining biomethane

The increase in global carbon dioxide emissions and the associated environmental and economic costs (including emission allowance prices) are forcing a search for low-carbon alternatives to fossil fuels. One promising solution is the use of biomethane, a fuel derived from biomass that can replace natural gas. However, the implementation of biomethane into widespread use requires efficient methods for purifying raw biogas from CO_2, nitrogen and other impurities so that it meets the quality requirements of natural gas.

This paper analyzed the membrane separation process as a method for biogas purification, focusing on optimizing process parameters (pressure, temperature, flow rate) and system configuration. The study was conducted in the CHEMCAD environment, simulating three variants of system complexity. Simulations were carried out based on two-component (CH_4/CO_2) and three-component ($CH_4/CO_2/N_2$) mixtures. Preliminary simulation results showed the possibility of achieving methane concentrations of 96% in the product stream with minimal methane losses. It was confirmed that increasing the number of membranes improves the selectivity of the process. The need for experimental validation of the results using industrial membranes (UBE) was also indicated at the AGH laboratory.

Keywords: biogas, biomethane, membrane separation, biogas purification, process modeling, CHEMCAD.

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Piorun

STUDENCKIE KOŁO NAUKOWE PIORUN

Can perovskite cells replace monocrystalline cells in photovoltaic farms?

The report presents a techno-economic analysis of monocrystalline and perovskite solar panels, using a 1 MW photovoltaic farm as a case study. In the face of growing demand for renewable energy, particularly in sustainable development goals for 2030, there is a pressing need to explore more efficient PV technologies. The comparison of both technologies includes parameters such as efficiency, production costs, durability, degradation susceptibility, environmental sensitivity, recyclability, and future development potential. A SWOT analysis highlights the strengths and weaknesses of both solutions, as well as the opportunities and threats associated with their development.

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AGH ECOnstruction

"E-BIKE with recuperative system and centrally located engine"

Within the framework of the project "E-BIKE with recuperative system and centrally located motor" carried out by AGH ECOnstruction, a prototype of a mountain bike with cenral electric drive Bafang M510 was developed. The project fits into the theme of the Renewable Energy, Nuclear and Alternative Fuels Section by applying alternative electric propulsion to the transportation sector. The key element of the structure is the proprietary frame, designed from scratch in CAD environment according to the project's requirements, taking into account the geometry typical of mountain bikes and the integration of the propulsion system. Made of 6061 aluminum, the frame features a compartment for a centrally located Bafang motor and a specially designed, team-built battery. High-end components were used: RockShox suspension, wheels on Novatec hubs and WTB rims, Shimano Deore XT brakes, and a cockpit with NSbikes bearings. The integration of electric propulsion with a proprietary battery design and an engine energy recuperation system demonstrates the technological possibilities of alternative power sources in a form never before seen widely on the market, addressing the challenges of energy efficiency and reducing the carbon footprint.

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Feniks

"How the biodegradable fraction can change our approach to waste"

The use of waste for energy purposes is growing in importance every year and is a key component of a closed-loop economy. Waste of both municipal and industrial origin, including waste biomass, has very different characteristics and morphology. One of the more important parameters is the organic carbon content. This parameter is important, among other things, when accounting for emissions in thermal waste treatment processes. However, the determination of organic carbon content can pose many problems. The aim of this study was to adapt one of the methods for determining the organic carbon content in the form of the so-called biodegradable fraction in accordance with ISO 21644:2021 and D4373 in wastes such as brewery grist and RDF alternative fuel under available laboratory conditions. The results were juxtaposed with each other, identifying potential uses for the contained organic carbon or the need for further technological processes to enhance the waste's usefulness.

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Feniks

Determination of critical elements in waste materials

The demand for recovery and recycling of strategic raw materials such as critical elements is a development of modern technology and industry. Researchers are developing an accurate and reliable method to determine the presence of critical elements such as lanthanum, dysprosium, europium, neodymium, tantalum and niobium in waste materials. The study aims to evaluate the potential of these materials as alternative sources of critical elements. Certified reference materials are used during the study to ensure accurate and reliable results. Atomic absorption spectrometry (AAS) is used to analyze the samples, with solid samples dissolved in a microwave mineralizer for precise determination of elemental concentrations. Activities related to this research include the selection of a suitable method for sample mineralization, the establishment of analysis parameters on the spectrometer, calibration, and analysis of the prepared samples. The developed methods will be validated to determine important parameters, such as the limit of detection and quantification, working range, accuracy, and precision of the method.

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Application of Multiphysics Simulation of the Innovative Small Modular Reactor (i-SMR) Using Coupled MASTER/CUPID Codes.

Abnormal behavior in nuclear power plants during accident scenarios poses serious safety risks. Simulation tools are essential to evaluate the consequences and to ensure that the reactor core remains intact. For advanced reactor concepts such as the Integrated Small Modular Reactor (i-SMR), a multi-physics approach is required to accurately reflect the complex core behavior. Coupling different simulation codes - such as neutron kinetics, thermal hydraulics and fuel performance - provides a more realistic and comprehensive analysis. This is particularly important because reactor power and thermal-hydraulics are closely linked through reactivity feedback mechanisms, including moderator temperature and void coefficients.

The purpose of this study is to demonstrate the implementation and benefits of coupling the CUPID thermal-hydraulic code with the MASTER neutron kinetics code developed by the Korea Atomic Energy Research Institute (KAERI) in South Korea. The CUPID/MASTER system demonstrates that integrated multi-physics simulations can significantly improve safety margins and provide greater operational flexibility compared to stand-alone codes.

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Bit

Experimental Evaluation of Molecular Filters

We study the effectiveness of filters commonly used in chemoinformatics for molecular screening. Filters are rule-based tools, based on physicochemical descriptors or sustructural patterns, used to preprocess molecular datasets and remove unwanted compounds, e.g. potentially toxic. Despite their widespread use, there is a lack of quantitative evaluation of those methods, and even experimental procedures for such evaluation. To remediate this, we assess over thirty common filters across a number of molecular datasets.

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BioMetr

Multimodal analysis of people with neurodegenerative diseases in augmented reality

The diagnostic system using Microsoft HoloLens 2 analyzes multimodal data for Parkinson's disease diagnosis. The study involved 45 healthy individuals and 37 patients, performing 17 tasks while recording voice, gait, and hand movements.
Machine learning classifiers (Random Forest, SVM, MLP, Naïve Bayes) achieved the best results for voice analysis (84% – Random Forest), gait (74% – MLP), and hand movements (55-63%). Data fusion methods (weighted, Dempster-Shafer, fuzzy) did not improve classification, with a maximum accuracy of 66.7%.
The main limitations were the small sample size and uneven data distribution. Although modality fusion did not enhance results, voice analysis showed significant diagnostic potential. Future research should include more participants and additional motion sensors.

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AGH Code Industry - CoIn

Designing Stealth Sequences in Video Games as a Tool for Building Tension

Stealth encounters are a complex element of game design that require close collaboration between level architecture, AI systems, and clear information delivery to the player. This paper focuses on analyzing how spatial design, enemy patrol pathing, and the definition of their fields of vision contribute to creating tension and a sense of threat during gameplay.
Based on an original project developed in Unreal Engine 5 – created in consultation with a mentor – as well as selected examples from existing games, the iterative process of designing stealth sequences will be presented. The talk is aimed at individuals interested in game design, the psychology of player-system interaction, and iterative problem-solving in the field of level design.

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AGH Space Systems

It's (not) rocket science - data visualisation for space engineering

In modern society, decisions are increasingly data-driven - and there are few fields where their communication is as important as engineering. In our refereed talk, we will show the best practices and challenges that we had with displaying data, communicating it within an interdisciplinary team of engineers, and comparing it to showcase of data to people who are not involved in rocket engineering on a daily basis. We will present a case study of a tool for processing and presenting data from rocket telemetry developed by AGH Space Systems (the "Zdzislaw" application), as well as talk about data visualization in our other applications. Ultimately, we will compare our solutions with those used by software developers in space and engineering industry, as well as in the broader field of data visualisation for scientific and popular scientific purposes.

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SKN Analizy Danych Anatomicznych

Artificial Intelligence and the Anatomy Exam - A Comparison of 7 Language Models

Introduction: Artificial intelligence is currently one of the most rapidly developing branches of technology. It has proven to be a helpful tool in various fields, including medicine. Significant advancements in the development of new language models prompt an evaluation of their effectiveness in different areas of medicine, such as anatomy.
The aim of this study was to assess the effectiveness of artificial intelligence in solving theoretical anatomy exams designed for medical students.
Methods: The study utilized 555 multiple-choice questions (150 in Polish and 405 in English) sourced from past anatomy exams for the medical program. The models tested included: ChatGPT Basic (4o mini), ChatGPT 4o, DeepSeek, Copilot, Gemini, and two Polish models: Bielik and PLLum. Each question was asked only once. For analysis purposes, the questions were categorized by type and by the anatomical structure they addressed.
Results: Out of 555 questions, ChatGPT Basic answered 394 correctly (71%), ChatGPT 4o – 461 (83.1%), DeepSeek – 427 (76.9%), Copilot – 442 (79.6%), Gemini – 439 (78.8%), Bielik – 166 (29.9%), and PLLum – 222 (40.0%). The language models performed poorest on multiple-answer questions (37.6%) and best on questions concerning the function of a given organ (75%).
Conclusions: Most of the tested language models are capable of independently passing the exam, which should serve as a warning to teaching staff supervising students during exams and assessments. Properly formulated questions can currently hinder students relying on artificial intelligence from passing, but ongoing AI advancements may result in even higher pass rates in the future. Furthermore, it is also worth focusing on the development of domestic language models, as our study revealed significant shortcomings in comparison to
international counterparts.

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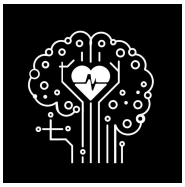
Artificial Intelligence in Medicine



Classification of cardiomegaly in chest X-ray images using machine learning.

Cardiomegaly is an enlargement of the heart silhouette which can suggest serious medical conditions. Early diagnosis of these conditions is crucial, as it enables prompt and effective treatment. Chest X-ray (CXR) is one of the primary tools used to assess the size of the heart. Unfortunately, interpreting these images can be both time-consuming and prone to human error. This project aims to develop a tool to support the diagnosis of cardiomegaly.

The project is based on the analysis of lung and heart segmentation from CXR images. From this, geometric and proportional features are generated to represent the shape of the heart. Different configurations of classification models (e.g., KNeighborsClassifier, RandomForestClassifier) are then tested with sets of these features to find the best combinations of features and models.

Initial results are encouraging and suggest that the models may support a diagnosis of cardiomegaly. With an accuracy above 70%, the model shows promising potential as a supportive medical decision.

This project demonstrates how machine learning techniques can assist in diagnosing cardiomegaly from CXR.

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Bit

Ordinal regression and application to ML-assisted RPG game design

Many real-life scenarios require the prediction of ordinal variables, a task well-suited for ordinal regression methods. These methods include classical regression models with rounding as well as specialized approaches designed specifically for ordinal data. In this talk, I will introduce the topic of ordinal regression and its algorithms and evaluation methods.
One of many possible applications of these methods is determining challenge levels of monsters in pen & paper RPG games. Currently there is no automatic way to estimate these levels. However, it is a natural task for machine learning, as opponents are described by long vectors of numerical features and levels are ordinal values. Usage of ordinal regression can help reduce costs for publishers during the design process.
I will describe the experiments, evaluation framework, and results.

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Creative

Autonomous targeting system based on image analysis

With the dynamic development of unmanned aerial vehicles, the demand for advanced automatic recognition and targeting systems is growing. Despite the increasing number of scientific publications on this topic in recent years, this field still offers vast research and application opportunities.

The aim of this project was to develop an autonomous targeting system capable of detecting and tracking selected objects in real-time based on image analysis.

The system utilizes a machine learning model for object detection, which was trained on a printed model of the Shahed 136 drone. Using this model, the program processes images received from a camera in real-time and determines the position of the object. This allows for the calculation of the adjustments required by the servomechanisms placed on the robotic arm. The calculated adjustments are sent to the servo control board. The signals sent to the control board ensure precise tracking and alignment of the object within the targeting field.

The designed system has potential applications in both the military sector, as a targeting aid, and in monitoring systems.

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Bit

Transfer Learning from Microgames

The project focuses on developing intelligent agents for playing Mill across different board sizes, with emphasis on the strategic differences between the three game phases: placing, moving, and "flying" pieces.
Two approaches are compared: the classic Minimax algorithm with alpha-beta pruning and phase-specific heuristics, and Deep Reinforcement Learning using Deep Q-Networks (DQN), including both single-agent and multi-agent (mDQN) architectures. Symmetry-based state space reduction techniques are also explored.
Agent development and evaluation start with a simplified variant – Six Men's Morris (SMM) – whose state graph (~430 million states) allows for full analysis. Successful strategies are then scaled to the much larger state space of classic NMM (~280 trillion states). The game state is modeled as a graph vertex, enabling analysis of possible gameplay flows.

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AGH Code Industry - CoIn

User Experience Adaptation System Based on Player's Emotional State

One of the main challenges of narrative media today, including computer games, is creating deeply immersive and personalized experiences. Although games offer interactivity on the level unachievable by other forms of media, they are often limited to static, binary choices that lead to predictable and universal results, regardless of the player's individual emotional reactions. The aim of the presented project is to overcome these limitations by creating a system that dynamically adapts the game experience to the user's emotional state.

The EDEN (Emotion-Driven Extended Narrative) system uses biometric data, in particular analysis of the player's facial expressions using a camera and artificial intelligence tools, to recognize emotions in real time. Using this data, it modifies the behavior of NPCs, matching their reactions to the emotional context. For example, an empathetic merchant can offer the player a special discount if he detects sadness. Importantly, the system remembers the relationships and emotional history of interactions, allowing the characters to develop a bond with the player and react in a continuous manner, consistent with previous experiences.

The lecture presents the theoretical and technological assumptions of the EDEN system, analyzes the problems that the project addresses, and indicates possible directions for further development and application of adaptive emotional systems in gamedev.

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BioMetr

"Speech Emotion Recognition in Naturalistic Conditions"

The goal of the project is to design and implement a Speech Emotion Recognition (SER) system, operating under possibly naturalistic acoustic conditions. The main goal is to develop a solution that will be able to classify emotions contained in speech signals both categorically and dimensionally (attribute-based).
The project focuses on two parallel tasks: 1. categorical emotion recognition: Classify voice samples into one of eight emotional categories: anger, joy, sadness, fear, surprise, contempt, disgust, and neutral state. Test data will include a balanced distribution of emotion classes. 2 Prediction of emotional attributes: Representation of emotions in a three-dimensional space described by: arousal (arousal), valence (valence) and dominance (dominance). The goal will be to regress the values of these attributes for each speech sample.

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Synaptica

Automation of data extraction for systematic reviews

Systematic reviews (SRs) are a vital tool for summarizing existing scientific literature in all fields. The growing number of papers makes SRs cumbersome and time-consuming, data extraction being a key bottleneck. This process can however be automated, and our approach was to use Retrieval-Augmented Generation with iterative refinement. After defining a query, it is expanded through subquestions and query reformulation in the subsequent steps. Extracted data is then synthesized into structured reports, with optionally coded answers. An evaluation was performed that showed a 90% alignment with manual, expert-verified results for an existing SR (n=14). This approach has a potential to streamline SR workflows, improving efficiency in evidence synthesis. Further work, aimed at optimizing the retrieval aspect as well as evaluation accuracy is required. We plan on switching to LangChain and agentic approach.

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Synaptica

SYNAPTICA

Repository of tools enabling automation of systematic reviews

Conducting systematic reviews (SRs) is crucial, yet very time-consuming at the same time. We examine the role of Artificial Intelligence in automating various stages of the review process: articles selection, extraction, quality assessment, etc. We performed a database search on Web of Science for papers potentially utilizing or describing tools for automation or semi-automation of these stages. We identified 92 such papers. We introduce Awesome Systematic Reviews, a GitHub repository that compiles automation tools along with information on their price, open-source status and stages of a review process they can be applied to. In the future, we aim to extend our search to other databases and cooperate with developers and scientists to make this repository alive.

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Synaptica

SYNAPTICA

Assessing the quality of systematic reviews beyond medicine: Towards an evaluation framework for Artificial Intelligence research

Systematic reviews (SRs) are a vital tool to assess the state and quality of existing literature. They are especially predominant in medicine, where they evaluate the evidence presented in trials. However, SRs only provide valuable information if they are performed correctly. There exist tools to check for such correctness in medical trials, namely AMSTAR, JBI Critical Appraisal Tools and others. We performed a preliminary review of the 100 most cited SRs in the field of psychiatry, which showed poor quality of these SRs from several angles. This begets a question - is this the case in other areas, for example Artificial Intelligence (AI) research? We propose an AMSTAR-like tool allowing for such an evaluation to be performed. Our future research will aim at using it to assess the quality of most cited reviews in the field of AI

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BioMetr

Aorta segmentation from CT images using deep neural networks

The presentation focuses on a deep learning solution for the automated segmentation of the aorta from CT images. The data preparation included windowing for Hounsfield scaling, and a supervised approach was applied using the U-Net architecture (via nnU-Net) combined with cross-validation to train five models. Predictions were merged to produce a coherent 3D model, followed by post-processing to remove unconnected components. The reported Dice score (0.921) and IoU (0.858) demonstrate high segmentation accuracy for larger structures. However, the method faces challenges in accurately segmenting small branch vessels and precisely delineating boundaries. The talk discusses these limitations and outlines potential research directions aimed at enhancing the capture of fine anatomical details.

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Bit

Peptide function prediction using molecular fingerprints

Peptides, or short chains of amino acids, are the subject of growing interest in their medical applications, such as treatment of cancer, viral infections, and infections caused by antibiotic-resistant bacteria.

Antimicrobial peptides, in particular, offer a promising alternative to traditional antibiotics in addressing the growing resistance crisis.

A key challenge in designing new peptide compounds is the ability to accurately predict peptide properties. In recent years, the research has focused on deep learning methods, such as graph neural networks and protein language models that work on amino acid sequences.

In our project, we proposed an alternative approach based on the use of classical methods for representing chemical structures. We show that molecular graph vectorization using molecular fingerprints, combined with tree-based ensemble models, can often achieve SOTA results and outperform deep learning methods across many datasets.

The proposed method is faster, has lower computational cost, better scalability, and is much simpler in implementation, making it a competitive approach for the task of peptide function prediction.

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Glider

Modeling the Spread of Disinformation in Social Media: An Agent-Based Approach

Rising disinformation online poses a serious threat to democratic institutions, public trust, and human rights. In this paper, we present an agent-based simulation model designed to analyze the mechanisms driving the spread of false information on social media. The model employs agents with varying susceptibility to disinformation, levels of trust, and interaction patterns, enabling a realistic representation of digital ecosystems. Our study considers both organic content dissemination and coordinated disinformation campaigns. Simulation outcomes reveal that key factors influencing the dynamics of fake news spread include social amplification, echo chamber effects, and the role of influential users. The proposed framework allows for testing intervention strategies before their real-world deployment, contributing valuable insights in the fight against disinformation. By identifying critical intervention points, this approach supports the development of effective strategies to mitigate the harmful impact of fake news and offers revolutionary potential for societal resilience. Findings underscore the need for innovation.

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Grupa .NET PO

Analysis of trends in programming language choice

This article explores how the development of artificial intelligence (AI) has influenced the popularity of different programming languages and examines current trends in languages used for mobile app development. Significant investments in advanced AI models like GPT-4 and Google Gemini Ultra have boosted the popularity of languages such as Python, appreciated for its simplicity and extensive library support for machine learning. In the realm of mobile applications, the evolution of iOS and Android systems has shifted developer preferences. Initially, iOS relied on Objective-C, which was later replaced by Swift, a modern programming language created by Apple. Android started with Java, but over time, developers have increasingly turned to Kotlin, valuing its modern features. Google also introduced Dart, which gained popularity for its versatility. The analysis is based on data from the TIOBE Index and PYPL, as well as statistics from GitHub, where the number of repositories, pull requests, and pushes reflects the dynamic evolution of developers' preferences in programming languages.

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New-Tech

ATM - Autonomous Training Machine

In an era of increasing digitization and sedentary lifestyles, maintaining good physical condition poses a growing challenge. Not only is regular exercise essential, but correct technique is also crucial to prevent injuries. This engineering project focuses on developing a system based on motion capture technology for precise movement analysis and error detection in exercise performance. The system collects motion data and utilizes machine learning methods, including ANFIS and LSTM neural networks, to identify incorrect movement patterns and suggest corrections. This approach enhances training efficiency while minimizing the risk of injury. The work highlights the importance of technology in supporting health prevention, especially in the context of an aging population and rising healthcare costs. Motion capture opens new opportunities in sports and rehabilitation, promoting safe and effective physical activity across all age groups.

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SKN Analizy Danych Anatomicznych

Can artificial intelligence pass a practical anatomy exam for you?

Introduction: In recent years, artificial intelligence has become widely accessible. On November 30, 2022, the first GPT Chat model was launched and has been continuously developed ever since. One of the introduced features was the ability to analyze uploaded images. Chat GPT has often been used to generate written assignments, for example, on behalf of students, and in the era of online education, also for cheating on various types of tests.
Study Objective: The aim of the study is to evaluate the effectiveness of Chat GPT-4o in recognizing anatomical structures in images.
Methodology: Selected anatomical structures were marked with an identical indicator on specimens from the Department of Anatomy at Jagiellonian University Medical College. These specimens were then photographed and assigned to specific body regions. Using a standardized prompt, the free version of Chat GPT-4o was instructed to identify the marked structures. In cases of incorrect responses, a standardized command was issued for reattempting the identification. The process was repeated up to a maximum of three attempts. During our study, we analyzed 200 anatomical structures.
Results: The general accuracy of AI in recognizing structures was 15,5%. The structure was correctly identified on the first attempt in 13 cases, on the second attempt in 10 cases, and on the third attempt in 8 cases. AI frequently misidentified not only the type of the marked structure but also its anatomical region. In some cases, Chat generated non-existent anatomical names.
Conclusions: The current level of advancement of Chat GPT-4o is not an effective tool for assisting in the recognition of anatomical structures, and its use would therefore be impractical. It often fails to correctly define the body part in which a given structure is located, something that a human can easily identify. It is likely that future versions of Chat GPT will be able to better recognize image elements, and as a result, more accurately identify complex things, such as the anatomical structures of the human body.

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Glider

Machines can learn to cooperate - Application of RL in Agent Systems

This project aims to design a multi-agent environment in the Unity engine, where autonomous agents learn both cooperation and competition with other agents using reinforcement learning techniques, implemented via the Unity ML-Agents framework. The conducted experiment demonstrates that agents are capable of independently developing cooperative strategies to achieve a common goal, adapting their behavior in response to opponents' actions.

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AGH Code Industry - CoIn

Sudoku, quantum physics, and procedural terrain generation in video games

Procedural Terrain Generation (PTG) is an essential aspect of many modern video games, significantly impacting replay value and the uniqueness of the player experience. It provides unpredictability in the explored world, even when its overall characteristics remain familiar.

This paper presents a novel PTG algorithm whose concept combines inspiration from the logic of solving Sudoku puzzles and the principles of quantum mechanics – two seemingly unrelated domains. The proposed approach enables the generation of complex virtual environments based on a predefined set of rules or by adapting and extending pre-existing terrain structures.

A key advantage of the algorithm is its ability to generate worlds that exhibit both naturalness and consistency with the established game world. The paper presents the algorithm's genesis, discusses potential implementation variants, and provides a comparative analysis of its capabilities and limitations against traditional PTG techniques.

A prototype of the solution was implemented using the Unity engine. However, the algorithm's architecture is independent of this specific environment, allowing for its relatively straightforward adaptation to other game engines and development tools.

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Creative

Design and implementation of a CNC machine training system in a virtual reality environment

The work demonstrates the possibilities of implementing a CNC operator training system in virtual reality. The required modules comprising the machine were identified, followed by the design of visual and functional representations within the Unreal Engine 5.3 environment. The VR application developed as part of the project operates independently of an external computer, using the Meta Quest 2 virtual reality headset. In the described version of the software, it is possible to conduct two CNC machine configuration procedures based on materials presented within the application. The procedure is presented to the user on a video player placed in the 3D scene. All elements of the application were designed with a focus on extending functionality and minimizing resource consumption on the system where it will ultimately be run.

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im. Stanisława Staszica w Krakowie

Studenckie Koła Naukowe AGH

Book of Abstracts

62nd HKSKN

Conference of the AGH University of Science and Technology

May 8th, 2025

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Ekonometryk

Analysis of health care systems in selected countries

A well-performing healthcare system is one of the key pillars of every country. Limited financial resources, a shortage of medical staff, and organizational complexity make ensuring effective healthcare one of the greatest challenges modern countries face. Patients often face difficulties accessing treatment due to financial barriers or long waiting times for appointments. The situation varies by country – some have well-organized systems, while others struggle with persistent structural and organizational issues.

These inequalities in access to healthcare raise the question of how efficient healthcare systems are across different countries. The study will use multidimensional comparative analysis techniques, including linear ordering and cluster analysis to assess performance.

The outcome of the research will be a ranking of countries based on healthcare system efficiency, along with an attempt to group them by similar characteristics. The results will help place Poland in an international context, highlight its relative position, and identify potential areas for improvement and reform.

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Hexa

Chern Topological Insulators in Theoretical Models and Numerical Simulations

Topological insulators are materials that, while conducting current on their surfaces or edges, remain insulating in the bulk. A special case of such systems are Chern insulators, in which the quantum Hall effect occurs without the need for an external magnetic field or the presence of Landau levels. Their non-trivial topological structure is related to the so-called Chern number—a quantity describing the global properties of an energy band.

The aim of my presentation is to introduce two computational models that describe such systems. The first is the classical Haldane model, in which introducing complex hopping to next-nearest neighbors in a graphene-like honeycomb lattice leads to a Chern insulator. The second model is based on more recent studies of moiré bilayer structures composed of $MoTe_2$ and WSe_2. In these systems, a moiré honeycomb lattice is formed, where the sublattices reside in separate layers. It has been shown that such a system behaves like a Chern insulator under the application of a small magnetic field.

In the presentation, I will discuss both the theoretical assumptions and the results of numerical simulations performed in Python and with the Kwant package, based on the Haldane model as well as the latest theoretical and experimental research.

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AGH Code Industry - CoIn

Overview of selected modules of the "Archimedes" game engine

In this paper, we will briefly present the "Archimedes" game engine, developed in "AGH Code Industry" scientific circle, and explore details of 3 of its modules:
- Entity Component System
- Audio system
- Resource manager

In part of this paper we will explain how does ECS in Archimedes work. We will discuss data structure used, i.e. sparse set, and algorithms operating on it while analyzing computational and memory complexity. We will present benefits and drawbacks of our solution, comparing it with other methods of organizing components.
We will also present the audio system, which can turn selected objects on the scene into sources of sound. We will discuss loading sounds into memory and control over its state. We will explain what spatial sound is and present its implementation. Moreover, we will show how audio system was intergrated with ECS.
In this paper we will also present a layered architechture of the resource manager in terms of module cooperation in order to minimize I/O overhead, scalability and optimization of runtime resource processing. We will discuss resource processing pipeline and mesh conversion to a format that enables direct mapping to GPU buffers.

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Creative

Omnichain token arbitration system

The developed system is designed for the automatic detection of arbitrage opportunities between decentralized cryptocurrency exchanges operating on different blockchain networks, with a focus on cross-chain arbitrage. The main goal of the solution is to identify price discrepancies between these exchanges and assist users in effectively capitalizing on them.

The system operates in a client-server architecture and consists of two main components: an opportunity scanner and a client application. The scanner analyzes market data retrieved from the DexScreener service, identifies potential arbitrage opportunities, and stores the results in a database. The web application allows users to browse these opportunities and carry out token transfers between networks within a unified interface.

The solution has been tested in real-world conditions, confirming its effectiveness in identifying actual profit opportunities and meeting functional requirements.

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AGH Code Industry - CoIn

Procedural Generation of Corridor-Based Levels in Unity: Design and Performance

Optimization (FPS)

In recent years, games — especially those in the horror genre — have increasingly adopted procedural level generation mechanics. This approach enables the creation of unique map layouts for each playthrough, enhancing the variety of gameplay experiences and encouraging continued exploration even after the player has encountered all available content.

The goal of this project was to design a generator for random corridor-based levels that provides space for exploration while maintaining a stable frame rate (FPS). Performance becomes particularly important when generating larger, more complex maps, where the risk of frame drops significantly increases.

The proposed solution uses systems based on a graph structure representing the map, allowing the game to dynamically determine which rooms should remain active depending on their proximity to the player. This makes it possible to reduce resource usage and improve overall performance in a game developed using the Unity engine.

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Creative

Software and Measurement System Development for a Machine Controlling the Dieless Drawing Process

The project involved the development of comprehensive software and a measurement system for a machine executing the dieless drawing process. The application was adapted to operate in the Windows environment, and the project structure was rebuilt according to object-oriented programming principles, including improved error handling and code organization. Bidirectional communication with an Arduino microcontroller was implemented, enabling full integration between control and measurement systems. An absolute encoder was incorporated, and a dedicated algorithm was developed to calculate strain and strain rate in real time. The data visualization system was also enhanced to allow real-time tracking of test results. The implemented solutions were validated through a series of static tensile tests and multi-stage dieless drawing processes.

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Era Inżyniera

Applications and benefits of augmented reality (AR) in everyday life

The purpose of this lecture is to increase knowledge about augmented reality (AR). Research also shows how AR can be used in everyday life. The lecture presents the following issues: basic issues related to augmented reality (AR), own research, and statistical data on the comfort of using AR, as well as sample products on the everyday market.

The above research showed that augmented reality can not only help in everyday life with simple tasks, but also teach future generations many useful things. In our own research, we presented sample results of temporary use of AR technology. The potential problems that may occur during the use of such technology were also discussed. The last topic in this lecture was explaining how AR technology turns the current world into a virtual one and how these two worlds are connected at the same time. The research also touched on the important and interesting topic of so-called smart glasses, which are currently one of the most advanced devices using AR technology. These glasses are currently available and used by the average person.

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Bit

Implementation of a Framework Supporting the Analysis of Combinatorial Games

The objective of the project was to develop a universal framework to support the implementation and analysis of combinatorial games, as well as to streamline the use of popular game tree search algorithms. The framework enables modelling games that require remembering previous game states, handling complex, multi-stage moves performed in varying order, and operating on abstract boards such as graphs. As part of the project, the following algorithms were implemented: Monte Carlo Tree Search, Minimax (both in its basic form and with alpha-beta pruning), and a module supporting analysis using neural networks.

The framework provides a convenient way to compare the effectiveness of applied algorithms under various parameters, such as the exploration factor and number of iterations (MCTS), or heuristic functions and search depth (Minimax). At the same time, the framework serves as a flexible tool that facilitates the design, testing, and comparison of strategies in combinatorial games. Thanks to its architecture, it also enables rapid implementation of various game theory algorithms and significantly accelerates the process of their experimental verification.

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Automation and Robotics

INTEGRATED SYSTEM FOR COLLECTING, ANALYZING, AND MANAGING HOUSEHOLD UTILITY DATA

People use electricity, water, gas, and other services at home every day. With digital tools, it is now possible to submit meter readings online. However, each utility provider has its website, system, and deadlines, which makes it very uncomfortable to perform the appropriate manipulations. Users must log into several accounts, send data, pay bills in a bank, and remember when to do that. Moreover, in case of issues, many people store photos of meters or record readings on paper.

Our market research revealed the absence of a single tool that simplifies this process. The project aims to develop a platform that will allow users to effectively and quickly manage and transmit data to the provider, pay all their utility bills, store timestamped photos, and set reminders for each utility. Additional features include statistics, monthly cost distribution analysis, and monitoring utility usage.

The platform uses Node.js and Express on the backend, React with TypeScript and Vite on the front end, and PostgreSQL as the database.

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AGH Solar Boat

Structural Analysis of the Housing for a Propulsion System in a Racing Solar Powered Boat

The paper presents an analysis of structural simulations for the housing of a propulsion system in a racing solar-powered boat. It outlines the stages of developing the numerical model and the computational methods applied, with particular emphasis on the finite element method. The analysis focuses on a structure that must combine low weight and favorable hydrodynamic properties with the ability to withstand complex and variable loads encountered during operation. The housing geometry will be tested under various loading scenarios to assess its behavior under conditions resembling real-world use. Special attention is given to the accuracy of the simulation results and their usefulness in designing structural components that must meet strict strength requirements. The conclusions will indicate how these methods can support informed and effective engineering design decisions.

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New-Tech

Knock Detection System Based on ESP32

The goal of this project was to develop a moderately advanced real-time knock detection system based on the ESP32 microcontroller. Engine knock, or knock combustion, is a phenomenon where the air-fuel mixture in the engine cylinder ignites uncontrollably. This results in explosive combustion occurring at multiple points within the cylinder, rather than at the intended ignition point. This phenomenon is harmful as it generates strong vibrations, noise (a characteristic knocking sound), and can lead to damage to engine components such as pistons, as well as potential engine overheating. It reduces engine efficiency and shortens its lifespan. One of the main causes of knock combustion is incorrect ignition timing—if ignition occurs too early or too late, it may result in excessive cylinder pressures and undesirable detonations, leading to knock.

The system was built around the ESP32 microcontroller, which processes signals from a piezoelectric vibration sensor. This sensor captures all vibrations generated by the operating engine. However, it was necessary to implement a technique to distinguish knock-related vibrations from other types. To achieve this, the Fast Fourier Transform (FFT) was used to convert the signal from the time domain into the frequency domain. This allows analysis of the frequency components of the signal. Knock combustion produces vibrations at higher frequencies (typically around 6000–7000 Hz), which makes them easier to isolate and analyze.

The ESP32 microcontroller, due to its high sampling rate (100,000 Hz), meets the requirements for processing signals up to 7000 Hz in accordance with the Shannon-Nyquist criterion. Initially, the Arduino platform was considered, but it was found that its limited sampling rate was insufficient for accurately analyzing knock-related vibrations. Since the signal from the piezoelectric sensor has a low voltage, amplification was required, which was achieved using a microphone amplifier. The amplified signal is then analyzed by the microcontroller, which performs an FFT on the latest 128 samples. If the amplitude in the characteristic frequency range exceeds a certain threshold, the system detects knock combustion and signals it using an LED indicator.

Additionally, the analysis results are displayed on an OLED screen, allowing real-time monitoring of engine operating parameters. The use of the ESP32 microcontroller, instead of a more limited Arduino board, enabled high real-time precision and improved system efficiency. Thanks to the use of commercially available components, the system not only effectively detects knock combustion but is also cost-effective and easy to implement.

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New-Tech

Investigation of the Influence of 3D Printing Parameters Using ABS Filament on the Sealing Performance of Structures Under High Pressure Conditions

Influence of 3D Printing Parameters Using ABS Filament on Structural Sealing Under High Pressure Conditions

The aim of this study was to investigate the influence of selected FDM 3D printing parameters, using ABS filament, on the sealing performance of structures exposed to high pressure. For the purpose of the experiments, a custom-built testing device was developed to simulate pressure conditions equivalent to a depth of 70 meters underwater. A total of 108 hollow cube samples were printed, varying in parameters such as layer height (0.2 mm, 0.3 mm, 0.4 mm), number of outer layers (5, 7, 9), and printing temperature (245°C, 260°C, 275°C).

The tests clearly showed that ABS filament is not inherently waterproof under standard printing conditions. However, selecting appropriate printing parameters can significantly reduce the amount of water that penetrates the printed structure. Additionally, the phenomenon of print swelling was discussed, as it can impact sealing capabilities. The results of this study provide a solid foundation for further research into optimizing 3D printing for applications requiring high pressure resistance and water exposure durability.

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AGH Solar Boat

Optimization of the Delta solar racing boat propulsion unit housing

This paper presents the design and optimization process of the drive unit housing for the innovative Delta solar boat. The main objective was to reduce hydrodynamic drag and improve the overall energy efficiency of the propulsion system. Advanced engineering tools were employed, including CAD-based surface modeling to create a precise geometry of the housing, Finite Element Analysis (FEA) to assess its structural integrity, and Computational Fluid Dynamics (CFD) simulations to evaluate and minimize water flow resistance around the component. An iterative design approach was applied to achieve a balance between mechanical strength and hydrodynamic performance. The final optimized housing demonstrated a significant reduction in drag forces and enhanced propulsion efficiency, contributing to increased range and speed of the solar-powered vessel while maintaining its environmentally friendly character.

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AGH Solar Boat

Comparison of selected FEM programs in engineering applications

The lecture presents a comparison of selected finite element analysis (FEM) tools used in engineering. The paper aims to assess various software solutions' accuracy, efficiency and functionality based on uniform calculation cases. The results obtained from numerical simulations were compared with analytical results, which enabled the assessment of the quality of individual tools. Additionally, the analysis took into account practical aspects, such as ease of use, intuitive interface and the possibilities of expanding and personalising the work environment.

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KiNeMaTicS

Design of unconventional, lightweight, high-performance solid-fluid heat exchanger.

Growing demand for high-performance, lightweight heat exchangers for aerospace and motorsport applications combined with rapid advancements and rising availability of additive manufacturing processes has led to the development of unconventional heat exchangers which were previously impossible to produce. Their geometries are distinguished by sophisticated internal structures mainly Triply Periodic Minimal Surfaces (TPMS) which have been subjected to wide range of research due to their outstanding thermal and mechanical properties. This presentation describes the design process of solid-liquid heat exchanger utilizing TPMS to achieve superior thermal and structural properties. Its primary application is cooling inverters of an electric formula student racecar. There are multiple concepts, both conventional and unconventional, presented and compared. The design process relies on Computer Aided Design (CAD) modeling and Computational Fluid Dynamics (CFD) simulations.

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AGH Solar Boat

Motor selection through torque analysis of the drive of a solar boat

In this year's Monaco Energy Boat Challenge, a new AI Class category has been established. Its main premise is automatization of a boat's navigation, to allow travel without any input from the helmsman. At AGH Solar Boat we have decided to prepare one of our boats, Celka, for the challenge. To select a proper motor for the drive rotation system, I have performed a CFD analysis, in which I have taken into consideration the set of velocities and angles of attack, which the team has deemed as important. I will talk about the measures I have taken to shorten the time or improve the quality of the results. After having considered the worst-case scenario from the obtained results, the imperfections of computational simulations compared to real life, and any friction forces that may yet appear, we have decided the necessary torque our motor should be able to exert.

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AGH Drone Engineering

The Concept of Torque Transmission in a Hybrid Drive System Based on the Example of an Unmanned Aircraft

This paper presents a concept of torque transmission in a hybrid drive system, demonstrated using a model drone that could be built with materials available to a student research group. The main idea is to use a planetary gear system to efficiently control the power of an internal combustion engine via an electric motor, while maintaining low fuel consumption. The aim of the work is to showcase a practical small-scale implementation of such a solution, which could be a step toward broader adoption of this technology in aviation. The paper also addresses key technical challenges that may arise during the design and prototyping phases, and proposes possible solutions to these issues.

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Mechaniki Stosowanej "SIMCAD"

Test stand to examine electric aircraft propulsion systems - design and testing

The aim of the project was to study electric aircraft drives used in small unmanned aerial vehicles (UAVs), including those participating in the SAE AERO Design competitions. The constructed test bench consists of a base, a drive and control system, and a measurement system.

The drive and control system consists of all the components necessary for the operation of the UAV: a 22.2V Li-Po battery, a motor controller, a receiver, a three-phase motor, and a propeller assembly. It is possible to replace the battery with a 24V laboratory power supply. The measurement system allows for the measurement of the thrust generated by the propeller and the current drawn from the battery. The signals from the sensors are transmitted by the Arduino microcontroller to a computer, where the measurement data is recorded.

Using the test stand, measurements were conducted for a brushless motor and propellers 16x10 and 20x10, and based on these, it is also possible to determine the stall and speed characteristics of the drive system. The setup also allows for checking the correctness of the assembly and operation of the drive system components without the need for tests in the BSP.

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Mechaniki Stosowanej "SIMCAD"

Investigation of airfoils for use in unmanned aerial vehicles

The objective of this study was the selection of appropriate airfoils for an unmanned aerial vehicle (UAV). Based on an analysis of the subject literature, a set of five candidate airfoils was chosen, meeting the assumed criteria regarding lift force, aerodynamic drag, and stability within the considered speed range. A preliminary aerodynamic evaluation was conducted in the QBlade environment, using flow simulations based on characteristic Reynolds numbers (Re) for the given case. The software generated plots of polar aerodynamic characteristics, enabling a direct comparison of the lift and drag properties of individual airfoils within the selected flight parameter range.

More advanced analyses were performed using computational fluid dynamics (CFD) tools in the Ansys Fluent environment. The assessment included, among others, the pressure distribution on the airfoil surfaces, the nature of airflow, and potential flow separation areas, allowing for a detailed evaluation of the aerodynamic efficiency of each configuration. To verify the numerical results, experimental tests were conducted in a wind tunnel. The obtained measurement data enabled a comparison of real flow characteristics with simulation results, as well as the calibration and refinement of computational models.

The results of the verified simulations will be used to optimize the drone's geometry. The main goals will be to increase the payload capacity and reduce aerodynamic drag, which will translate into extended flight time.

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AGH Solar Boat

Design of counter rotating drive unit for Delta solar racing boat

This paper presents the design and development of a dual propeller propulsion system powered by a single electric motor for the solar racing boat Delta. The primary goal of the project was to reduce hydrodynamic drag by minimizing the cross-sectional area of the submerged drivetrain components. A major design challenge was achieving a slender and compact structure that could deliver efficient power transmission while maintaining high system performance. The use of two cooperating propellers driven by a single motor enabled a more balanced thrust distribution and improved stability during operation.
This solution represents a balance between performance and energy efficiency, aligning with the principles of sustainable, low-energy water propulsion systems designed for competitive solar-powered marine applications.

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AGH Solar Boat

Numerical Structural Analysis of Carbon Fiber Sandwich Bulkhead System for the Delta Solar Racing Boat

The paper presents a numerical structural analysis of a carbon fiber sandwich bulkhead system designed for the Delta solar racing boat. The primary objective of the study was to determine an appropriate layout and geometry of the bulkhead system, ensuring sufficient load-bearing capacity and stiffness under critical operational conditions of the boat. Two critical loading scenarios, typical for racing conditions, were considered in the FEM simulations: a dynamic drop of the boat from hydrofoil wings and an emergency sharp turn maneuver. Preparation of the simulations included detailed modeling of composite layers in ANSYS ACP, covering definitions of local coordinate systems (rosettes), fiber orientations, and layer stacking with realistic orthotropic parameters for honeycomb cores and PMI foam. Subsequently, the model was transferred to ANSYS Mechanical for comprehensive numerical analyses. The results provided a detailed evaluation of stress and deformation distributions within the bulkhead structure, facilitating appropriate selection of structural parameters. Ultimately, these analyses will serve as the basis for further design work, enhancing the safety and performance of the entire boat.

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Mechaniki Stosowanej "SIMCAD"

Unmanned aerial vehicle meant for the SAE Aero Design competition - conceptual project and design

The goal of our work was the design and construction of an unmanned aerial vehicle (UAV), which is meant to participate in the SAE Aero Design competition, which in turn created guidelines and restrictions for its realisation.

Two variants of 3D models have been made: one for the needs of the pending construction work and the other for CFD analysis. During the design process it had been an important goal for us to create an outline for our work as well as to compile resources in order to be able to complete a similar project quickly and efficiently in the future. To achieve this, a template for designing wings and fuselages with unrestricted variance in their profile along their length was created in AutoDesk Inventor. Additionally, basing on literature, a computational model accelerating design work for this type of UAV was developed.

For the construction, different materials and manufacturing methods were considered and tested. Among them were included: traditional manual wood modelling, modern 3D printing supported by optimization algorithms, as well as the use of a laser cutters, allowing for a compromise between precision and mechanical strength.

Realisation of the project was made possible by a close cooperation with the other sections of our construction group, in particular by the wing analysis team and the propeller-engine performance testing station, which allowed experimental verification of our design approaches.

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New-Tech

Automated smoker design

The project carried out as part of this thesis involved designing and constructing a prototype of a smokehouse, as well as developing systems for the automation or mechanization of the main process variables, based on their importance in the smoking process. The work included the creation of a wooden smoking chamber, a heating system equipped with a PID controller, and a smoke generation system. Tests were conducted to evaluate the temperature regulation quality, identify potential cold spots within the smoking chamber, and analyse combustion conditions in the smoke generator. Additionally, a thermal model of the smokehouse was developed using optimization algorithms. Interviews with other operators of this prototype smokehouse were conducted to assess design flaws objectively. Based on the findings from both the tests and interviews, proposals for further project development were formulated.

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AluminaTi

Strength tests of the rapid solidification EN AW - 6060 alloy

Aluminum alloys, due to their properties, are widely used in various sectors of the economy, e.g.: transport, construction and the food industry. They are widely used all over the world. Samples were made from extruded rods and then strength properties were tested in a tensile test. In the next stage of the research, the influence of heat treatment (precipitation strengthening) on the properties of the tested materials was determined. The extruded and heat treated materials were subjected to fatigue tests. The test results obtained for the rapidly solidified 6060 alloy were compared with the material extruded from the ingot.

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MITHRIL

Coloring titanium jewelry components using oxide coatings.

Jewelry, meaning small items used to adorn the body or clothing, has traditionally been associated with precious materials such as gold, silver, and gemstones. However, an increasing number of other materials are being used—either to imitate these valuable and noble ones or to offer a unique and distinctive appearance, including color.

Colored oxide coatings on titanium result from the phenomenon of light interference on a thin layer of TiO_2. The observed color corresponds to a specific coating thickness, which can be precisely controlled. Two competing methods for producing such coatings will be presented: electrochemical anodizing in electrolyte solutions and heat treatment in an air atmosphere under controlled temperature conditions. The relationships between process parameters (voltage, temperature, time) and the resulting color will be discussed.

The range of colors obtained on titanium substrates will be presented, along with the results of coating thickness measurements carried out using a spectroscopic ellipsometer. Particular emphasis is placed on the practical aspects of coloring titanium jewelry components, including guidelines for their application in jewelry making and an example setup for anodizing.

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Hexagon

Wooden metals: Investigating anisotropy in nature and materials engineering

Natural materials have long served as a rich source of inspiration for engineering structures, often mimicking the patterns and solutions developed by nature. Among these materials, wood stands out as one of the most widely studied and utilized. Classified as a natural composite, wood consists of a distinct matrix and reinforcement phase. Much like synthetic engineering composites, wood exhibits pronounced anisotropy in its mechanical properties - a key factor influencing its functionality and load-bearing capabilities. This study investigates the anisotropic mechanical behavior of three selected wood species: ash, spruce, and larch. Mechanical testing was performed on samples machined at angles of 0°, 45°, and 90° relative to the grain direction, enabling a detailed analysis of how orientation affects mechanical performance. The experimental procedures included uniaxial tensile and compression tests, Brinell hardness measurements, and microstructural examination using scanning electron microscopy (SEM). Additionally, the study explores advanced engineering materials inspired by wood's hierarchical structure and highlights the significance of anisotropy in modern metallic engineering components.

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Hexagon

Analysis of the anisotropy of mechanical properties of titanium Grade 4

The study focuses on the analysis of the anisotropy of mechanical properties of commercial
Titanium Grade 4 (Ti Grade 4), which is widely used in industry due to its exceptional properties, such as high mechanical strength, corrosion resistance, and biocompatibility. The
research was conducted on samples machined at 0°, 15°, 45°, 60°, 75°, and 90° with respect to
the extrusion direction, allowing the evaluation of the orientation on the mechanical properties.
The experimental work included uniaxial tensile tests to determine ultimate tensile strength,
yield strength, and elongation at fracture. Fracture surface observations were carried out using
scanning electron microscopy, and the microstructure and texture were analyzed using the
EBSD method, which enabled the identification of characteristic deformation products and
changes in crystallographic orientation. These studies aimed to understand the anisotropy effect
on the mechanical properties of the material.

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Hexagon

Analysis of the possibilities of producing thin-walled structures from selected metallic materials by the L-PBF method.

The subject of this work was to analyze the possibility of manufacturing thin-walled structures from M300 maraging tool steel using Laser Powder Bed Fusion (L-PBF) additive technology. The research was carried out using the XM200C 3D printer from Xact Metal. The laser power used was 100 W, the layer thickness was 0.03 mm, and the powder size was in the range of 20 to 90 µm. The structures with a height of 10 mm and 20 mm and wall thicknesses of 0.2 mm, 0.4 mm, 0.6 mm, 0.8 mm and 1 mm were evaluated, manufactured at different angles of inclination to the work platform: 30°, 45°, 60°, 75° and 90°. The research aimed to determine the effect of the angle of inclination of the walls on the geometric and structural quality of the elements. As part of the work, 3D scanning was performed, which allowed for the comparison of geometric deviations from the CAD model, analysis of wall thickness and assessment of surface flatness. The initial assessment of porosity using the Archimedes method did not yield reliable results, therefore computed tomography was used, which allowed for a precise characterization of internal defects of selected samples. Surface roughness analysis, microhardness measurements using the Vickers method and microstructure observations using optical microscopy were also carried out. The obtained results clearly indicate that the angle of wall inclination significantly affects the quality of the manufactured structures. The greatest inaccuracies and roughness were observed for samples built at an angle of 30° and 45°, while the 90° orientation allowed for obtaining the highest quality of reproduction and a homogeneous microstructure. The work confirms the validity of considering the orientation of elements as a key technological parameter in the additive manufacturing process of M300 maraging steel using the L-PBF method and provides a basis for further optimization of parameters for the production of thin-walled structures.

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AluminaTi

Selection of the Optimal Welding Method for Steel Structure in Photovoltaic Installation

The aim of this study was to select the optimal welding method for a steel structure designed to support a photovoltaic installation, made from galvanized steel pipes. Three welding methods were compared: manual metal arc welding (MMA), MAG welding with CO_2 shielding gas, and MAG welding with an Ar+CO_2 gas mixture.
The evaluation was based on the analysis of the microstructure and mechanical properties of the welded joints. The results showed that the differences between the methods in terms of joint quality, microstructure, and mechanical performance were minimal. Therefore, the final choice of the optimal method was based primarily on economic considerations.
As a result, the method that offered the lowest execution cost while maintaining the required technical standards was selected as the most advantageous.

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Inspired Science (InScience)

Optimization of Additive Manufacturing Parameters as a Method to Improve the Corrosion Resistance of Maraging Steel M350

The aim of this study was to assess the influence of additive manufacturing parameters using the Laser Powder Bed Fusion (LPBF) method and surface finishing techniques on the corrosion resistance of M350 maraging steel. Samples were produced with varying laser powers (80 W, 100 W, 120 W) and subsequently subjected to mechanical polishing. Corrosion testing included long-term immersion in a 3.5% NaCl aqueous solution and potentiodynamic polarization measurements. Microstructural and surface topography analyses were performed using optical microscopy, SEM-EDS, and confocal laser scanning microscopy.

The results demonstrated that higher laser power improved material consolidation, reduced porosity, and increased corrosion resistance. Mechanically polished surfaces exhibited significantly enhanced protective properties. A notable increase in corrosion rate was observed at 45°C compared to room temperature. These findings emphasize the importance of optimizing printing parameters and post-processing techniques to improve the durability of maraging steel components operating in corrosive environments.

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AluminaTi

Structural and mechanical evaluation of TIG welding possibility for 2017 alloy

Aluminum alloys of the 2xxx series, primarily alloyed with copper, offer high mechanical strength but present significant challenges in welding due to their susceptibility to hot cracking and the deterioration of mechanical properties in the heat-affected zone. Due to these limitations, this study aimed to evaluate the weldability of 2017 aluminum alloy using the TIG welding method with various filler materials.
The research involved welding 2017 alloy sheets using three different filler materials: AlSi5, AlMg4.5Mn, and AlCu4MgSi. The resulting joints were compared in terms of microstructure using optical microscopy and scanning electron microscopy (SEM), along with chemical composition analysis performed by energy-dispersive spectroscopy (EDS). Mechanical properties of the welds were also assessed through tensile testing, hardness measurements, and bending tests.
The study results allowed for the assessment of how different filler materials affect the structure and quality of TIG-welded joints and helped identify the most suitable material combination for welding 2017 aluminum alloy.

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Hexagon

Comparative studies of the microstructure and mechanical properties of rapidly solidified and conventionally cast AZ91 magnesium-based alloy

Magnesium and its alloys, due to their low density, are widely used in industry, especially where weight reduction is essential. Despite many advantages, these materials are characterized by limited plasticity resulting from strong deformation texture, unfavorable grain orientation, and a limited number of active slip systems. To improve the mechanical properties of magnesium alloys, modern and unconventional processing methods are increasingly used, allowing for microstructure modification. This paper presents the results of a study on the AZ91 magnesium alloy, produced using two different methods: conventional casting and rapid solidification. The aim of the study was to determine the effect of the manufacturing method and extrusion temperature on the microstructure and mechanical properties of the material. In the experimental part, detailed microstructural analyses were carried out using scanning electron microscopy (SEM), X-ray diffraction (XRD), and texture analysis. Mechanical properties were evaluated based on uniaxial compression and tensile tests, as well as fracture analysis.

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Hexagon

An analysis of the effectiveness of precipitation hardening heat treatment in welded Al 6082 alloy

This study focuses on analyzing the effectiveness of precipitation hardening heat treatment applied after welding aluminum alloy 6082-T6. The primary objective was to determine the impact of post-weld heat treatment (PWHT) on the microstructure and mechanical properties of MIG-welded joints. The experimental work was conducted on 4 mm thick 6082-T6 aluminum alloy plates, joined in a butt joint configuration using ER5356 filler wire and argon shielding gas. Heat treatment was performed according to the T6 temper condition, using two variants differing in cooling methods post-welding. In the first variant, specimens were air-cooled and then subjected to artificial aging at 180 °C for various durations: 0.5 h, 1 h, 2 h, 4 h, 6 h, 8 h, and 24 h. In the second variant, specimens were water-quenched and aged under the same time–temperature conditions. To evaluate the effects of the heat treatment procedures, Vickers hardness testing and detailed microstructural analyses were conducted. Observations were carried out using optical microscopy (OM), scanning electron microscopy (SEM) with electron backscatter diffraction (EBSD), and transmission electron microscopy (STEM and TEM).The results revealed that both the cooling method after welding and the duration of artificial aging significantly influence the hardness and microstructural uniformity of the welded joints. These findings confirm the effectiveness of precipitation hardening in restoring the mechanical properties of welds in 6082-T6 aluminum alloy. The collected data provide a foundation for further optimization of heat treatment parameters for aluminum joints.

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Creative

Numerical investigation of substrate influence on fractures in PVD deposited TiN thin films

In the era of rapidly advancing industrial integration and digitalization, numerous innovative design solutions for everyday devices are being developed. A key aspect of the production process remains the appropriate selection of materials, which are increasingly being enhanced with thin protective coatings to improve product durability and functionality. In response to the growing demand for high-performance protective layers, advanced methods for the analysis and modeling of thin-film materials are being developed.

One of the critical aspects of numerical studies on TiN coatings deposited with using PVD process is the realistic representation of their columnar microstructure. In this work, a dedicated plug-in was implemented to automate the process of generating column morphology in 2D and 3D models. This module allows for the parametric definition of column density, shape, and distribution, enabling a precise reconstruction of the TiN thin film microstructure in the finite element environment (FEM) for the purpose of evaluating its resistance to complex deformation states.

To verify the accuracy of the numerical model, a Python script with using OpenCV library was also developed. This tool enables automatic processing and analysis of scanning electron microscope (SEM) images, allowing for the identification and comparison of TiN island shapes and sizes obtained from simulations and experimental observations. The implementation of this functionality significantly accelerated the analysis process and enabled an objective assessment of the model's consistency with the actual material structure.

The combination of numerical fracture modeling (XFEM and cohesive elements) with automated image analysis represents an innovative approach to studying the behavior of thin-film structures subjected to mechanical loads, with a particular focus on the influence of substrate mechanical properties.

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Powierzchnia

Green corrosion inhibitors – potential application of floral hydrolates as a corrosion inhibitors for steel in a corrosive environment

Corrosion remains a significant challenge, causing substantial economic losses and environmental damage. One of the key strategies for mitigating corrosion is the use of corrosion inhibitors—substances designed to slow down or completely stop the degradation of metals. While conventional inhibitors are often effective, their use is associated with health risks and harmful environmental impacts. As a result, there is growing interest in environmentally friendly alternatives derived from biodegradable, natural sources.

This study aims to evaluate the potential of hydrosols obtained from rose, lavender, and chamomile as eco-friendly corrosion inhibitors for steel. Hydrosols, which are by-products of steam distillation of flowers, contain water-soluble, polar compounds such as alcohols, aldehydes, phenols, esters, acids, ketones, and ethers—substances that may exhibit anticorrosive properties. Unlike synthetic inhibitors, these natural extracts are non-toxic and more environmentally benign.

The research assessed the effectiveness of these hydrosols as corrosion inhibitors for S355 steel in a 1M hydrochloric acid (HCl) solution. To this end, electrochemical tests (linear polarization), immersion tests, and weight loss measurements were conducted. Surface morphology of the samples after exposure to the corrosive environment was analyzed using optical profilometry and scanning electron microscopy (SEM). Preliminary results suggest that the tested hydrosols can effectively reduce the corrosion rate, making them promising candidates for more sustainable corrosion management

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Hefajstos

Comparative analysis of the effectiveness of sodim tetraborate and argon atmosphere in the diffusion welding process of bimetals

The goal of the project is to compare two methods of protection against oxidation used during the welding process of bimetals:
a protective atmosphere with argon and the traditionally used sodium tetraborate (borax).
As part of the project, welding was carried out on a hydraulic press using both methods, and then their microstructure was analyzed and the welded joint was tested.
The results obtained allowed us to assess the impact of protective conditions on the quality of the joint and the mechanical properties of the material.

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Metaloznawców

Analysis of the microstructure, mechanical properties and determination of the glass forming ability of Zr50Cu40Al10 alloy cast in a stepped mold

The paper presents the synthesis and casting of the glass-forming $Zr_{50}Cu_{40}Al_{10}$ alloy into a step mold, followed by subsequent stages of cast analysis. The newly developed mold is intended to improve the accuracy and efficiency of critical diameter determination.
In this study, a comprehensive characterization of the alloy was performed, including the determination of the critical diameter based on microstructural analysis and X-ray diffraction, as well as the evaluation of selected mechanical properties.

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Era Inżyniera

The influence of austenitizing temperature on the microstructure and hardness of cast steel G200CrNiMo4-4-3

The paper deals with the effect of austenitization temperature on the microstructure and hardness of G200CrNiMo4-4-3 cast steel. The tested cast steel is a high-carbon, ledeburitic alloy used for hot working. The analysis of the results of the study concerns the changes in temperature and its effect on austenitic grain size and the dissolution of carbons. Too low austenitization temperatures can lead to incomplete phase transition, while too high can lead to excessive grain growth. Optimal austenitization allows to obtain a fine-grained martensitic microstructure. The hardness of the material increases with the temperature to a certain level, after which it can decrease. The research shows that the right temperature selection is crucial for the mechanical properties of cast steel. These studies can be crucial in selecting the right heat treatment parameters.

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Metaloznawców

Influence of Laser-Induced Crystalline Phase on the Mechanical Properties of the $Zr_{48}Cu_{45}Al_7$ Amorphous-Crystalline Composite

Metallic glasses are amorphous metal alloys characterized by the absence of long-range crystalline order. They are produced through rapid quenching of molten alloys at cooling rates on the order of 10^5–10^6 K/s to suppress nucleation and growth of crystalline phases. Due to their unique non-crystalline structure, metallic glasses exhibit superior mechanical strength compared to their crystalline counterparts. However, their limited plasticity poses a significant constraint for practical applications. Therefore, research was undertaken to investigate the effect of a ductile crystalline phase embedded within a metallic glass matrix on the mechanical properties of the resulting composite material. In the course of the study, a glass-forming alloy with the composition $Zr_{48}Cu_{45}Al_7$, known for its relatively high glass-forming ability, was fabricated. Plate-shaped samples were cast using the suction casting method into a copper mold, with the cooling system maintained at a temperature of 17°C. The obtained castings were subjected to laser-induced crystallization to produce an amorphous-crystalline composite structure. Subsequent characterization included phase analysis by X-ray diffraction (XRD), hardness distribution measurements, and microstructural investigations. Mechanically, the prepared specimens underwent three-point bending tests to evaluate their mechanical performance, and fracture surfaces were examined using scanning electron microscopy (SEM).

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Metaloznawców

Production and consolidation of powders used as a matrix in diamond impregnated tools

Powder metallurgy technology is used, among others, for the production of metallic-diamond tools, especially working elements of tools. The properties of materials produced by powder metallurgy depend on the chemical composition of the mixture, the type of powder, the parameters of the consolidation process.
The paper presents the possibility of producing inexpensive iron-based powders intended as a matrix in metallic-diamond tools.
A powder containing over 90% Fe by mass was designed and produced using a method developed at AGH and covered by patent protection. The second mixture was prepared from elementary powders. The test samples were cold pressed and sintered.
The obtained sinters were subjected to density, hardness, three-point bending test and microscopic observations. It was shown that as a result of free sintering, sinters with over 95% of theoretical density and a good combination of hardness and bending strength can be obtained.

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Era Inżyniera

Tribological wear processes of CoCr bi-alloy in saliva environment obtained by additive printing technique

Modern dental prosthodontics is of great importance for improving the quality of life of patients who face problems related to the dentition and the masticatory system, which includes the upper jaw, lower jaw and temporomandibular joint. The dynamic development of prosthetic technology now allows the use of increasingly sophisticated methods of producing retentive components with complex shapes. Taking into account the specific conditions in the oral cavity, such as varying loads during chewing, changing saliva pH, the variety of foods consumed, smoking or other external factors, metallic materials used in the production of prosthetic restorations must be characterized by high mechanical strength and appropriate tribological properties. One innovative manufacturing method is the technology of selective laser melting of metal powders, known as Direct Metal Laser Sintering (DMLS). This state-of-the-art additive 3D printing method enables the precise fabrication of metal parts based on a 3D CAD model by selectively sintering layers of metal powder using a laser beam. As part of the research work, tribological wear tests were carried out on samples made by the DMLS method from Co-Cr powder with W and Mo micro-additives both dry and wet. In addition, hardness measurements, surface roughness tests, and microscopic and profilometric observations of the samples after tribological wear processes were carried out.

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Metaloznawców

3D - printed microlattices fabricated via two-photon polymerization for biomedical implant applications

In the context of an aging population and the increasing prevalence of chronic diseases and disabilities, the search for advanced treatment methods has become a priority in modern medicine. Addressing these challenges requires the dy-namic development of technology, including innovative solutions in biomedical engineering. A key area of research involves the topography of the contact interface between an implant and living tissue, which plays a crucial role in the integration of the implant with the host organism.

This study presents a comprehensive approach to the design and fabrication of microlattices intended to serve as scaf-folds for the electrodeposition of metals and metal alloys. The microlattice structures were fabricated using additive manufacturing techniques, specifically two-photon lithography, which enables precise reproduction of complex geom-etries at the microscale.

The primary objective of the research was to develop microlattices with controlled geometry, tailored properties, and optimized printing parameters to enhance the manufacturing process. Preliminary electrodeposition tests were also conducted to evaluate the feasibility of depositing metallic coatings onto the scaffold surfaces.

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Promat

PROMAT AGH

Comparative studies on corrosion of tool materials used for drills.

This paper presents a comparative study of the corrosion behavior of drills made from high-speed steel, high-speed steel with a TiN coating, and WC-Co cemented carbide. The research included gravimetric analysis, open circuit potential (OCP) measurements, and the potentiodynamic method. In the gravimetric study, the mass loss of the samples was measured after being exposed to a 3% NaCl solution for two weeks, followed by a macrostructural analysis of the tested materials. The open circuit potential and potentiodynamic tests were conducted in a 0.1 M H_2SO_4 solution. The OCP method allowed for comparing the electrochemical potentials of the drills and observing changes in potential over time. The potentiodynamic method was used to determine the corrosion current density and to assess whether passivation and repassivation regions were present in the tested materials. The results showed that the WC-Co cemented carbide drill exhibited the highest corrosion resistance. The TiN-coated steel drill demonstrated better corrosion resistance than the uncoated steel drills. Among the uncoated steel drills, differences in corrosion resistance were observed depending on their origin.

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Powierzchnia

The effect of various sintering conditions on microstructural changes in zirconium-based metallic glasses.

The amorphous Cu43Zr43Ag7Al7 (%at.) alloy in powder form was obtained by atomization in an inert gas. Two consolidation methods were used: the Spark Plasma Sintering process at 750°C/35MPa and 900°C/35MPa and High Pressure – High Temperature sintering at 900°C/7,8GPa. Differential scanning calorimetry combined with X-ray diffraction studies showed that the SPS method resulted in complete crystallization, while for sintering at elevated pressure, a partial presence of an amorphous phase was observed. Microstructure studies were carried out using advanced scanning and transmission electron microscopy methods in the materials obtained.

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Metaloznawców

Effect of the sintering atmosphere on the properties of sintered Fe-Cu-Sn-P materials

The present study focuses on analyzing the effect of the sintering atmosphere on the properties of a material with a composition of Fe-Cu-Sn-P, which is a potential matrix for metal-diamond tools. This type of material is characterized by high hardness, good wear resistance and satisfactory ductility, which makes it an attractive solution for the tool industry.

For the study, samples were prepared from a powder mixture of carbonyl iron, iron-phosphorus, alloyed tin bronze powder and nickel powder. The mixture was subjected to cold pressing and then sintering in a protective atmosphere of hydrogen and nitrogen, at two different temperatures: 900 °C and 950 °C. The resulting sinters were subjected to density, hardness, and bending strength tests, and metallographic scans were taken to analyze the microstructure of the materials.

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Metaloznawców

Production and investigation of sintered materials intended for friction linings of brake pads for use in high-speed railway systems

The aim of the research is to develop a material for friction linings of brake pads intended for use in high-speed railway rolling stock. The requirements for this type of material are diverse and can be met by multicomponent composite materials. Among all known friction materials, sinters obtained from a mixture of metallic and non-metallic components best meet these requirements. Metallic components provide the friction material with appropriate mechanical strength, plasticity, and good thermal conductivity. Non-metallic components increase the coefficient of friction and prevent welding and adhesion of the friction surfaces.
Samples for testing were made from copper powder, graphite, and mullite. The mixture was consolidated by cold pressing and sintering, as well as hot pressing. The obtained sinters were subjected to density and hardness testing, along with microscopic observations.

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Metaloznawców

Soldering of aluminum alloys used in the automotive industry - evaluation of microstructure and joint properties

Modern material joining methods, despite the dynamic development of technology, still consider soldering as one of the key joining techniques. Despite the growing popularity of methods such as arc welding, electro-slag welding, gluing, or welding, soldering maintains its position due to the ability to precisely join complex shapes using simple, easy-to-manufacture components.

It plays a particularly important role in industries such as electrotechnics, telecommunications, and automotive. Soldering, as a process that is easy to automate, is also economically advantageous, which further increases its attractiveness and application in industry. The appropriately selected soldering technology allows for high-quality joints while maintaining process repeatability.

The subject of the report is the analysis of the microstructure of soldered joints used in heat exchangers, which are components of various systems employed in premium-class vehicles. The study involved metallographic observations, chemical composition analysis, and hardness measurements in key areas of the soldered joints.

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Section XIII Casting, Metallurgy and Recycling

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Zgarek

Design, execution and selection of the optimal 3D technique in order to fully reproduce the polymer housing

This engineering project describes the manufacturing process of a new polimer housing, designed to hold an old broken case for wireless earbuds. To ensure a proper fit of the cavity with the old case, its surface was 3D scanned in three different technologies in order to obtain its three dimensonal model. Subsequently, dimensions and the time for scanning and processing the scans were compared to determine the optimal method for obtaining the final 3D model, based on which the design of the new polymer housing could be prepared. In the next part of the work, the finalized design was 3D printed using an FDM printer with three different materials. Finally, strength tests were conducted to verify the durability of the produced housings and to simulate the natural conditions of using the case. Based on the obtained data, the best housing for further use was selected. The engineering thesis also examined whether the technologies used have applications for hobbyist purposes.

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Wydział Odlewnictwa

Artefakt

ARTEFAKT
KOŁO NAUKOWE STUDENTÓW
WYDZIAŁU ODLEWNICTWA

Designing and making jewellery inspired by Slavic culture

This study is dedicated to the reconstruction of jewellery worn by Slavic communities in the early Middle Ages, based on archaeological materials found across Europe. The research focuses on the most common types of ornaments, identified in the context of silver hoards and burial finds. The project involved a comprehensive creative process – from examining historical sources and traditional production techniques to the practical creation of finished jewellery pieces. The outcome is a set of unique ornaments that combine cultural heritage with a modern approach to jewellery design and making, using the lost-wax casting method. The study is based on specialist literature in the fields of archaeology and metal casting.

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Wydział Odlewnictwa

Artefakt

KOŁO NAUKOWE STUDENTÓW
WYDZIAŁU ODLEWNICTWA

Project of making an aluminium AlSi9Cu3(Fe) oil pan using high-pressure die casting technology

The aim of the paper is to present the technology of casting an oil pan made of AlSi9Cu3(Fe) alloy using high-pressure die casting (HPDC), as well as to verify the design solutions of the gating and overflow system through computer simulations in the MAGMASOFT® environment. A model of the oil pan was developed, along with geometric and technological analyses, including calculations for key elements of the gating system. Three variants of the gating system with overflows were analyzed, and their effectiveness was evaluated using MAGMASOFT® simulations. The assessment focused on parameters such as mold cavity filling, temperature distribution, metal flow velocity, trapped air, hot spots, and porosity. The results were used to formulate conclusions.

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Wydział Odlewnictwa

Artefakt

ARTEFAKT
KOŁO NAUKOWE STUDENTÓW
WYDZIAŁU ODLEWNICTWA

Design and Production of a Commemorative Medal for the 35th Anniversary of the METAL-KOLOR Sp. z. o. o.

The paper presents issues related to the development of technology and production of a commemorative medal created to mark the 35th anniversary of METAL-KOLOR Sp. z o.o.
The introduction provides a brief history of the company and explores the symbolic and commemorative significance of medals from both historical and contemporary perspectives.
The main part of the article shows a comprehensive overview of the technological process, including model design using computer software, selection of appropriate technologies and materials, mold preparation, and the casting process.
The document contains detailed information on pouring molten alloy into the mold and the final processing steps aimed at achieving a high-quality product.
The article emphasizes the importance of selecting the right technology and materials is emphasized in relation to the precision, aesthetics, and durability of the finished medal.

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AGH Rapid Prototyping

Design, construction and production of a prototype sports brake caliper for motorbikes based on additive technology.

The paper presents design process of a prototype brake caliper intended for a motorcycle, developed with additive manufacturing in mind using the SLM technology and the Ti6Al4V alloy. The objective of the project was to achieve maximum weight reduction compared to the original caliper body while maintaining the required strength under operational conditions. The design was based on an existing brake caliper, manufactured using traditional methods, designed for a sport-touring motorcycle. As part of the work, reverse engineering was utilized with the application of 3D structured light scanning technology, ensuring compatibility with the previously selected motorcycle. The geometry of the prototype caliper was developed based on finite element method (FEM) stress simulation analyses and topology optimization, considering the calculated load system under maximum braking conditions. A total of 15 iterations of FEM analyses were conducted to design and refine the caliper body geometry in CAD software. The result of the work is a computer model of a prototype brake caliper body, whose mass constitutes 39% of the original design's mass, along with the fabrication of a non-functional prototype made of plastic. The paper outlines the design process based on structural optimization for additive manufacturing techniques, demonstrating an approach that can be adapted to the production of a broader range of automotive components.

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Wydział Odlewnictwa

Zgarek

The effect of hardening temperature on the microstructure, hardness and impact strength of chromium cast iron

The aim of this study was to examine the effect of hardening temperature on the microstructure, hardness and impact strength of chromium cast iron. These studies are crucial for optimizing heat treatment parameters, as they enable the determination of the optimal hardening temperature, which helps reduce casting production costs while maintaining the required alloy properties. The scope of the thesis included conducting impact tests, measuring hardness using the Rockwell method and analysing the microstructure. Additionally, a proprietary program written in Python, and ImageJ was used to investigate the relationship between hardening temperature and the volumetric fraction of carbides in the microstructure. The results showed that as the hardening temperature increases, so does hardness, reaching stabilization at 950°C. In contrast, impact strength and the volumetric fraction of carbides decrease with increasing temperature. The study confirms that conscious management of the hardening process can contribute to cost reduction and improvement in the quality of castings.

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Wydział Odlewnictwa

Artefakt

ARTEFAKT
KOŁO NAUKOWE STUDENTÓW
WYDZIAŁU ODLEWNICTWA

Reverse engineering for virtual reconstruction of Bronze Age artefacts.

The aim of the thesis is an interdisciplinary analysis of Bronze Age casting technology based on archaeological artefacts provided by the Archaeological Museum in Biskupin. The artefacts with preserved technological traces and accompanying fragments of casting moulds enable a virtual reconstruction of the production processes using reverse engineering.

The analysis of the diversity of casting technologies used, together with knowledge of the principles of mould design and gating system, was determined on the basis of macroscopic observations, 3D scans and microcomputed tomography (μCT). The results of analytical tests, combined with observations of the surface and structure using computer modelling and simulation methods, allowed for an attempt to reconstruct the casting-mould system and an analysis of the processes of pouring and solidification of castings in moulds.

The work utilised a range of analytical, imaging and reverse engineering methods. The chemical composition of the alloys was determined and the technologies used were analysed, together with an attempt to reconstruct the casting process. Contemporary interdisciplinary research methods and reverse engineering processes enable virtual reconstruction of products from the Bronze Age.

Work carried out as part of the IDUB AGH project, Action D12 Integration of the education process with scientific research, Research education path - edition III for the academic year 2024/25, ID 10927.

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Artefakt

ARTEFAKT
KOŁO NAUKOWE STUDENTÓW
WYDZIAŁU ODLEWNICTWA

Development of technology for the casting of the pump housing from ductile iron GJS-400-15

The objective of the research project presented at the 62nd Metallurgical Conference of AGH Student Scientific Circles was to develop a manufacturing technology for a pump housing casting and to verify it through a simulation of the pouring and solidification processes. A schematic and model of the casting were introduced, and a detailed production technology was devised—including the selection of machining allowances, determination of the parting surface, setting of the pouring time, and specification of the dimensions and design of the gating system. Subsequently, to validate this technology, simulations of the pouring and solidification processes were performed. Based on the results, modifications were introduced and the simulations were repeated, leading to further process refinements.

Over the course of the work, three technological variants were developed, differing in feeder configurations, the use of foam filters, and the application of chills. The first variant included a bottle riser and a foam filter, ensuring laminar metal flow and uniform filling of the mold cavity. However, solidification analysis showed that the riser neck solidified too early, resulting in two areas of porosity within the casting. The second variant involved adding a riser with an exothermic sleeve above the thermal center and increasing the dimensions of the bottle riser. This eliminated porosity in the thermal center zone under the riser, although isolated porosity still appeared in the flange of the casting. The third variant introduced chills on the casting flange to accelerate solidification in the upper flange region and force directional heat flow toward the bottle riser. While this approach reduced the extent of porosity, it did not eliminate it entirely.

Final conclusions from the simulations indicate that further enlargement of the bottle riser is possible, or that a trial casting could be produced and subjected to both non-destructive and destructive testing to fully confirm the results. The work presented demonstrates that proper design and optimization of casting technology can significantly reduce foundry defects, bringing the process closer to achieving a high-quality pump housing casting.

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Artefakt

ARTEFAKT
KOŁO NAUKOWE STUDENTÓW
WYDZIAŁU ODLEWNICTWA

Application of aluminum alloys for firefighting equipment

The aim of this engineering thesis was to investigate the application of aluminum alloys in the production of firefighting equipment, with particular emphasis on water-foam fittings. The thesis presents the characteristics of aluminum alloys, their mechanical properties, and casting technologies used in the manufacturing process of firefighting equipment components. Special attention was given to the analysis of the AlSi11 (AK-11) alloy, which is widely used in the construction of lightweight and corrosion-resistant components.

In the theoretical part of the thesis, the fundamental properties of aluminum and its alloys were discussed, including mechanical strength, corrosion resistance, and their broad applications in industry. Particular focus was placed on Al-Si alloys, characterized by high castability and suitability for casting technologies. The thesis also described the processes of metal mold casting (permanent mold casting), highlighting their advantages such as high precision, repeatability, and improved mechanical properties of castings. Furthermore, the diversity of water-foam fittings, including distributors, nozzles, and hydrant stands, was presented, emphasizing their strict operational requirements.

In the research section, detailed analyses of the chemical composition of firefighting equipment components obtained from a volunteer fire department (OSP) unit were conducted, followed by experimental melts based on the obtained results. The resulting samples underwent metallographic analysis and mechanical property testing, such as tensile strength measurement, elongation, and Brinell hardness testing. Thermal analyses were also performed to determine the effect of alloying additives on the crystallization process of the studied alloys.

The research results revealed that the aluminum alloys used in the analyzed components did not fully meet the requirements specified in material standards. The components were made of the AlSi11Cu2FeZn alloy rather than the declared AlSi11. It was found that permanent mold casting technology, due to faster heat dissipation, significantly improves the mechanical properties of castings compared to sand casting. Moreover, the alloy modification process using strontium demonstrated a positive effect on the silicon structure and the plastic properties of the studied materials. The results confirmed that aluminum and its alloys play a crucial role in the construction of modern firefighting equipment, offering an advantageous strength-to-weight ratio, high corrosion resistance, and the ability to precisely shape components.

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Artefakt

ARTEFAKT
KOŁO NAUKOWE STUDENTÓW
WYDZIAŁU ODLEWNICTWA

The influence of vacuum on the quality of die castings.

One of the key challenges in high-pressure die casting is the reduction of porosity, which affects the functional properties of cast components. The aim of this study was to determine the impact of vacuum technology on the quality of castings produced by the high-pressure method. Comparative tests were conducted on two production series — with and without the use of vacuum — under identical process parameters. The quality assessment of the castings was carried out under industrial conditions, based on visual inspection and radiographic analysis. The results confirmed the effectiveness of vacuum technology in reducing gas porosity, which may serve as a basis for further optimization of the casting process design.

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Zgarek

Investment Casting of Propeller Blades

The aim of this paper is to present the process of designing and selecting the manufacturing technology for precise blades with thin edges, intented to enhance the performance of a boat. Due to the difficulties in achieving the required accuracy using plastic materials, it was decided to employ investment casting technology. The paper discusses the stages of technological design, including the selection of suitable materials and the analysis of blade geometry. It also presents the results of computer simulations, which made it possible to evaluate the effectiveness of various technological variants and confirmed the validity of the chosen solutions. The work completed so far, such as the preparation of molds and models, is also described. In conclusion, the paper summarizes the findings and outlines future directions for the project, including the possibility of changing the casting technology.

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Promat

Incremental Sheet Forming – Design of a Device Based on a 3D Printer

The project involved modifying a 3D printer to adapt it to the process of incremental sheet metal forming. A key aspect was the design of a device based on the 3D printer's framework, using components produced by FDM technology. An important element was the design of a sheet mounting frame and the development of a shaping tool compatible with the printer head. The project also included the development of a method for generating G-code that allowed the head to move correctly in the negative Z-axis direction, as required by the incremental forming process. An effective method for generating the control code was developed, enabling precise sheet metal forming. Tests of the device were conducted on selected model geometries, using aluminum sheet with relatively high ductility.

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Metalurgii Surówki i Stali

Development of LPBF process parameters for new Al alloys for elevated temperature applications.

Currently, new aluminum alloys are among the most extensively studied materials in Laser Powder Bed Fusion (LPBF). The goal is to develop new and improved alloys with low cracking susceptibility and good strength at elevated temperatures. This study presents preliminary parameters for producing highly spherical powder using Ultrasonic Atomization (UA), as well as LPBF parameters optimization for a novel AlFe6Cr4MoNb alloy.

The UA-produced Al alloy powder was used to determine the LPBF process window. The lowest porosity values (<0.3%) were obtained within an energy density range of 46–55 J/mm^3. Lower values resulted in lack-of-fusion porosity, significant elemental segregation, and the presence of large primary precipitates. In contrast, higher energy input led to keyhole-type porosity but improved microstructural homogeneity. Microstructural analysis revealed numerous submicron precipitates in the aluminum matrix, and the observed segregation was attributed to the high dynamics of the process. The results indicate a need for further research to improve microstructural uniformity while maintaining minimal porosity, as well as to better identify the precipitates.

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Metalurgii Surówki i Stali

Influence of parameters and scanning strategy in laser powder bed fusion on surface roughness of low alloy steel

3D printing (additive manufacturing) enables the manufacturing of complex elements layer by layer based on a digital model. One of the most precise methods is Laser Powder Bed Fusion (LPBF), which, despite advantages such as high accuracy, still generates significant surface roughness, making it insufficient for high precision applications.
This study examined the impact of process parameters (laser power, scanning speed, and scanning strategy) on the side surface roughness. Twelve samples were printed, mainly using the meander strategy with a 90° rotation between layers. The lowest roughness (Sa ~12 µm) was achieved for a sample produced with parameters of 140 W and 1400 mm/s. In contrast, the strategy with a 67° rotation did not improve the result (Sa ~16 µm), while the addition of a contour scan and sandblasting significantly reduced Sa to around 9 µm. The results show that achieving lower surface roughness requires both the optimization of LPBF parameters and the use of appropriate surface treatment. Combining these approaches allows for improved surface quality, which is essential in industrial applications.

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AGH Eko-Energia

Analysis of methods of applying a UV-resistant protective coating for carbon fiber reinforced epoxy composites.

The purpose of this report is to analyze methods for applying a UV- resistant protective coating to large carbon fiber-reinforced epoxy composites, such as the chassis of the electric vehicle "Perła," developed by the AGH Eko-Energia student research group. The study will be conducted by the authors of the report. The paper will discuss the method currently used for producing this surface layer and explain why it cannot be applied at the current stage of the project. The report will clarify the purpose and importance of the protective coating. In particular, various industrial methods for applying the protective layer—such as spraying, rolling, and brushing—will be examined. The analysis will be carried out on samples replicating the structure of the actual component. The report will compare the benefits and limitations of each method based on specific evaluation criteria. Finally, the most effective method for applying the protective coating to large surfaces will be identified.

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Hefajstos

Determination of the durability of the joint of hammer forging tools using thermal fit

Interference fits, also known as shrink fits, are commonly used for joining machine components and tools designed for cold forming processes. This study investigates the phenomenon in detail, focusing on its application for hammer forging tools. Specifically, it addresses die assemblies that consist of a base part and a replaceable insert. The components are joined using a thermal interference fit.

A key objective is to determine the optimal stress intensity values in the connection zone between the components. Both analytical calculations and numerical simulations will be performed to analyze different joint configurations. Additionally, a testing methodology will be developed to evaluate the joint quality and the forces required to disrupt the connection.

The aim of this research is to define the optimal conditions for joining tool components used in hammers forging process, ensuring high tool performance and operator safety in industrial forging conditions.

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Hefajstos

The impact of reduced heating temperature on the forging process and quality of industrial anchors

The study focuses on analyzing the impact of reduced heating temperature on the forging process and the mechanical properties of anchors forged from ribbed bars. The research was conducted to explore the possibility of forging anchors at lower temperatures in order to reduce the energy required for billet heating. The work was based on computer simulations using the QForm software and industrial-scale anchor forging. The results showed an increase in the initial forging force as the forging temperature decreased. The mechanical properties of anchors forged at lower temperatures were examined. It was found that in most cases, the products met quality standards. At the same time, the temperature reduction led to lower energy consumption and thus lower energy costs. The final results suggest the need to find an optimal compromise between product quality and the energy efficiency of the forging process.

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Creative

Construction of a device and implementation of software for performing uniaxial tensile tests.

The project involves the construction of a device and the development of software for conducting uniaxial tensile testing. The machine is responsible for the uniform stretching of selected elements. The system enables the study of the mechanical properties of materials. A key component is image analysis, which allows for calculating the specimen's strain during the test. The software generates visual charts, facilitating the interpretation of results. Data is recorded for further analysis. The application synchronizes force measurements with strain data. This testing setup enables faster and more cost-effective testing, and most importantly, it is mobile, allowing it to be transported from one location to another.

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Creative

Robotic single-point incremental forming workstations as an efficient solution for low volume production and prototyping

With the dynamic development of modern industry, there is a growing demand for custom-made products from steel, aluminum, and copper alloys—particularly thin-walled components with complex shapes used in architecture, automotive, and aerospace sectors. Due to the economic aspects of production and the limitations of traditional stamping methods, the main objective of the project was to develop robotic laboratory workstations that enable rapid prototyping and extensive research on sheet metal forming technologies for low-volume production.

The research was based on the single point incremental forming (SPIF) method, utilizing industrial robotic arms from Dobot and Kawasaki. The developed system allows for the precise manufacturing of non-standard shapes, meeting the requirements of small-batch production while maintaining high geometric accuracy.

The study presents a detailed description of the development process of the sheet metal forming workstation, with a focus on designing toolpath generation algorithms and implementing a communication protocol between the software and the robotic arm. Finally, the results of a series of operational tests are presented, including an analysis of the forming process for various materials and an evaluation of the geometry and quality of the final products.

Research carried out under the IDUB grant titled “ROBOSPIF Project – Single Point Incremental Forming of Sheet Metal Using a Robotic Arm and 3D Printing” (application no. 9027, Action: D12, Edition: IV).

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Metalurgii Surówki i Stali

The influence of local thermo-mechanical treatment on the mechanical properties and microstructure of additively manufactured AlSi7Mg alloy

Additive manufacturing, particularly laser powder bed fusion (PBF), are increasingly used for producing aluminum alloy components with complex geometries. Despite high precision, additively manufactured parts often exhibit porosity and residual stresses, which can negatively impact their mechanical properties.
The aim of this study was to evaluate the influence of localized thermo-mechanical treatment on the mechanical properties and microstructure of four variants of AlSi7Mg samples produced by LPBF. Selected samples underwent localized thickness reduction using a hydraulic press.
The research included uniaxial tensile tests, deformation analysis via numerical simulations, and microscopic observations to assess microstructure and porosity. The results showed that local plastic deformation, especially when combined with heat treatment, leads to significant changes in mechanical properties, including improved ductility and localized strengthening.
The findings suggest the potential of using complex thermo-mechanical processes to enhance the quality of additively manufactured components, although further research is needed to determine optimal processing parameters.

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Creative

Functionality Enhancement and Structural Modernization of a Machine for the Dieless Drawing Process

The project focused on modernizing a machine used in the dieless drawing process, both in terms of its mechanical design and functional capabilities. The work included redesigning the carriage mechanism of the heating system, which led to improved process precision and repeatability. The machine's operational scope was extended to allow the execution of multiple multi-stage dieless drawing processes within a single run. Additionally, the system was adapted to support static tensile tests with control over the strain rate. An absolute encoder was integrated, and an algorithm was developed to convert measurement signals into relevant mechanical parameters of the specimen. The effectiveness of the implemented solutions was validated through a series of tensile tests and analysis of results obtained during dieless drawing processes.

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3AXES

Research on Composite Materials with Copper Particles Manufactured using Additive Selective Laser Sintering Technology

The presentation outlines research on the potential use of 3D printing via Selective Laser Sintering (SLS) technology for the fabrication of polymer matrix composite materials with copper powder additives. The talk introduces the 3D printing technology employed in the project and discusses the materials used within the SLS method. The scope of the research presented includes the implementation of a project aimed at developing a durable, flexible, and simultaneously antibacterial material intended for public use. In presenting the project's original findings, the initial focus is on the selection process for the powder mixing method, followed by the presentation of results from microscopic analyses, mechanical testing (hardness and compression), and antibacterial testing carried out in collaboration with the "Mygen" Scientific Society (Faculty of Biochemistry, Biophysics, and Biotechnology, Jagiellonian University in Kraków). The latter part of the presentation introduces the concept for the next phases of the project, which will include studies on impact resistance, abrasion resistance, as well as analogous research using silver as an additive.

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Hefajstos

Analysis of the possibility of using 34HNM steel for dynamic hot die forging tools

Tools used in metal forming processes must meet a number of stringent requirements, especially in the processes of dynamic shaping of workpieces at high temperatures. The need to generate savings forces forging manufacturers to look for new solutions related to the reduction of production costs, including, among others, in the area of production and operation of the tools used. The results presented here concern the evaluation of the suitability of 34HNM steel for use on tools used in dynamic hot drop forging processes. A literature review of typical materials used in such technological processes was conducted. In the research performed, special attention was paid to the microstructure analysis and hardness measurements of 34HNM steel both before and after heat treatment. In addition, the material's impact toughness was evaluated at different temperature variants, which made it possible to determine its behavior under operating conditions. The results of the study made it possible to assess the effect of heat treatment on changes in the microstructure of the steel and their significance for mechanical properties such as hardness and impact strength.

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Telephoners

CYBER SHIELD - A PLATFORM FOR IDENTIFYING AND ANALYZING CYBER ATTACKS

The goal of the project is to create a platform that helps users recognize and analyze cyberattacks in real time. The solution will offer a web interface where a person who suspects a security breach can enter information about the symptoms of an attack (e.g., unusual system behavior, phishing attempts, or attempts to encrypt data). A custom-developed language model, trained on specialized data corpora related to cybersecurity threats, will analyze the report, identify the potential type of attack, and suggest possible solutions or recommend a consultation with a specialist available 24/7 on the platform. Unlike other commercial solutions, which usually rely on external, closed-source artificial intelligence systems, the project aims to develop its own language model. This model will be specialized in cybersecurity and computer-based attacks, allowing for much higher diagnostic accuracy and better adaptation to changes in the threat landscape (e.g., recognizing new varieties of phishing attacks, ransomware, or exploits). Training of the model will be based on publicly available analytical reports, security incident databases, and specialized industry forums and publications. A key innovation of the solution is the combination of natural language processing algorithms with contextual analysis — the system will understand descriptions of situations, not just search for keywords. This will enable the detection of rare attacks or unusual symptoms that are often missed by popular, rigidly defined threat detection systems. The project includes several stages of implementation. First, data on different types of attacks, such as phishing, ransomware, DDoS, exploits, and spyware, will be collected from industry reports and incident databases. The data will then be cleaned, anonymized, and categorized accordingly. Based on this, a language model using TensorFlow will be implemented in the Google Colab environment — it will be trained to accurately recognize patterns that suggest particular types of attacks. The platform will be developed in a client-server architecture. The NLP model, along with the logic layer, will be hosted on the server (e.g., in Python), while the user interface will be developed in JavaScript.

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Telephoners

Audio denoising using ML

The goal of this project is to develop and train an AI model capable of removing characteristic audio artifacts ("clicks") from vinyl record recordings. These clicks are typically caused by dirt or micro-damage on the record surface. The solution aims to automatically filter out such disturbances without manual cleanup or traditional filters, which often lack effectiveness. If building a click-removal model proves too complex, the project will be limited to removing Additive White Gaussian Noise (AWGN) from audio signals.

The project will be implemented in Python using NumPy, SciPy, and PyTorch. It includes data preparation, neural network implementation, training, validation, and final testing. Unlike conventional signal processing methods, this approach leverages machine learning to intelligently identify and eliminate specific noise without degrading audio quality—a challenge for standard algorithms. The project also has potential for future development in cleaning archival recordings, offering value to both analog music enthusiasts and institutions focused on audio preservation.

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Telephoners

RGBQR – Colored QR Codes with Increased Data Density

RGBQR – Colored QR Codes with Increased Data Density
The aim of this project is to develop and implement solutions that enable an increase in the data density stored in two-dimensional matrix graphic codes, particularly QR codes Model 1, 2, 10, and 40. The implementation of software that allows generating and reading these codes is planned to be carried out using the Python programming language along with available libraries. For testing and studying the readability of the generated codes, standard inkjet printers and digital cameras used in smartphones or digital scanners are planned to be utilized.
The possibility of increasing the data density stored in a QR-type code will be achieved by the RGB colour palette, allowing more than 1 bit to be encoded in a single module of the code. Two possible approaches to achieving the intended result are considered:

- Splitting the information into 3 parts, encoding each part using the saturation of a single colour: red, blue, or green, and then combining the three images into one to triple the data density.
- Assigning specific bit sequences to colours and then creating a two-dimensional matrix graphic code from them, either in accordance with the standard QR code information encoding algorithm or a custom-developed one.

Increasing the data density in a QR code will allow both for a higher volume of information to be stored in a code and for a reduction in the size of existing codes. Potential applications of RGBQR codes may include storing links and short messages, transmitting product information, e-prescriptions, storing and transferring small amounts of essential data (e.g., medical data) in the case of natural disasters or widespread telecommunication failures, storing contact details on business cards, and many more. The use of a broader colour palette in two-dimensional matrix graphic codes is a topic that is not widely explored, which is why further analysis may provide a better understanding of the possibilities for their physical implementation and performance in practical applications.

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AGH Drone Engineering

New Threat Vectors and Innovative Protection Strategies for Neural Networks in the Context of Attacks on Artificial Intelligence Systems

With the rapid development of artificial neural networks (SNNs) and their widespread use in key economic sectors, new and highly sophisticated cyber threats are emerging. The paper will present the latest types of attacks targeting SSNs directly, such as model poisoning, adversarial attacks, and manipulation at the machine learning stage, which can lead to erroneous decisions of AI systems and serious business and social consequences.

Innovative techniques for cybercriminals to use AI will also be discussed, including generating convincing phishing, automating brute force attacks and using deepfake for social engineering and phishing. Particular attention will be given to the challenges of identifying and neutralising these threats in real-time and the role of generative AI in cyber defence, from automating threat analysis to intelligently supporting SOC (Security Operations Center) operators.

The aim of the talk is to provide practical recommendations for threat modelling and risk management in the context of SSN, and to present the latest security standards and norms being developed at the European and global level. The paper will provide attendees with an understanding not only of current threats, but also of future directions for AI systems security, highlighting the importance of an interdisciplinary approach and continuous adaptation to the evolving cyber threat landscape.

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Duality and price equilibrium in selected economic models.

Mathematical economics is one of the key areas of economic analysis, enabling modeling and prediction of economic phenomenausing mathematical tools. In particular, models of exchange and production provide a theoretical foundation for studying market mechanisms, price equilibrium and optimization of economic decisions.
Particular attention is paid to the model of international trade. Production models are described, including the Leontiev model, the von Neumann growth model and the general linear production model, which are widely
applied in economic analysis.

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Telephoners

Acquisition and Analysis of Cyberatack Data Using a Honeypot System

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ACQUISITION AND ANALYSIS OF CYBERATACK DATA USING A HONEYPOT SYSTEM

The goal of the project is to launch an environment for monitoring potential cyberattack activity using a honeypot system and to thoroughly analyze the collected data. The project assumes the implementation of a set of network traps that simulate various vulnerable services and systems in order to record unauthorized network traffic. This will make it possible to collect real data on bot behavior, port scanning techniques, and attempts to exploit known vulnerabilities.

As part of the project, a virtual environment in Microsoft Azure cloud will be created, which will be publicly accessible from the Internet. On the prepared virtual machine, the advanced honeypot framework T-Pot will be deployed, integrating various network trap services such as Cowrie, Dionaea, and Honeytrap. A key stage will be the appropriate configuration of the system in such a way as to faithfully simulate a real production server operating in a cloud environment. For this purpose, ports associated with the most commonly used services will be opened, including 22 (SSH), 23 (Telnet), 80 (HTTP), 445 (SMB) and 1433 (SQL Server). This configuration will help attract the attention of bots, automated scanners, and real attackers, and increase the chances of recording various attack attempts and exploitation methods, as well as allow for the capture of malware samples, which is a key element of the project's scientific value.

The project is primarily intended to be research and analytical in nature. The collected data – including, among others, source IP addresses of attacks, used vectors, types of scans, and login attempts – will be analyzed in terms of frequency, geolocation, the specifics of techniques used by attackers, and time-based trends. A key element of the project will be data visualization and classification of attack types using ELK stack tools (Elasticsearch, Logstash, Kibana). This analysis will not only allow for a better understanding of the current threat landscape but also enable the development of conclusions regarding the effectiveness of passive detection methods and attacker behavior in contact with different service configurations.

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Telephoners

MOBILE APPLICATION – I KNOW WHAT I HAVE

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MOBILE APPLICATION – I KNOW WHAT I HAVE

The project of the mobile application “I Know What I Have” is aimed at smartphone users who wish to efficiently manage their food supplies at home. The main goal of the application is to reduce food waste and save time by automating the meal planning process.

The application will be developed using Flutter technology and the Python programming language. The project will include a barcode scanner feature, allowing users to quickly add food products to a virtual inventory. Based on this inventory, system will analyze available ingredients and suggest meals that can be prepared with them. Additionally, a food recognition system based on product photos is planned to be added.

The “I Know What I Have” project aligns with current trends in sustainable development and conscious consumption. Thanks to this application, users will gain a practical tool that facilitates everyday food stock management, reduces food waste, and simplifies the cooking process.

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Telephoners

Smart Lock

The aim of the project is to create a smart lock controlled by an app on a phone. This lock will only open when the phone with the app is in close proximity to it. The application will be additionally authorised by utilising a biometric reader embedded in the phone. The project will use UWB (Ultra WideBand) technology, with the help of which the lock will detect that it is in close proximity to its key (phone). An arduino module will be used as the operating computer for the lock, with a UWB network-enabled module installed, which will connect to the phone. This lock will only be able to be opened in close proximity to the phone with the application, using very accurate distance determination via the UWB network. Then the app, after confirming the identity, will allow the lock to be opened. You can also configure the option to automatically connect and open the door when you are close to it. The configuration will include: an electromotive lock, an arduino module, a UWB module for the arduino and a phone with a built-in UWB module.

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Telephoners

AGH Rescue Drone - connectivity system

AGH Rescue Drone - connectivity system
The aim of the project is to design and use Wi-Fi and 5G wireless communication systems to provide access to the Internet and the ability to make voice calls. The developed solution will be prepared for installation on an unmanned aerial vehicle and use of battery power. To provide Wi-Fi Access Point functionality, hostapd and dnsmasq utilities will be utilised. Configuration will be performed via a web application based on the Flask framework. In addition to configuration, the web application will enable monitoring of system parameters in real time and visualisation of time series related to each metric. To fulfill transmission requirements of different service types, configuration of multiple traffic classes and packet queuing policies will be implemented. Traffic will be classified by user-configured filters and a model trained on ISCX VPN dataset.

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Telephoners

NETWORK ATTACK DETECTION AND VISUALIZATION SYSTEM USING MICROSOFT AZURE CLOUD

The aim of the project is to create a system for detecting and analyzing anomalies in network traffic using Microsoft Azure cloud services. The project consists of three main stages: network traffic generation, attack detection, and data visualization.
In the first part, a Python-based application will be developed to simulate various types of network attacks, such as DDoS (Distributed Denial of Service) and port scanning. Next, the data collected through Azure Sentinel will be analyzed to detect anomalies. Additionally, the use of Azure Machine Learning will allow for training a model to automatically identify unusual traffic patterns.
The final stage will involve creating an interactive dashboard using Flask as the backend and Grafana for data visualization. The system will enable real-time presentation of analysis results and live monitoring of network traffic.
This project demonstrates a practical application of Azure cloud to enhance network security and threat identification, which is especially important in the context of today's cybersecurity challenges.

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Telephoners

Prototype of a chatbot application supporting the first line of support in order to effectively resolve issues reported by end users

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PROTOTYPE OF A CHATBOT APPLICATION SUPPORTING THE FIRST LINE OF SUPPORT IN ORDER TO EFFECTIVELY RESOLVE ISSUES REPORTED BY END USERS

The aim of the project is to create a chatbot application that a customer will contact to ask a question related to the store's website and/or purchase. The chatbot's purpose is to provide fast and precise answers, eliminating the need to contact the customer service for simpler inquiries. The application will be trained to handle FAQs (Frequently Asked Questions), complaints and personalization of purchases.

To achieve the project's goal, a Large Language Model (LLM) will be used and further trained on specialized data related to the store's operations. Additionally, the model will be corrected using appropriately prepared prompts, which will allow it to better understand the intentions of customers and provide more accurate answers. The chatbot will be implemented as a chat application, starting with data collection from sites such as Hugging Face, and will then be tested and improved. The project will utilize LLM models from the most popular solutions, such as ChatGPT and DeepSeek. The implementation of the project will allow for adjustments to the initial behavior of the trained model. Sentiment analysis will enable the chatbot to recognize negative emotions in order to appropriately adjust the tone of the conversation.

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Telephoners

Analysis and Cryptographic Adaptation of Hashing Algorithms in the Context of Ternary Systems

The paper presents an analysis and adaptation of popular hashing algorithms, SHA-1 and SHA-256, for use in ternary systems, which operate on three logic states instead of the traditional binary (0 and 1). The project focuses on converting bitwise operations—such as XOR, AND, ROTR, and ADD—into their ternary equivalents using trits, and implementing simplified models of the algorithms in Python. The main objective is to evaluate how the transition to ternary logic affects the properties of the hash functions, including the length and entropy of the generated digest, resistance to collisions and preimage attacks, and computational efficiency in terms of time and resource usage. The final outcome will include a set of Python tools for experimental hashing based on ternary logic, as well as a comparative report. The project aims to support further research into alternative logic architectures and their potential applications in cryptography.

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Telephoners

Experimental Verification of the Feasibility of Conducting Advanced Wi-Fi Attacks Using Different Models of Network Cards

The aim of this project is to investigate the feasibility of modifying firmware to enable advanced attacks on Wi-Fi networks. Many such attacks were previously described in the publication “Advanced Wi-Fi Attacks Using Commodity Hardware” (ACSAC 2014) by Prof. Mathy Vanhoef; however, this project aims to use different models of Wi-Fi cards than those based on the Atheros AR7010/AR9271 chipset. This research will verify two key aspects: the feasibility of modifying the firmware of alternative Wi-Fi cards, and whether after such modification it is possible to carry out all five attacks described in that prior work – namely, unfair channel usage, bypassing defense mechanisms, continuous jamming, selective jamming, and a channel-based man-in-the-middle (MitM) attack. All experiments will be conducted using the Linux operating system, as it provides relatively straightforward means to modify Wi-Fi driver code. The project is primarily practical in nature, focusing on experimentally verifying the effectiveness of these attacks and the capability of firmware modification; however, if technical difficulties are encountered, a theoretical analysis will also be considered.

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Spectrum

E-MOTO AGH – TELEMETRY SYSTEM PROJECT FOR A MOTORCYCLE COMPETING IN THE MOTOSTUDENT VIII EDITION

The project involves the development of an electronic and teleinformatics system for comprehensive telemetry support of an electric racing motorcycle. The system will consist of a series of interconnected subsystems that span various thematic areas.
The first planned subsystem is a set of electronic control and measurement circuits responsible for monitoring key physical quantities occurring within the motorcycle. These control and measurement units will be connected via a dedicated wired computer network, which will enable their integration with the onboard computer subsystem.
The onboard computer is a specialized computing system used, among other things, for operating the motorcycle's cockpit display, aggregating data from the control and measurement subsystem via the computer network, performing preliminary data processing, and transmitting measurements and motorcycle status wirelessly to a remote IT system.
The final subsystem included in the project is a cloud-based IT system responsible for aggregating, presenting, and performing advanced real-time analysis of the motorcycle's telemetry data. The system is intended to support the work of the engineering team, mechanics, and operational and support personnel during test runs as well as actual races.

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Telephoners

AGH RESCUE DRONE – Artificial intelligence model extending rescue operations in mountainous areas

As part of the project, the first version of a model will be developed to detect potential casualties in images transmitted from drones. For this purpose, object detection architectures such as YOLO will be utilized. Additionally, the team's work will focus on optimizing the model's effectiveness in object detection, taking into account requirements specific to rescue operations: high accuracy, and hardware constraints that allow for low-latency inference on limited computational resources.
The model is a significant component of the AGH Rescue Drone faculty project. Its goal is to support the crisis response team during search and rescue operations in challenging environments, specifically mountainous terrain. When the crisis team commander sees a high probability of a human presence in a given area, they can dispatch a search team accordingly. The dataset will include images obtained through collaboration with the Faculty of Geoengineering, Mining and Geology (WGGiIŚ), as well as photos taken during the implementation of the project, all with labeled annotations. For data labeling, we have chosen the open-source tool Label Studio, which we have hosted on our own server.

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Cipher

DoS detection system for IoT networks using machine learning

The paper addresses the issue of detecting Denial of Service (DoS) attacks in Internet of Things (IoT) networks using machine learning techniques. In the era of increasing number of IoT devices, security of these networks becomes crucial, especially in the context of threats of malicious activities overloading the infrastructure. The work focuses on securing Internet of Things (IoT) networks in the context of threats from malicious activities overloading the infrastructure. The work discusses the specifics of DoS attacks in IoT environments and the challenges of detecting them. An overview of selected supervised machine learning methods, such as decision trees or the maximum margin classifier (SVM), which are used to classify network traffic into correct and attack-related, is presented. The purpose of the paper is to show the potential of machine learning as a tool to help protect IoT networks from DoS attacks, and to highlight the need for further research in this direction.

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Cipher

Application of post-quantum cryptography in IoT networks.

The gradual development of quantum computer technology promises access to breakthrough computing power. Unfortunately, it also brings about significant risks to digital security as we know it today. These concerns prompted initiatives to introduce post-quantum cryptography - they offer vastly improved security in quantum computer context, but require significantly more compute power to keep comparable communication efficiency. Our research aims to test the feasibility of implementing post-quantum solutions in existing IoT infrastructure based on the widely used ZigBee protocol. These networks are becoming an attractive attack target - in 2022 alone, over 112 million attacks on IoT networks were recorded, and this number is rising steadily year-over-year. IoT devices tend not to have significant compute resources, which might result in a noticeable impact on network throughput when implementing a more demanding cryptographic protocol. We think that a solution compatible with existing ZigBee devices is key to widespread adoption, especially among end-users in a smart home context.

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Telephoners

KRAKVENTURE – WEB APPLICATION FOR CRACOW RESIDENTS

The goal of the project is to create a modern web application that enables Cracow residents to efficiently search for and review sports facilities. The application will provide detailed information on the availability, functionalities, and occupancy of venues, while also allowing users to share their experiences through a review system. A key component of the solution will be an advanced recommendation system based on Retrieval-Augmented Generation (RAG), which will significantly improve search result relevance and personalization of recommendations. The application will consist of three main modules:

- Sports facilities overview - an interactive map and a list of venues with filtering options based on location, type of sport, and available amenities,
- User reviews and ratings - a review system where users can submit textual feedback and rate facilities on a 1 to 5-star scale,
- Intelligent recommendation system - an innovative RAG-based model combining traditional information retrieval methods (e.g., feature-based filtering) with generative AI. This model will use user queries and available data (such as community reviews, search history, and real-time occupancy data) to generate accurate sports facility recommendations.

The key distinguishing feature of the project is the use of RAG for intelligent facility search. Unlike traditional recommendation systems that rely solely on filters and rankings, RAG integrates a knowledge base (including user reviews, facility availability, and features) with generative AI. As a result, users will receive more personalized and context-aware recommendations, and the system will be able to respond more effectively to uncommon queries, such as: "Find me a basketball court open until 10 PM with low occupancy on weekends."

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ZeroDay

Cyber threat awareness among students - a case study of a two-phase phishing campaign

The project involves sending out, under controlled conditions, a two-phase phishing campaign. The purpose of the experiment is to assess the vulnerability of the student community to phishing attacks. Emails will be sent to students containing an incentive to click on a link. This fact will only be recorded and, unlike in real campaigns, no harmful action will be performed. By conducting a two-phase campaign, the impact of previous phishing experiences on the fact that such incidents will occur in the future will be taken into account. The experiment will use open-source tools such as Gophish (a framework for simulating phishing), Shlink (a tool for generating shortened URL links with the ability to track click statistics), nginx (a reverse proxy server that handles user requests) and a server running Proxmox VE (as a hypervisor to host the necessary virtual machines). An external SMTP server complying with EU security and privacy standards or an in-house mail server will be used to distribute messages (it was assumed that the entire infrastructure would be built in-house in accordance with the self-hosted concept). In addition, a big-data solution - Splunk Enterprise - will be used to collect logs from individual infrastructure components and accurately analyze statistics of traffic generated by potential victims. The project will also analyze the effectiveness of various phishing message contents and the degree of compliance with the university's official guidelines for reporting such incidents.
The results of the project will include an analysis of users' susceptibility to phishing according to the data collected, the effectiveness of the attack methods tested, and recommendations for improving cyber security awareness in the student community. Conducting the study will bring a number of benefits to the university:
• raise students' awareness of the phishing threat,
• popularization of methods of reporting this type of content within the university,
• develop more effective strategies to protect against phishing and implement new security measures at the university.

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Telephoners

Premier League football match prediction bot

The goal of the project is to create a bot that predicts Premier League match results using machine learning. The process will begin with collecting match result data from the Flashscore website for the years 2018–2025. The data will be cleaned and stored in a database. Next, machine learning techniques will be applied to identify patterns and build a predictive model. Several methods will be tested to select the one that provides the best results. The best model will then be integrated into a bot that will automatically generate predictions for upcoming matches. The project combines data analysis, machine learning, and automation to explore how accurately football match outcomes can be predicted based on historical data.

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Improving the security of the Modbus TCP protocol in Internet of Things systems

The Modbus TCP architecture has provided a modular approach to building IoT networks. There is an urgent need to improve the Modbus TCP implementation by optimizing its performance. Practical improvements are proposed and tested that address performance issues in backward compatibility. Recommendations for real-world deployment in IoT networks are developed. A traffic model for industrial workloads is created using the open-source Python library Pymodbus. TLS encryption for secure data transmission and IP address filtering are introduced to limit unauthorized access. Implementation of the proposed security features and performance tuning will lead to a more robust and secure Modbus TCP implementation.

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