ACADEMICA

AGH

STUDENCKIE KOŁA NAUKOWE AGH

STUDENCKIE TOWARZYSTWO NAUKOWE Rok zał. 1997

61th. Conference of the AGH University of Science and Technology

Student Research Groups

May 9, 2024

CONFERENCE MATERIALS

Spis Treści

STUDENCKIE KOŁA NAUKOWE AGH

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AGH Rapid Prototyping

Numerical analysis of selected types of loads of a wheelchair design for a dog with hind leg paresis made using 3D printing technology

Animal prosthetics is still a rarely discussed topic in the context of the discipline of biomedical engineering and engineering biomechanics. A dog wheelchair is a solution that facilitates the functioning of pets who have suffered accidents, serious injuries, congenital motor disabilities or neurological and orthopedic spine diseases. These diseases prevent them from moving freely on all fours. Compared to wheelchairs for humans, wheelchairs for dogs vary depending on the size and weight of the dog, the type of condition and the function performed. 3D printing and the ability to personalize a medical device meet the above and often unique requirements. The paper presents an example of the use of 3D printing in the implementation of a wheelchair design for quadrupeds with motor paresis of the hind legs. Numerical analysis using the finite element method is an important point of research that allows finding new design solutions. The author formulates design assumptions and presents the concept of a wheelchair based on geometry parameterization, adapted to the anatomy and diseases of animals. The work is completed by the presentation of the 3D printed prototype.

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Koło Naukowe Akustyki Architektonicznej

Analysis of the effect of speaker grille hole parameters on sound transmission

Structures characterized by the presence of multiple holes in their surface are referred to as perforated. They are an important part of many modern solutions, especially in the field of acoustics. They are used both as sound absorbing structures or decorative masking elements. Microperforated materials are called materials in which the holes have a very small diameter. This not only alters the element's absorbing properties, but also causes additional distortion in sound transmission. For this reason, it is important to study how an acoustic wave passes through small holes, as occurs, for example, in cell phone speakers or microphones.

This project will discuss the concept of microperforation, its importance and its effect in speaker grilles on sound transmission. The models made, both computer and real, will also be presented. There will also be a discussion of the results of simulations performed using the finite element method. Finally, the outcomes of measurements that were carried out on the printed elements will be shown.

Research supervisor of the paper:

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Komfort

Sound insulation analysis of a semi-anechoic room located inside a reverberation room

The project analyses the sound insulation of a semi-anechoic room (S-A) located within a set of reverberation rooms. The modular S-A room is situated in the receiving room of the reverberation set, precisely where the measurement window is positioned for acoustic insulation tests. This setup creates a reverberant field in the sending room and a field approximating free field conditions in the receiving room. The project's main objective is to enable the measurement of power radiated by the tested partition using the intensity method.

Studies on acoustic insulation in reverberation rooms employing intensity methods represent innovative approaches continuously evolving to achieve greater measurement accuracy and reproducibility. Currently, test measurements and studies are being conducted to determine whether the acoustic insulation of S-A is sufficient or whether additional modifications are necessary.

As part of the project, measurements of the acoustic pressure level difference were conducted inside S-A and in the receiving reverberation room, using a sound source to generate signals in both the sending and receiving rooms. The obtained data were utilized to determine the acoustic insulation of the S-A room.

Research supervisor of the paper:

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Koło Naukowe Akustyki Architektonicznej

Study on the potential application of cellular metamaterial membranes for enhancing acoustic insulation.

Resonant membrane structures, also known as membrane metamaterials, represent an innovative approach in the field of sound insulation materials. Traditional materials adhere to the law of mass, meaning their acoustic insulation increases with mass and frequency. In the case of membrane metamaterials, a flexible membrane placed within a rigid frame is supported by additional elements designed to regulate membrane resonances. This approach allows for enhanced acoustic insulation within specific frequency ranges and enables control over this range through manipulation of additional elements on the membrane.

The paper focuses on developing a numerical model to calculate the vibroacoustic parameters of the membrane and analyzing methods to manipulate the acoustic insulation characteristics. The study also explores the possibility of integrating individual membranes into a larger multicellular structure, examining the impact of this integration on acoustic insulation properties. Combining membranes into multicellular structures allows for larger surface area coverage and enables the creation of systems with broader operating ranges compared to single-cell systems, achieved by customizing cells for different operational ranges. Additionally, the paper includes experimental verification of the introduced modifications based on measurements conducted in an impedance tube according to ASTM E2611-09 standard.

Research supervisor of the paper:

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Koło Naukowe Akustyki Architektonicznej

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Research on the sound pressure level distribution in the modal region with the special analysis of the lowest frequency band in small room acoustics

The occurrence of eigenmodes is one of the fundamental phenomena in the acoustics of small rooms. To determine the resonance frequencies and their distributions, analytical methods (for selected shapes), numerical methods (for any shape) or experimental studies are used. This is an indispensable step for planning the acoustic adaptation of rooms. The issues of modal room analysis are well studied in the literature, but there is a lack of methods and studies on strategies for positioning the listening point or adaptation in the range below the first modal frequency of the room. This paper will analyse the results of measuring sound pressure level distributions in a room, with a particular focus on the 20-30 Hz frequency range. The study will also take into account different variations of the source placement. The analysis will allow the optimum positioning of the listening point in the room to be determined, with particular emphasis on sound propagation in the lowest frequency ranges.

Research supervisor of the paper:

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"BioStrat : Exploring the Stratosphere - Biomedical Experiments and Discoveries through High-Altitude Balloon Missions"

The stratosphere offers unique conditions, for example: the temperature in this layer varies from -60°C to -15°C, and very low atmospheric pressure, and these conditions are difficult and costly to reproduce on Earth. High-altitude balloons are excellent tools for exploring this environment and provide a cost-effective platform for conducting innovative experiments. They also facilitate the development of solutions that will be used in deep space exploration and long-term missions. These are the main reasons for the development of the BioStrat project.

So far, 6 stratospheric missions have been conducted, with the highest flight reaching an altitude of 35,469 meters. Experiments have included imaging urban and rural areas using AgroCam, testing real-time telemetry systems, and testing prototypes of the lab-on-chip platform.

This year's project edition focuses on further developing the lab-on-chip platform using 3D printing, improving communication with the balloon using LoRaWAN technology, and researching power sources that can be used in stratospheric and near-space missions.

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Construction of an analog audio effect controlled by brainwaves

The aim of the presented project was to construct an audio effect with the ability to control its parameters using electroencephalographic waves (EEG) recorded on the human scalp. As an example, a "phaser" type effect was chosen, which modulates the audio signal by changing the center frequency of band-stop filters. The modulation speed depends on the frequency of the triangular signal generated by a voltage controlled oscillator, with the envelope of the recorded EEG waves applied to its input. Additionally, the constructed phaser can also operate in a mode where the EEG signal directly modulates the sound, bypassing the oscillator, enabling control over both modulation speed and depth. Both the effect and the brainwave recording circuit were constructed entirely in the analog domain, with the use of PCB design software. Lastly, the user's control over the effect parameters and their repeatability were analyzed.

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Koło Naukowe Akustyki Architektonicznej

The construction of a recording chamber according to the design and the measurements of the system's properties

Sound absorbing structures are special structures designed to reduce the reverberation time in a room by absorbing sound energy. They are used in a variety of interiors, from concert halls to offices. The recording chamber, which is one of the types of absorbing structures, is particularly important in the field of recording. It provides a controlled environment with neutral and repeatable listening conditions, reducing first reflections as well as reducing the perceived decay time of the emitted sound. The paper discusses the construction of such a structure, in accordance with a previously prepared design, and measures the properties of the system, including the reduction of the acoustic power level in accordance with the ISO 23351-1:2020 standard. The result of the presented work is a functional recording chamber used to record sound tracks at home.

Research supervisor of the paper:

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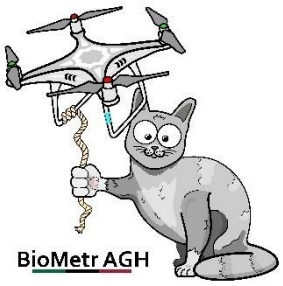

Voice-based automatic classifier for Parkinson's disease diagnosis

Parkinson's disease is a serious neurodegenerative disorder characterized by slow movements, tremors, muscle stiffness, impaired balance, and speech problems. Early detection is crucial for effective treatment and improving patients' quality of life. Currently, diagnosis relies on regular specialist visits, which can be burdensome for the predominantly elderly patient population. This project aims to develop a simple, non-invasive tool that can accurately detect Parkinson's disease through voice analysis. The tool will utilize voice samples from both Parkinson's patients and healthy individuals of similar age, focusing on the analysis of vowels. Machine learning models will be trained to classify voices as belonging to either Parkinson's patients or healthy individuals. It is expected that such a classification will reduce the burden on doctors, while at the same time being unhealthy and reducing access to appointments. The solution may become a breakthrough in the fight against Parkinson's disease.

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Discover the power of nature in your skin care: Secrets of natural cosmetics

The skin is not only our outer protective layer, but also an expression of our health and well-being. Since ancient times, people have used the riches of nature not only to improve their appearance, but also to care for their bodies. Today, we are going back to our roots by designing modern cosmetics that use solutions inspired by nature. This paper, based on a literature review, contributes to the understanding of the increasing use of natural substances in cosmetology, highlighting their effectiveness and beneficial properties.

Research supervisor of the paper:

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PolyTheremin - Optimization and prototype improvement

The project aims to develop a polyphonic version of the instrument proposed by Leon Theremin. In its traditional form, it consists of two antennas that detect hand movements, thereby controlling the pitch and volume of the tone. The concept of PolyTheremin takes it a step further - it will be equipped with a set of antennas tracking the movements of individual fingers of the hand. This step will introduce polyphony to the classical theremin.

The instrument's antennas will be placed closer together, introducing mutual correlation between individual channels. To mitigate this effect, an appropriate decorrelation algorithm will be applied. However, prior to this, it is necessary to minimize the influence of the antennas by changing their geometry. For this purpose, a numerically prepared model of the device will be utilized. Additionally, an optimization algorithm will be necessary to find the appropriate geometry of the antennas.

The application of optimization to the dimensions of the instrument will significantly facilitate the subsequent signal processing. Furthermore, one of the preliminary versions of the instrument prototype will be presented, serving as a testing platform for further work on the PolyTheremin.

Research supervisor of the paper:

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Energon

Presentation of the modern Trebuchet "Hurricane"

The "Hurricane" is currently the most modern and largest MURLIN-type trebuchet in the world. The aim of the project is to develop dynamic launchers and gain an in-depth understanding of their dynamics, and also to break the Guinness World Record for throwing a 20kg keg of beer from a trebuchet at a distance, which is currently held by a group of engineers from the United States.

Already a small prototype has proven that trebuchets (i.e. launchers using only the potential energy stored in the lifted weight - the counterweight) are capable of achieving efficiencies in excess of 70%. A multi-membered counterweight arm converted into a spiral inspired by the Fibonacci sequence, a novel approach to the geometry of the throwing arm and the use of modern extremely strong and non-stretchable Dyneema ropes have resulted in a fantastic range and a perfectly smooth duty cycle.

Our design is currently nearing completion. The "Hurricane" trebuchet measures 15m long, 6m high and 12m wide and weighs over 2.5 tonnes. Its current range is ~110 metres, throwing a 10kg beer keg. Our target after this year's refit is over 150 metres, throwing a 20kg keg.

Research supervisor of the paper:

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Koło Naukowe Akustyki Architektonicznej

Project and Construction of a Measurement Setup in the Form of an Impedance Tube for Studying Acoustic Metamaterial Structures

The sound absorption coefficient is a significant parameter for acoustic materials. It indicates how much acoustic energy a material absorbs and is useful in acoustic adaptation and designing noise protection in rooms. For most materials, its value can only be determined through precise measurements.

Testing the sound absorption coefficient in a reverberant chamber using the ISO 354 method is costly, time-consuming, and requires samples of large dimensions. Since the sound absorption coefficient can be determined using the transfer function, one possible solution to these problems is conducting research in a special impedance tube. Despite the straightforward measurement method, the cost of commonly available market solutions is high.

Therefore, the aim of the project is to create a modern research setup at low cost, based on the transfer function method in an impedance tube, enabling precise measurements of acoustic properties of materials, with a particular emphasis on sound absorption and transmission loss in the material.

During the presentation, the project assumptions regarding the construction of the impedance tube itself and the implementation of the code responsible for determining the sound absorption coefficient and transmission loss in the material will be presented. The construction of the tube and the implementation of the code will comply with the PN-EN ISO 10534-2:2004 and ASTM E2611-09 standards.

Research supervisor of the paper:

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Design of a multimodal system for measuring subjective time perception

An extremely important element of the space exploration mission is effective time management. The mechanism of human perception of the passage of time is a phenomenon that depends on many external and internal factors. Its changes are intensified in a difficult environment, which undoubtedly includes the space environment. The change in the perception of the passage of time in the space environment is triggered by at least isolation, altered diurnal rhythm and potential physiological changes. M3Space is a project in which measurements of subjective perception of time will be made, taking into account physiological measurements as well. We want to find out how the passage of time is perceived in individual people and how physiological parameters affect these measurements. The system we have developed will be able to study how a person perceives the passage of time. It will be integrated with medical apparatus sensors in three main areas. The first is the cardiovascular area, where we will use sensors that measure electrocardiograms (ECG), pulse, blood pressure and temperature. The next area is the cerebral area, where we will use sensors for electroencephalography (EEG) for measurements. The final area is broadly stress monitoring. The entire system will be bundled with software so that you can connect to the sensors and simultaneously collect data to a computer or smartphone.

Research supervisor of the paper:

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Sensor

Design of a comparative testing station for the acoustic power of drone propellers with complex topology.

This paper describes an experimental measurement station design aimed at examining the acoustic power of drone propellers. The paper explores the need for addressing this problem, the method of modifying propeller topology, and the presentation of a comparative testing setup design. To avoid a large computational burden associated with numerical modelling, a research method based on rapid prototyping was developed. A measurement station design was created based on guidelines for designing sound-absorbing/isolating enclosures. To obtain data related to the noise generated by the propellers, 5 MEMS microphones connected to a Raspberry Pi microcontroller were used. The lift force generated by the propeller was to be measured with a strain gauge connected to the Raspberry Pi. The single-board computer enables fast measurements and result computation. This research method will facilitate the quick identification of the parameters of the designed propellers that most affect their acoustic power without damaging their aerodynamic properties.

Research supervisor of the paper:

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Listenings for auditory perception training

During movement, we mainly rely on the sense of sight, but when it's run out, we must learn to assess space very precisely using other senses. A blind person can recognize their immediate surroundings through touch, but should be able to evaluate a large space using hearing.

I have developed a method of auditory training for children with visual impairments in the form of listening for learning spatial prepositions and developing spatial orientation through auditory stimuli. I have designed the structure and format of these listenings so that they can teach individuals to recognize the world, both with a mentor and independently. Binaural recordings serve as exercise components.

Two types of listenings have been created in the form of YouTube videos, along with their analysis. They have multiple applications, but primarily serve an educational role, allowing anyone to train their hearing skills in the comfort of their own home.

Research supervisor of the paper:

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Koło Naukowe Akustyki Architektonicznej

Test station for demonstrating the performance of sound absorptive acoustic metamaterials in circular waveguides

This paper is concerned with the construction of a demonstration kit to illustrate the applications of acoustic resonance-based suppressors in the context of narrowband industrial noise suppression. The kit consists of two main components - a circular waveguide and interchangeable silencer elements inserted into the waveguide channel. The functionality of the attenuators is demonstrated using an application that compares the acoustic spectrum of the signal recorded at the outlet of the waveguide without the attenuators installed and with the attenuators in place. The application then determines the insertion loss of the resonant attenuators and the frequency of greatest attenuation. The energy losses introduced into the waveguide by the acoustic metamaterials are narrowband in nature. The next steps in the construction of the demonstration set are presented, the process of optimising the geometry of the resonator dampers and the difficulties of using 3D printing in the manufacturing processes of acoustic metamaterials are presented. The possibilities of using the demonstration set in the context of teaching, popularising science and tackling acoustic noise pollution were also discussed. The broad possibilities for further development of the design, particularly the potential for use in prototyping new geometries of acoustic metamaterials, were also addressed.

Research supervisor of the paper:

Dr inż. Bartłomiej Chojnacki

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Cardiovascular stents based on shape memory polymers (SMPs)

The project aims to create polyurethane heart and vascular stents that, when placed in the appropriate blood vessel location, return to their original shape and conform to the vein or artery under the influence of human body temperature. The entire volume of the stent contains an antimutagenic substance designed to prevent tissue growth. Stents are formed using electrospinning and then subjected to temporary shape programming. After these stages, the stent needs to be activated by a specific temperature, causing it to return to its original shape and adapt to the blood vessel. The material begins to deform at 36°C, making the human body an appropriate stimulus for returning to its initial shape. FTIR spectroscopy, contact angle measurements, and mechanical analysis on a DMA device were analysed to characterise the material's properties. Future research planned for the project aims to investigate the concentration of the released drug and assess cytotoxicity.

Research supervisor of the paper:

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Technologii Kosmicznych AstroBio

System for fall detection based on wearable sensor and machine learning algorithm.

The project aims to create system that is targeted towards the elderly, for whom falls can result from various disorders or weakened fitness. Each such event can be dangerous for the person, especially if appropriate care is not administered quickly.

Project uses a wearable device, which is unnoticeable to the user, while still providing long battery life and continuous, robust measurements. Data from this sensor, namely accelerometer and gyroscope readings, are collected by a mobile application, which uses machine learning to detect the moment of the fall, and allows fast response, such as notifying the caregiver of the elderly person.

Research supervisor of the paper:

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Sensor

The application of IMU sensors to analyze the dynamics of human lower limb motion

This presentation explores human motion dynamics analysis, a field crucial for technological advancements. By understanding biomechanics, the science behind human body movement, researchers can improve medical diagnoses, analyze athletic performance, and contribute to entertainment and robotics. This project analyzes lower limb movement dynamics using a specialized motion capture suit with IMU sensors. It will focus on leg kinematics and dynamics using data from accelerometers, gyroscopes, and magnetometers. The goal is to enhance knowledge of lower limb movement. The research will involve developing a research procedure, acquiring and preparing data, and filtering it. Following this, the analysis will delve into general kinematic and dynamic parameters of walking and running, along with individual gait phases. This project contributes to research at the intersection of motion dynamics, human locomotion, and bipedal robot control algorithms.

Research supervisor of the paper:

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Application of frequency-modulated signals in airborne sound insulation measurements

Broadband noise is commonly used as the excitation signal during acoustic insulation measurements. However, there are times when it becomes necessary to employ harmonic or polyharmonic signals. Unfortunately, such signals in reverberation rooms can form standing waves, resulting in an uneven acoustic pressure distribution. To address this issue, the use of appropriately modulated signals is proposed. The project aims to verify whether the utilization of frequency-modulated harmonic signals can enhance the spatial uniformity of acoustic energy density throughout the acoustic field. The paper presents the results of experiments in which various acoustic signals were tested as excitations for the reverberation chamber, including broadband noise, harmonic signals at different frequencies, and modulated signals. The effectiveness of the investigated solutions is also discussed.

Research supervisor of the paper:

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Sensor

Adaptive Reinforcement Learning for Nonlinear Control Systems with Variable Load Conditions

This paper introduces a novel approach to controlling overhead cranes, addressing the challenges posed by variability in sling length and load weight. Traditional control methods are often inadequate for practical applications due to their reliance on fixed-load scenarios. To tackle this issue, the paper develops a reinforcement learning (RL) algorithm that is robust to object nonlinearity. Specifically, the Twin-delayed Deep Deterministic Policy Gradient (TD3) algorithm with randomization of object features is proposed. This algorithm learns a universal control method capable of handling a wide range of load mass changes. Simulation studies demonstrate the effectiveness of the proposed method, achieving satisfactory control performance compared to classical Linear Quadratic Regulator (LQR) algorithms. The study emphasizes the importance of RL in addressing the complexity and nonlinearity of modern control systems, offering benefits such as adaptability to dynamic environments and immunity to disruptions. Furthermore, the paper presents the object of study, which is a bridge crane, and outlines the methodology employed, including the use of comprehensive mathematical models and simulation experiments conducted via MATLAB/Simulink. The training phase of the RL algorithm is discussed, highlighting the computational intensity and neural network architecture utilized. The results section presents outcomes from simulations under different load masses, showcasing the system's robustness and reliability in achieving satisfactory regulation. Finally, the conclusions emphasize the promising results obtained, with plans for further optimizations and real-world testing to validate the system's performance in practical scenarios.

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Sensor

Artificial intelligence algorithm for detection of anomalous operation of rotating devices

The essence of the paper was to design an intelligent predictive maintenance system, which task was to detect abnormal operation and classify faults of rotating machinery, simulating defects in wind turbines. Prepared measurement setup consisted of a BLDC motor with mounted propellers with 5 degrees of damage. The condition monitoring was based on vibration measurements, which carry a lot of information related to the technical condition of the device, indicating potential issues and serving as a sufficient tool for detecting abnormal operation. From measured signals, most popular diagnostic indicators were calculated.

This paper concerns the gravity of thorough data analysis, which can prevent from risk related to large number of dimensions (the so-called "curse of dimensionality") and the benefits associated with their reduction. The ultimate goal was to compare the performance of machine learning algorithms (SVM, Random Forest), with more complex models based on neural networks, and to demonstrate that networks are not required for satisfying performance of the PdM system. The aim of this work is also to draw attention to an ensemble learning algorithm – Voting Classifier, the benefits of which may exceed the capabilities of all the above models, while learning significantly faster than neural networks.

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LF Robotics

Alternative Drone Control System in the Technology Era

"The article discusses the project of a hexacopter and a system that introduces inertial sensors and advanced visual technologies instead of using GPS for drone flight stabilization. This system is a response to the challenges associated with GPS signal disruptions, the need for precise navigation in urban areas, and the difficulty of flying in indoor spaces. Thanks to this system, drones will not only be able to cope with dynamically changing environments but also guarantee the continuity of safe flight even where GPS signals are unavailable. This aims to increase efficiency and expand the range of possible drone applications while enhancing drones as a platform for their current uses.

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Avader

Indoor arena for algorithm testing for autonomous drones

As robotics applications grow more complex, the need for convenient and effective testing also increases. To ensure the detection of potential implementation errors, it is necessary to perform validation under controlled conditions. A popular method is to use a set of cameras in a Motion Capture system. This allows for the precise localization of the robot (or drone) and comparison of the actual position with the one determined using sensors present on the tested platform (e.g. cameras and visual odometry).

The paper will present the next stage of the project of an indoor arena for testing algorithms for autonomous drones, built by SKN AVADER. The developed system uses a set of Basler ace cameras, with a target set of 4 to 8 sensors. They enable recording at a maximum frequency of 227 FPS and have increased sensitivity in the near infrared bands. The Jetson Nano Developer Kit platforms were used for image pre-processing, and the final position is calculated by an external computer, based on data sent via Ethernet network or Wi-Fi. The application was written in Python. It implements various calibration methods (in 2D plane and in 3D) and calculation of the drone's position (using passive or active markers, foreground object detection methods). It has been prepared to be easily run on PC.

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Autonomous line-following drone - implementation of detection and control algorithm

Line following is a well-known competition among individuals interested in mobile robotics, involving programming a robot to track and follow a designated line. This year, ONT company, in collaboration with MathWorks, organized such competitions for autonomous drones. The challenges to be tackled included defining a velocity vector, environmental lighting instability, the influence of air gusts, and drone inertia.

The first stage of the competition took place in a simulated environment. Image processing algorithms such as binarization, segmentation, and Hough transformation were used to detect the red line and determine its parameters. Points of Interest (PoI), such as intersections, the end, and the beginning of the line, were located based on the intersections of the determined edges. Additionally, verification was done to determine if such a point could exist in a given area. The landing pad was detected by counting the sum of pixels in the segmentation object and calculating the average distance from the center of gravity to the boundary pixels.

The paper will also describe the next challenge posed by the limited computational power of the real object during the second stage of the competition, which required a different approach to the problem. An approach based on PID controllers and image areas of interest was applied, similar to algorithms commonly used in line-following mobile robots.

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Avader

Autonomous system for drones for flight with obstacles

Unmanned aerial vehicles (UAVs), commonly called drones, thanks to their high mobility, are used in an increasing number of tasks. They minimize human involvement in simple activities (e.g. monitoring agricultural crops) and also allow work in hard-to-reach or dangerous places (e.g. inspection of urban sewage systems). Additionally, they are sometimes equipped with autonomous systems, which allows to further reduce the operator's participation and thus increase the number of scenarios they are able to perform.

In this paper an autonomous flight system will be presented, which is developed in regard to the drone swarm built by SKN AVADER. The project involves implementing an algorithm for planning movement trajectories in the presence of obstacles, and also allows to follow a marked object. The 3DVFH* (3-Dimensional Vector Field Histogram Star) method was used, which is available in the open source library “avoidance”, owned by PX4. It has been adapted to individual needs, including the source code being optimized in terms of memory consumption and the number of operations. It was accelerated on the eGPU platform, and later initially tested in the ROS and Gazebo environment. To detect encountered obstacles a depth camera was used.

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Avader

Collision-free flight of a drone swarm using the flocking algorithm - simulation in the NVIDIA IsaacSim environment.

Swarms and drone formations are increasingly finding various applications in many areas of life. Significant advancements in robotics autonomy and rapid progress in control algorithms have opened the doors to the development of controllers for systems with multiple agents, capable of meeting diverse needs, including the basic one - collision-free flight and obstacle avoidance. One of the first controllers for formations that meet these goals were flocking algorithms based on the idea of potential fields and the work of Reynolds, who proposed a methodology for controlling a swarm based on three simple rules: separation, alignment, and cohesion. In this project, a selected solution was implemented using the NVIDIA IsaacSim and PegasusSimulator simulation environments, allowing for the realization of a photorealistic simulation. The project successfully implemented a speed controller for the quadcopter drone 3DR Iris and a flocking controller for a formation of six units, which was then evaluated during a simulation flight navigating through obstacles represented by geometric shapes. The work highlights the strengths and weaknesses of the selected drone formation flight control algorithm and shows possible further paths for its development. The project thus lays the groundwork for the implementation of such a solution for real drone formations, the significant expansion of which is currently being carried out by the SKN AVADER academic circle with the grant funds from IDUB.

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Sensor

Deep Eye - Intelligent Device for Creating Digital Models of Underwater Topography

This project endeavors to advance underwater mapping technologies through the development of algorithms tailored for mapping, analyzing, and creating digital models of bathymetry. A key aspect of this research involves the integration of advanced technologies, specifically Lidar and a purpose-designed sonar system. By leveraging these tools, high-resolution point cloud data and precise representations of submerged geographical structures can be obtained.

The project also aims to construct a waterproof device, operated by a diver, incorporating both Lidar and sonar sensors. This device will enhance data collection and mapping capabilities in challenging underwater environments, addressing complexities associated with underwater terrains.

Several critical questions are central to this research. Primarily, the investigation seeks to understand how artificial intelligence algorithms can be optimized to harness the collective potential of Lidar and the specially crafted sonar system. Additionally, the research endeavors to evaluate the comparative efficacy and accuracy of the proposed sonar system and Lidar in underwater mapping, particularly under adverse environmental conditions where visibility is compromised by high particle concentrations.

Through these efforts, this project aims to contribute to the advancement of underwater mapping technologies, offering insights into optimizing sensor integration and algorithm development for enhanced mapping accuracy in challenging underwater environments.

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AGH Solar Plane

Modular system for measuring mechanical loads, measuring temperature and handling lighting, suitable for mounting in a flying model.

The paper describes a system designed to measure mechanical loads occurring on a model aircraft during flight. During the design process, the ability to support temperature sensors, digitally controlled LEDs and high-power LEDs was added. In order to optimize the amount of space used, some of the functionality was realized on optionally added shield.

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Avader

From Theory to Practice: Designing and Testing a Visual Navigation System on the Example of an Autonomous Vehicle Model

The presentation continues the SKN AVADER project initiated in previous years, focusing on developing algorithms for detecting traffic lanes and identifying objects on them. Based on the existing infrastructure of the mock-up, it has been expanded with additional urban elements such as walls and buildings, creating a more complex testing environment. The current phase of the project aims to design, implement, and evaluate an advanced vision-based navigation system for autonomous vehicle, utilizing Simultaneous Localization and Mapping (SLAM) technology. This system is intended for precise mapping of the terrain the robot traverses, its localization on the map, and route planning, including the exploration of unknown areas.

The project consists of several stages, including the integration of a previously trained neural network model with an application, developing the logic responsible for recording routes based on visual data, and developing decision-making mechanisms that guide the vehicle's movements based on environment recognition and detected objects.

At the upcoming conference, current recordings of the built vehicle moving through the mock-up will be presented, and the continuously updated Django framework application that enables vehicle control will be discussed in detail. Additionally, a comparison of routes generated based on encoder data versus routes obtained solely from visual data will be presented. This presentation will illustrate the progress in integrating system components aimed at creating virtual maps of the terrain and collecting data through a mobile vehicle, opening new possibilities for autonomous navigation.

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Realisation of drone trajectories using the MPC algorithm

In recent years, unmanned aerial vehicles (UAVs) have gained immense popularity due to their versatile applications. Currently, most missions are supervised by operators, which constitutes a significant limitation and negatively impacts the scalability of operations. Therefore, one of the key objectives in the development of UAVs is the automation and autonomization of their operations.

This presentation focuses on the topic of executing a drone flight along a designated reference trajectory. One of the methods enabling this task is Model Predictive Control (MPC), a technique used for predictive control based on a model.

A commonly used controller, NMPC (Nonlinear Model Predictive Control), employs nonlinear optimization methods, which result in significant computational complexity constraints. Therefore, the implementation included three versions of the MPC controller: nonlinear, based on successive linearization, and using the quasi-linear parameter varying (qLPV) model. Each of these algorithms was evaluated in the PyBullet Drone simulation environment on prepared test trajectories. The conducted research included assessment of trajectory tracking accuracy, analysis of computational complexity, and testing for disturbance robustness.

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New-Tech

Vision system - construction of a test station and qualitative analysis of parameters

A vision system has been planned as part of the PAPIC project, which involves mounting components on prototype PCBs. A testing station has been developed to ensure parallel development with the construction team and to select the appropriate camera mounting within the machine. This station includes a frame, a lighting system, and a lens-equipped camera connected to a Raspberry Pi. Properly selecting operational parameters and component characteristics is crucial for the vision system to function effectively and efficiently. The research aims to optimize working conditions for the camera, enabling the development of simpler and faster algorithms for detecting desired objects, such as SMD resistors and capacitors. Tests have been conducted to accurately adjust the camera's operating conditions, including a lens distortion test and a test of light diffusing materials for the lighting system.

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Avader

Utilization of UAV for crop inspection

With the continuous advancement of technology, unmanned aerial vehicles find applications in various areas such as delivery services and verification of hard-to-reach locations. An application proposed by the organizers of the ICUAS '24 competition was the recognition and counting of vegetables grown in a greenhouse.

As part of participation in the mentioned competition, an autonomous drone was programmed with the task of reaching designated vegetable bushes without collision, detecting, identifying, and counting vegetables, and ultimately returning to the starting point. For this purpose, the widely known robotics environment ROS (Robot Operating System) was utilized along with simulation in the Gazebo program. The entire system was configured within Docker software, enabling proper system configuration, testing, and fruitful collaboration within the project.

To determine the optimal path, algorithms solving the traveling salesman problem (TSP) were applied, and for vegetable detection and counting, vision algorithms utilizing both RGB and depth cameras were employed. Additionally, a program was created for automated testing of the solution for various bush configurations. The proposed solution demonstrated high effectiveness, allowing for a 6th place finish in the simulated stage of the mentioned competition, with a small gap to 4th place.

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AGH Drone Engineering

Application of genetic algorithms and neural networks to control a line follower robot

This paper presents a simulation of a line follower, a robot capable of tracking lines based on sensor data. The simulation uses the Python language and the Numpy bilbiotic to generate the route and control the robot. The robot is controlled by a neural network that was optimized using a genetic algorithm.

The system presented reflects the versatile nature of fields such as artificial intelligence, robotics and genetic algorithms. The article discusses the process of learning the neural network and its adaptation to changing route conditions. Simulation results show the effectiveness and flexibility of the proposed solution in the context of line tracking, making an important contribution to the development of autonomous path-tracking robots.

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Analysis of methods for capture of carbon dioxide, its storage and industrial use

With the dynamic development of industry and the related widespread use of fossil fuels, the problem of excessive propagation of the greenhouse effect and the associated global warming, especially related to the emission of anthropogenic carbon dioxide CO2 into the atmosphere, has arisen. Many initiatives have been undertaken to reduce greenhouse gas emissions through, among others, its capture, storage and industrial use. The paper included a comparative analysis of, among others, various CO2 capture methods, with particular attention paid to adsorption technologies. However, as emphasized, the successful use of the mentioned technologies depends on the use of materials with appropriate properties. Attempts have been made to use activated carbons, zeolites, organometallic structures and porous polymers in the above-mentioned processes. However, the mentioned microporous activated carbons turned out to be particularly promising due to their physicochemical advantages and relatively low production cost, high thermal and chemical stability and ease of repeated regeneration.

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Titanium anodizing: metal coloring using physical and chemical phenomena

The purpose of the research conducted is to verify the properties and durability of the coating on the surface of titanium in the anodizing process. The process itself involves the electrolytic formation of an oxide layer of one of the electrodes. The study is performed to find the parameters that give the most intense color and to examine the properties of this oxide coating on titanium. The formation of the coating is affected by various factors such as the concentration of the solution, the electrolyte used, the voltage, and the current. The number of variables creates the possibility of different configurations of these factors and obtaining other properties of the oxide film such as biocompatibility or corrosion resistance. For testing, materials classified as waste are used, making the whole process environmentally friendly and based on recycling. The results of the anodization were tested for corrosion potential and color intensity.

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Nucleus

BioPrintLife - Hydrogel Prints

BioPrintLife is a project co-created by two scientific clubs, SKN Nucleus and AGH Transpeed, aimed at constructing a 3D bioprinter and designing and producing bioink. 3D bioprinting is an additive manufacturing technology that utilizes materials containing living cells (bioinks) to build multi-dimensional structures. The project is based on additive manufacturing technology, specifically Fused Filament Fabrication (FFF), which involves layering successive layers of semi-fluid material extruded from a nozzle.

Commercially available bioinks are expensive and sold in small quantities, significantly increasing the costs of developing and advancing 3D bioprinters. Therefore, the project aims to create an innovative, ecological, and economical bioink composed of a hydrogel containing live bacterial cultures. We are working on two types of hydrogels, primarily composed of natural polymers: sodium alginate derived from seaweed and gelatin of animal origin. The hydrogels produced during the research have been modified with methacrylate, among other methods, to enable their rapid crosslinking. Various crosslinking methods for the obtained hydrogels have also been tested. Ultimately, the injectability properties, as well as properties such as viscosity and shear responses as a function of temperature and time, crucial for determining the correct extrusion conditions, have been investigated.

Bioprinting technology, initiated in the 1980s, still remains innovative and pioneering, and the market seeks further solutions in this field. Bioprinting currently enables the production of lab-on-a-chip systems, organ-on-a-chip models, or tissue models, and in the future, with advancing development, we hope it will enable the production of functional organs, revolutionizing the known field of medicine.

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Inspired Science (InScience)

One-step synthesis of a bimetallic catalyst deposited on a nickel sponge for the removal of azo-dyes from waste solutions.

The synthesis of single- and binary catalysts based on noble metals (Pd, Pt) was carried out in a batch reactor at constant temperature (20°C), deposition time (5 min.) and mixing rate (1000 rpm). For this purpose, a chemically cleaned nickel sponge with dimensions of 1 x 1 cm was introduced into a glass reactor containing an aqueous solution of palladium and/or platinum ions. The composition of the catalyst was modified by changing the concentration of metal ions. In order to deposit precious metals on the sponge, the so-called cementation process, was applied. As a result of the process, a series of catalysts with different chemical compositions of Pd (100%), Pd-Pt (Pd content: 25%, 50%, 75%) and Pt, were obtained. The material obtained after the cementation process was separated from the solution, then rinsed and dried. The catalysts prepared in this way were tested in the process of azo dye removal from a synthetic waste solution. The research used, among others, UV-Vis spectrophotometry to analyze the composition of solutions and to monitor the dye removal process; scanning microscopy to analyze catalyst morphology and composition.

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CarbON

Development of innovative materials for DAC technology- directions and challenges in reducing CO2 emissions

In response to the global challenge of CO2 emissions, the "Aircarbon" project focuses on developing an innovative method for capturing carbon dioxide from the atmosphere using carbon composites with metal-organic framework (MOF) networks. The goal of the project is to create advanced materials that have a high capacity for selective adsorption of CO2. We will present the synthesis process of these materials, their characterization and research methodology, which includes X-ray diffraction (XRD), CO2 adsorption isotherms, and porous texture characterization. The project also includes eco-design and construction of a prototype DAC device. We place great emphasis on an innovative design approach that integrates sustainability principles at every stage of production and operation.

The Aircarbon project responds to the urgent need to develop effective technologies that reduce the concentration of CO2 in the atmosphere, thereby contributing to the advancement of DAC technology and increasing public awareness of the key role of CO2 reduction in achieving carbon neutrality. These activities not only respond to current environmental challenges, but also contribute to the development of new approaches in industry and environmental policy in support of global sustainable development goals.

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Synthesis, sintering and study of the structural and transport properties of arsenic-doped Cu2Se

Thermoelectric materials can convert thermal energy to electric energy. They are used e.g. in space industry in thermoelectric radioisotope generators such as those in the Curiosity rover. The efficiency of generators in energy conversion is related to the thermoelectric figure of merit

ZT=(α^2)·σ·(λ^(-1))·T parameter, which depends on the Seebeck coefficient α, electrical conductivity σ and thermal conductivity λ. Recently, one of the most researched thermoelectric materials is copper(I) selenide. Increasing the ZT parameter and the efficiency of thermoelectric materials can be achieved e.g. via doping the original materials.

This work presents the analysis of arsenic-doped Cu2Se sintered using the Spark Plasma Sintering method with the nominal composition Cu32Se(16-x)Asx (x = 0÷3). The density of obtained sinters, its phase composition (XRD), chemical composition (scanning electron microscopy SEM–EDS) and, crucial in determining of the ZT value, transport properties (α, σ, λ) as a function of temperature were examined.

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Green Energy

Soft skills of a modern engineer

In today's dynamically changing industry and economy, the role of modern engineers goes far beyond technical skills. While technical skills are undoubtedly crucial, the modern engineer must also possess a diverse set of so-called soft skills to complete their tasks and be successful, which is what this paper is devoted to. The paper pointed out that not only flexibility, creativity and critical thinking, as well as the ability to solve technical problems, including quick response to unexpected situations, are crucial in engineering practice. As highlighted in the work, modern engineers often work with international teams with different competences, which requires the ability to communicate and cooperate effectively. Additionally, it was emphasized that contact with contractors, clients and co-workers requires the ability to behave in various situations, negotiations, protection against criticism and effective management, and leadership skills are particularly important in managing multi-person teams and making strategic decisions. The paper also analyzes effective methods of developing soft skills and shaping leadership qualities.

Research supervisor of the paper:

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Green Energy

The use of carbon adsorbents to purify drinking water

The lecture presents an analysis of the problem of access to drinking water, which affects many inhabitants of our planet on a daily basis. The analysis used data from various continents, as well as from individual countries and regions that are mainly affected by this problem, as well as from those regions where the drinking water situation is relatively stable. The data analyzed included: supply, demand, prices of drinking water, aspects of the national economy, population, as well as other data necessary to conduct a detailed analysis of this problem. The lecture focuses not only on the analysis of the causes of this problem, but also presents various directions of its solution, taking into account technical, economic, ecological and social aspects. One of the proposals presented drinking water purification technology using activated carbons.

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AGH Solar Boat

Using 3D scanning technology to optimize manufacturing processes of propellers for solar-powered racing boats

The research focuses on a detailed analysis of the accuracy of the zero emission solar-racing boat's propulsion components, with particular focus on the composite propeller blades, the molds used to manufacture them and the hubs in which they were embedded. The blades were made using hand lamination technology, while the molds were milled from MDF. After the lamination process is complete, the blades are removed from the molds and their edges are processed by hand grinding. The hubs were made using 3D printing technology. The components were then scanned using a 3D scanner, and their theoretical model was compared with the actual geometry of the objects. Through a detailed analysis of the geometric accuracy of these components against their theoretical models, possible deviations and manufacturing errors are identified. In addition, through this research it was possible to determine the accuracy of the 3D prints being made, as well as the parts being milled and further processed. The goal of the research is to improve the manufacturing process and ensure the highest quality and efficiency of the propellers.

Research supervisor of the paper:

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Inspired Science (InScience)

Designing a "Stop & Go" chemical reaction.

The topic of the thesis was the design of a stop & go reaction, which is a process that can be stopped and restarted. The inspiration for choosing this topic was the process of ascorbic acid oxidation and its changes resulting from the application of additional factors (such as a catalyst, the presence of metal ions) that change the course of this reaction. The influence of the presence of Pt and Pd ions on the course of the reaction was investigated. Changes in the course of the reaction resulting from the selection of different catalysts were demonstrated.

Before starting the research, a literature review was conducted on existing chemical reactions, including those that exhibit similar properties. In addition, the process of ascorbic acid oxidation was described as a model reaction to confirm the operation of the reaction on the stop & go principle.

Research supervisor of the paper:

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Section IV Planets exploration and Space Systems

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AGH Space Systems

Feasibility study of a space-based power plant concept

The study focuses on the technical and economic analysis of the orbital power plant concept, a novel project aimed at using space to generate electricity. The study focuses on presenting the theoretical basis for solar energy harvesting in space and the possibility of transmitting it to Earth. The key technologies required to build an orbital power plant are discussed, including photovoltaic systems and wireless power transmission. The breakdown, as well as the differences between concentrated and non-concentrated energy models are presented, noting not only the efficiency but also the potential capital expenditure. Concentrated power plants, using systems that allow concentrated sunlight, are characterised by lower mass and thus carry lower launch costs. However, due to their complex design, they are more unreliable, in contrast to non-concentric power plants, which, thanks to their simple, segmented design, can additionally be easily scaled up.

Research supervisor of the paper:

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AGH Space Systems

Autonomous Driving for Planetary Rovers

The presentation describes the autonomous navigation system implemented in Kalman, the flagship planetary rover of AGH Space Systems science organization. It will outline the computational architecture of this system, taking into account our custom simulation environment that mimics conditions on Mars. The presentation will address the problems encountered in the challenging terrain of the red planet and the respective solutions implemented in Kalman's software to overcome those issues. Attendees will be guided through the process of autonomous rover operation starting with the collection of spatial data, through the interpretation mechanisms for that data, up to the moment when the robot moves its wheels.

Research supervisor of the paper:

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AGH Space Systems

Design of the Kalman planetary rover sampling module

The presentation will discuss the design of the drilling and sampling mechanism used in the Kalman rover.The presenters will elaborate on the design challenges that engineers must face in order to meet the requirements of competitions like the University Rover Challenge series.

Research supervisor of the paper:

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AGH Space Systems

New science modules of KALMAN planetary rover

The topic of the paper is presentation and general overview of the current development of the Kalman Mars rover project in terms of the Science section, or in other words, scientific support. One of the main tasks of the section is to design and supervise the development of a mobile laboratory for analyzing soil samples for the presence of life. Continuous optimization of the chemical tests used for this purpose and the search for new solutions in close cooperation with other sections is required. Preparations for the 2024 University Rover Challenge have necessitated the introduction of a new, modular version of the mobile laboratory. Mobilab 3.0 is fully automated analizer of organic and mineral compounds in samples of Martian regolith with main sensitivity to chemical compounds indicating life signs. Isolated chambers enable veryfying many samples in the same time. Extraction is conducted with help of ultrasounds and analysis is conducted with dedicated research probe with research modes in the range of fluorescence and UV-VIS-NIR. In addition, the tasks of the Science team include geological recognition of rock samples where new RAFROCK module will help. RAFROCK (Reflectance And Fluorescence ROCK analyzer) is automated fiber optic probe identifying interesting objects on the rover's route. Continuous evolution of the Science section allows supporting the team to get high places at international Mars rover competitions.

Research supervisor of the paper:

dr inż. Mariusz Gibiec

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About Space Education Programs at Polish Universities

Given the high cost of training a space worker, the solution to the lack of experts in the industry seems to be to train students in space studies. However, are these majors in short supply in Poland? What offer of space studies do Polish universities have for the 2024/2025 academic year? Is it possible to place Polish space education programs against the background of European trends? The author of the paper seeks to provide answers to each of these questions and many more in her comprehensive analysis of space majors offered at Polish universities. Her study identifies the thematic areas of selected space studies and their compatibility with the SpaceCRAFT Framework, a tool indicating the framework competencies needed in the space sector. Finally, expert opinions were collected on the legitimacy of conducting such studies at Polish universities, providing a contrast to the number of space education programs offered.

Research supervisor of the paper:

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AGH Space Systems

BIOLOGEN project, or how to produce oxygen from bioluminescent algae for future space missions

The paper assumes the presentation of the BIOLOGEN project, carried out as part of the work of the AGH Space Systems research circle. The problem of the experiment involves checking the quantitative production of oxygen and light by bioluminescent algae of the Pyrocistis family. Dilemmas related to the preliminary stage of the research, such as the selection of the tested algal species, how to maintain them and its monitoring, will be addressed. In connection with the Direction: Space competition, the project will comply with ECSS-type technical requirements and be prepared for future launch into Earth orbit, to the International Space Station, where algal viability, oxygen and light production in hostile microgravity conditions will be studied. It will be necessary to establish a culture of a particular species of algae, design appropriate equipment to monitor the parameters under study and, in the future, conduct tests to send the experiment into space. Ultimately, the paper will present an argumentation of the study of algae in microgravity conditions and their potential application in terms of space missions.

Research supervisor of the paper:

Dr inż. Mariusz Gibiec

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AGH Space Systems

Design solutions for the electronics and control of a 6-degree-of-freedom manipulator for the Kalman planetary rover.

In the context of diverse tasks it needs to perform and expectations regarding its versatility, a planetary rover should be as universal as possible while maintaining high reliability. One of the key elements enabling the achievement of this goal is the manipulator, which effectively copes with various environmental conditions, ensuring the accomplishment of designated objectives.

Within the presentation, the electronics and software of the robotic arm located on the Kalman rover, which is the result of the work of the AGH Space Systems student team, will be thoroughly discussed. Numerous challenges and their solutions will be described, such as the CAN FD communication protocol implemented on STM microcontrollers, the arm controller implemented on the Linux system on ARM architecture, and the implementation of control and management in the ROS (Robot Operating System) environment using MoveIt libraries. Development plans for the autonomy of the manipulator will also be presented, showcasing the progress made in this area so far.

The robotic arm and rover have achieved many successes in international competitions such as the Rover Challenge series, effectively confirming their reliability and versatility. However, organizers continually introduce new challenges, leading to continuous improvement of the manipulator.

Research supervisor of the paper:

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AGH Space Systems

Development of a custom wireless communication system in Kalman planetary rover project

During the presentation, a new wireless communication system, currently developed within planetary rover section of AGH Space Systems student association will be introduced. It consists of three components: custom-designed printed circuit boards, embedded software controlling and supervising operations on the radio link, and generic libraries enabling inter-chip communication in a newly established standard. A range of issues existing in the current version of the project related to the range, throughput and data transmission reliability will be addressed. Deployed systemic solutions such as employing a dynamic time division multiple access to the radio channel, renegotiating channel parameters depending on the link conditions and ensuring quality-of-service will be presented.

Research supervisor of the paper:

dr. Mariusz Gibiec

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AGH Lunar Technologies

Electronic Systems in the First Polish Lunar Payload Lunaris

The Lunaris mission represents Poland's first lunar payload as a result of the international "Experiment on the Moon" competition. It is a 200-gram device designed to study the interaction of lunar regolith with various coatings, which is crucial for further exploration and exploitation of the Moon. The presentation will outline the mission operation concept, with a particular focus on key aspects of electronic architecture.

In the presentation, electronic solutions implemented in the Lunaris payload will be discussed, emphasizing the hazards associated with outgassing — the process of gas release in vacuum, and methods to mitigate this process. The paper also addresses challenges related to mitigating the impact of cosmic radiation on the device's subsystems. The importance of applying advanced electronic technologies in extreme space conditions will be highlighted, demonstrating an innovative approach to ensuring the reliability and functionality of critical systems within the Lunaris mission.

Research supervisor of the paper:

prof. dr hab. inż. Tadeusz Uhl

Section V Power and Electrical Engineering

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Piorun

Analysis of the D-type energy generation module adaptation in terms of reactive power management

The scope of the project includes the analysis of reactive power management of an actual D-type energy generation module (installed power above 75 MW and/or connection voltage not less than 110 kV) along with the adaptation of such facility to the requirements arising from the NC RfG network code. The results of analyzes performed in the form of numerical simulations in the DIGSilent PowerFactory program in various compensation variants, such as a compensator or reactive power control using inverters.

Research supervisor of the paper:

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Green Energy

The predictive analytics of electrical energy prices on TGE using linear regression

In the paper there was the analysis of electrical energy prices on TGE (Towarowa Giełda Energii) in the 2-month period from 01.11.2023 to 16.04.2024. There were chosen the following factors as having the particular impact on the electrical energy price in the selected day: production brutto from the conventional power plants and renewable energy sources and international exchange brutto from countries having the possibility to do so with Poland. On the basis of collected data there were the prediction model built, which have calculated the expected prices for a period from 17.04.2024 to 30.04.2024. In conclusions special emphasis has been placed on the effectiveness of such model, operating on collected data, and the analysis of additional factors that could affect the model. Advantages and disadvantages of such approach were pointed out in the end.

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Piorun

Analysis of the influence of power cable design on the propagation speed of voltage pulses.

Power cables are characterised by a diversity of designs in terms of their cross-sectional structure, geometry and the construction materials used, particularly the dielectrics that make up their insulating system. These factors have a major impact on the transmission properties of cables. That is, they determine the propagation velocity of both high-voltage surges and low-peak impulse signals characteristic of incomplete discharges and test pulses used in the reflectometric method of cable fault location.

The aim of the paper is to present theoretical analyses on the influence of power cable design on the pulse propagation velocity. These considerations will be based on a layered model of a coaxial cable, taking into account the properties of the dielectric making up the cable insulation and the properties of the semi-conductive shields located on the cable conductor and outside its insulation layer.

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Piorun

Analysis of the impact of connecting renewable energy sources on the operation of medium-voltage power system.

The project presents an analysis of the impact of connecting different types of renewable energy sources to the medium-voltage distribution network. The analysis includes a compilation and comparison of the impact of different types of renewable sources on voltage and short-circuit conditions in the MV network and other aspects affecting the safe and reliable operation of the power system. The necessary calculations were performed on a model of the real grid, prepared in the simulation environment of the PowerFactory software.

Research supervisor of the paper:

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Piorun

Analysis of earth faults in the MV power network in the context of the selection of protective devices

The project compiles and analyses the modes of operation of the neutral point and other factors influencing the value of the earth fault current in the medium-voltage network. The most relevant criteria forming the basis for the operation of devices protecting the line fields of medium-voltage networks against the effects of short-circuits were presented. Within the framework of the project, a simulation model of a selected network fragment was created using the EMTP-ATP programme, which was used to carry out a series of tests and analyses. Based on the results obtained, criterion values were determined, which are necessary for the correct selection of protection settings for each line field of the analysed network. The project has to do with ensuring safe and reliable operation of the MV network, guaranteeing the certainty of electricity supply to its consumers.

Research supervisor of the paper:

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Piorun

Investigations into the influence of temperature on the propagation velocity of voltage pulses in a power cable.

Various technical methods are used to locate faults in power cables. One of them, often used in operational practice, is the reflectometric method. To locate the damage, it uses short voltage pulses applied to one end of the cable, observing and measuring the return time of the pulse reflected from the point of change of the cable's wave impedance (in particular from the point of short circuit or break in the cable). The propagation velocity and attenuation of the impulse signal in the cable are cable-specific parameters. They depend on the dielectric properties of the cable's insulation system.

The aim of this project is to determine and evaluate the effect of cable temperature on the velocity and attenuation of voltage pulses propagating in the cable. The paper will present a laboratory system for investigating this effect and the results of measurements using pulses of different widths, carried out for a section of cable with XLPE polyethylene insulation.

Research supervisor of the paper:

mgr inż. Paweł Mikrut, dr hab. inż. Paweł Zydroń

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Piorun

Performance testing of photovoltaic modules cooperating with different types of charge controllers

The paper covers and presents performance studies of photovoltaic modules cooperating with MPPT and PWM charge controllers. Its main objective is to examine the operating parameters of photovoltaic modules depending on the type of controller used under different weather conditions, to compare the daily variability of energy generated by photovoltaic panels, energy stored by batteries and energy used by electrical loads. In addition, it also includes an analysis of the operation of both systems under low solar radiation and a comparison of the charging and discharging process of the battery, which is the local energy storage.

Research supervisor of the paper:

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Piorun

Can it be faster? The railway traction network in Poland and the associated problems

The direct current traction network with a nominal voltage of 3kV is one of the major constraints limiting the development of Polish railways. For high-speed railways worldwide, systems of 15kVAC, 25kVAC, and in very high-speed railway lines, 2x25kVAC are used. Currently, AC drives powered by high-power electrical converters are utilized globally. So why do we still use 3kV DC in Poland? The use of a direct current traction network is historically conditioned. In Poland, locomotives powered by 3kV DC constitute the majority of rail vehicles. Modern rolling stock is gradually joining this. We have modern Pendolino train sets in operation, capable of reaching a design speed of 250km/h. In this paper, the author will attempt to answer the following questions: Is the 3kVDC traction network ready to power high-speed rail sets, which require the delivery of electric energy with high power? What are the problems with operating rolling stock in Poland, and why are we unlikely to solve them anytime soon?

Research supervisor of the paper:

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AGH Solar Plane

Selection and optimisation of a high performance battery for a solar unmanned aircraft

One of the fundamental problems associated with mobile devices is the selection of a suitable power source for them. This problem is crucial in the design of a 6-metre-long unmanned aerial vehicle being built by members of the AGH Solar Plane Scientific Circle. In this study, commercially available lithium-ion cells were analysed and the most favourable ones were selected to power the solar aircraft under construction, and the optimum parameters for the energy storage were determined. The aim of the study was to achieve the highest possible energy density of the battery while keeping its weight low and respecting the cost-effectiveness of the design. During the work, the target capacity, operating voltage and discharge current of the battery were determined. Commercially available cells with satisfactory parameters were collected and all available catalogue data was consulted, paying particular attention to their discharge curves. On the basis of the above input data and based on the actual discharge characteristics of the cells considered, battery designs were developed based on them. On the basis of the analyses carried out, conclusions were drawn regarding the optimisation of component selection and the optimum set of cells with the best performance characteristics was identified.

Research supervisor of the paper:

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Elektrotermia

HCL 2.0 - Modular Lighting Focused on Human Needs

Human Centric Lighting is an innovative approach to lighting design aimed at satisfying personalized user needs. By following the user's circadian rhythm and learning from and mimicking habits with maximum usage of natural sunlight, it provides much greater care for human health and comfort. This lighting concept focuses not only on the user but also on their surroundings on a micro-scale—room, office, building—as well as on a macro-scale—minimizing environmental impact by reducing energy consumption and light pollution.

The Electrotermia Student Research Group introduces an additional innovation to the world of HCL—motion of the light source. It is a new parameter in the characteristics of lighting fixtures, whose modular construction allows for lighting adaptation to any space, room, and conditions. Another function of the device is its ability to communicate and integrate with building automation, sensors, building management systems, and communication with the user through specified changes in light color.

Research supervisor of the paper:

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Wydział Elektrotechniki, Automatyki, Informatyki i Inżynierii Biomedycznej
Elektrotermia

Mechanical and software modernization of a budget 3D printer to improve speed and print quality parameters.

The paper discusses the mechanical and software modernization of a budget 3D printer, aiming to increase the speed and quality of printing. The mechanical upgrade includes modifications to the printer's structure, such as improvements to the axle guidance system, the use of better construction materials, and increased frame stability. Software modernization, on the other hand, refers to updating the control software, which enables optimization of the printing process, reducing the time needed to print and improving precision. The implementation of these changes contributes to a significant increase in printing efficiency and quality, which is important for both professional users and hobbyists. Thanks to mechanical and software modernization, the budget 3D printer becomes more competitive on the market and more attractive to a wide range of users, ensuring faster and more accurate prints.

Research supervisor of the paper:

dr inż. Jakub Grela

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Elektrotermia

A software and hardware platform for Hardware-in-the-Loop (HIL) simulations

The topic of the presentation is a platform for conducting tests using the HIL methodology, developed as part of the activities of the Elektrotermia Student Research Club. This platform utilizes Simulink mathematical models and allows them to be tested in a soft real-time environment. Communication with the real world is done via NI digital acquisition cards, driven by the DAQmx driver. This driver is wrapped inside a DLL library and, with the usage of the @Source add-on, encapsulated functions are visible on the Simulink block diagram. This approach allows NI cards to be used directly from Simulink. The scope of this project was to prepare example models that would enable such communication. They were tested along with signal generation and acquisition capabilities. Changes in acquired signals can be monitored via a GUI application. Finally, the designed platform was used to verify a automatic gearbox model that was created by one of the Student Research Club members as part of their master's thesis project.

Research supervisor of the paper:

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Piorun

Measurements and analysis of overvoltages transferred through the windings of power transformers

Project has an experimental and research character and is related to the implementation of a series of laboratory measurements. The test objects are power transformers with different power ratings and voltage ratios. The input signals are voltages of different shapes, typical of the waveforms reaching the terminals of transformers operating in overhead distribution systems. In order to analyze the results obtained during the measurements, it is planned to compare them to the results of numerical computer simulations of transmitted overvoltages generated in 'transformer - power line' connection systems. The reference for the performed tests will be the description of the problem of transmitted overvoltages taking into account the relevant standards and guidelines, as well as the characteristics of this phenomenon. In comparative analyses of the response of transformers to excitations of different shapes, the reference will be both the results of laboratory measurements and those obtained as a result of simulations carried out on numerical models.

Research supervisor of the paper:

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Elektrotermia

Application of programmable logic controller as a weather compensated temperature controller of the heating node

The ever-increasing demand for thermal energy leads to the production of more and more pollution and, above all, to an increase in energy consumption, in order to deal with this it is important to use it efficiently and minimize losses. Thermal nodes have been used for years, however, the old designs often served a number of buildings and thus had a very high thermal inertia and generated large losses, so today individual nodes are used, which reduce this ratio.

Inherent in the aforementioned nodes is their control. Existing systems so far, as a rule, operate under the control of a weather controller. They make the operation of heating equipment dependent on the temperature measured outside the building and the characteristics of the heating system. Their task is to compensate for the averaged, flattened value of the outside temperature so as to ensure the thermal comfort of users. New generations of weather controllers are beginning to offer modern features like data logging, simple process visualization, etc. However, the use of Programmable Logic Controllers (PLCs) in the weather controller function is also being observed. This is due to the greater capabilities of PLCs, both in terms of implementing complex control algorithms or integrating with additional elements influencing the control process (for example, room measurement sensors).

The aim of the project is to analyze the possibility of implementing selected functions and complex control of the operation of a thermal center with the use of a freely programmable controller (PLC), which will replace the classical weather controller. For this purpose, the requirements of exemplary technological installations have been recognized and the functional assumptions for the implementation of the control system have been determined. Based on the analysis of the requirements and the literature review, the concept of using the selected PLC to implement a modern control system offering additional functions in relation to classical controllers will be presented. In addition, the paper will analyze the components of the selected PLC programming language, enabling the realization of the adopted control system concepts

Research supervisor of the paper:

dr inż. Aleksander Skała

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AGH Eko-Energia

Control and communication system of the "Perła" solar car battery.

The paper presents the design of the control system and communication methods for the main battery of the "Perła" solar car constructed by students of our scientific club. Control consists 2 BMS (Battery management system) systems: one purchased, which will be responsible for balancing the voltages between the cells and transmitting the main voltage outside the system. The second one, as an original PCB design, will support radio communication with the vehicle's crew and its staff outside the vehicle, as well as communication via the CAN bus with other vehicle systems. Another task will be to collect information about cell temperatures using many thermistors distributed in the battery. The report will also discuss the issue of connecting cells, collecting information from them, and cable management. The last element that will supervise the system will be the battery cooling system while charging the car using fans.

Research supervisor of the paper:

mg inż. Maciej Żołądek

Dawid **Soszyński**, II mgr
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Wydział Elektrotechniki, Automatyki, Informatyki i Inżynierii Biomedycznej
Piorun

The impact of the arrangement of sectional switches on selected indicators of power supply reliability in power distribution networks

The main goal of the presented research is to analyze and determine the impact of the number and location of sectional switches on selected reliability indicators of the medium voltage (MV) power grid. For a selected, real fragment of the MV network, the following reliability indicators were calculated and analyzed: - average (average) system duration of interruption in electricity supply; - indicator of the average system frequency of long interruptions in energy supply; - indicator of the average time needed to restore power to consumers. These indicators were defined, described and used to perform reliability calculations.

Research supervisor of the paper:

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Piorun

Application of high voltage direct current (HVDC) systems in power transmission.

The paper presents the use of high-voltage direct current (HVDC) systems in power transmission and a comparison of HVDC systems and HVAC systems. Configurations of HVDC systems (monopolar, bipolar systems, back-to-back connections, etc.), components of converter stations (thyristor systems, converter transformers, harmonic filters (AC and DC sides, DC reactors, grounding electrodes)) and also design solutions for overhead and cable lines will be presented in the paper.

The paper discusses issues and problems related to the operation of HVDC systems, including: characteristic harmonics generated by converter stations, methods used to reduce higher harmonics (AC and DC sides), compensation of reactive power consumed by converter systems and the control of HVDC systems.

The presentation of the topic is illustrated with examples of applied solutions along with an indication of the development trends of HVDC systems.

Research supervisor of the paper:

dr inż. Rafał Tarko

Viacheslav **Budnyk**, doktorant
Chernihiv Polytechnic National University
Computer Science
Metaenga

VR training in Electrical engineering

Development and implementation Virtual Reality training solutions for national distribution companies to improve workforce development in the energy sector.

Research supervisor of the paper:

Dr. Anatoliy Prystupa

Yevhenii **Yatchenko**, doktorant
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faculty of electronic and information technologies

analytical synthesis of the control law for a modular step-down DC-DC converter

Analytical synthesis of the control law for a modular step-down DC-DC converter involves formulating a mathematical framework to define the control strategy for optimizing the converter's performance. DC-DC converters are crucial for providing stable voltage levels in various electronic applications. A step-down (buck) converter, in particular, reduces input voltage to a desired lower output level. The modular approach indicates that the system can be scaled according to the power requirements by integrating multiple modules. The analytical synthesis process involves creating a set of governing equations that consider electrical parameters, such as inductance, capacitance, and resistance, to manage the converter's operation efficiently. By systematically analyzing these parameters, the control law is derived to regulate output voltage and current while maintaining stability, improving efficiency, and responding to load changes dynamically.

Research supervisor of the paper:

Ph.D., Anatoly Pristupa

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The use of metrology in ensuring the safety and protection of critical infrastructure.

Securing critical infrastructure requires high precision and reliability, which are provided through the application of metrological methods. Metrology plays a key role in achieving measurement accuracy and process standardization, which are foundational for effective protection and the prevention of false alarms. This work presents the main principles and methods of metrology used to protect critical infrastructure, along with descriptions of modern measuring devices and systems. Practical examples demonstrate how metrological approaches are applied in monitoring, diagnostics, and threat response, enhancing the security of facilities. The discussion also covers the latest technological innovations and developments in metrology that improve protective mechanisms. The conclusion emphasizes the importance of further research and development in metrology aimed at strengthening the security of critical infrastructure, while highlighting current challenges and future directions in this field. Special attention is given to the need to integrate the latest technologies to enhance the effectiveness of threat detection and neutralization, considering the rapidly changing nature of military conflicts and technological challenges. Furthermore, collaborative efforts among metrologists, engineers, and defense strategists are crucial for developing comprehensive solutions to address emerging threats effectively.

Research supervisor of the paper:

PhD Kulko Tetiana

Vladyslav **Hlybovets**, IV inż.
Chernihiv Polytechnic National University
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The use of energy efficient 10/0.4 kV transformers in urban power supply systems

The introduction explains the nature of power losses occurring in transformers and the technologies for minimizing them.

The main body explains the results of simulation the normal operation mode of the 10 kV electrical power networks, in which outdated transformers and modern energy-efficient transformers are installed.

The object of research is the processes occurring in the elements of the electrical power networks in which transformers are installed according to the requirements of eco-design.

The subject of research is the influence of the technical (certificate) parameters of power transformers on the technical indicators of the functioning of 10 kV power distribution networks.

The purpose of the work is to reduce electrical energy losses during its distribution in 10 kV electrical power networks.

Methods of research. The solution of the problem is based on the methods of simulation using the Power Factory software.

The practical value. The results of the work can be used to select the energy efficiency class of transformers when designing 10 kV distribution power networks.

POWER TRANSFORMER, ENERGY EFFICIENCY CLASS, ECODESIGN, POWER LOSSES.

Research supervisor of the paper:

PhD, Roman, Buinyi

Section VI Energy and Thermal Ecotechnologies

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Wydział Inżynierii Metali i Informatyki Przemysłowej
Caloria

Analysis of the possibility of heat recovery from process gases using TEG modules

The analysis carried out concerns the possibility of recovering heat from process gases using TEG (Thermoelectric Energy Generator) modules. The research focuses on the efficient use of heat generated in industrial processes. TEG modules use the thermoelectric phenomenon, in which the temperature difference between the two sides of the module generates an electric current. In the context of heat recovery from process gases, TEG modules can be installed on an absorber that is placed in the flue pipes. This allows the heat of the hot gases to be used to generate electricity. The research includes an evaluation of the performance of TEG modules and the potential for industrial application. The results obtained from the research could contribute to more efficient energy use in production processes and reduce greenhouse gas emissions.

Research supervisor of the paper:

Mgr inż. Piotr Górszczak, Dr hab. inż. Marcin Rywotycki

Wiktor **Krzewiński**, III inż.
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Wydział Energetyki i Paliw
AGH Eko-Energia

Numerical analysis of a solar car's battery cooling system

AGH Eko-Energia student research group is constructing a solar-powered vehicle named "Perła", which stores accumulated energy in a battery located at its front. During the presentation, various battery cooling system configurations considered for the solar car ”Perła”, will be discussed. The results of conducted numerical analyses utilizing computational fluid dynamics, along with encountered challenges, will be presented and discussed. The presentation will address issues related to the significance of selecting an appropriate battery cooling system and its impact on the proper functioning of the vehicle. The geometry of the proposed solution, as well as a graphical representation of obtained results will be presented during the presentation. The presentation will conclude with a discussion of further steps that may be taken based on the obtained analysis results.

Research supervisor of the paper:

mgr inż. Maciej Żołądek

Łukasz **Jaśkiewicz**, II inż.
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Wydział Energetyki i Paliw
Green Energy

The predictive analytics of electrical energy prices on TGE using linear regression

In the paper there was the analysis of electrical energy prices on TGE (Towarowa Giełda Energii) in the 2-month period from 16.02.2024 to 16.04.2024. There were chosen the following factors as having the particular impact on the electrical energy price in the selected day: production brutto from the conventional power plants and renewable energy sources and international exchange brutto from countries having the possibility to do so with Poland. On the basis of collected data there were the prediction model built, which have calculated the expected prices for a period from 17.04.2024 to 30.04.2024. In conclusions special emphasis has been placed on the effectiveness of such model, operating on collected data, and the analysis of additional factors that could affect the model. Advantages and disadvantages of such approach were pointed out in the end.

Research supervisor of the paper:

dr inż. Mirosław Kwiatkowski, prof. AGH

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Powierzchnia

Analysis of physicochemical properties of biochars, obtained by pyrolysis of waste biomass.

Nowadays, the world is confronted with the problem of emerging waste and emissions of harmful gases. People are not indifferent to these threats and are taking measures to neutralize the harmful effects. These measures include recycling waste, using renewable energy sources, abandoning the use of environmentally harmful products and reducing the consumption of raw materials. The problem affects not only households, but also large companies that generate pollution and residues through mass production. Among these is waste biomass, which is waste of organic origin. Biomass can be processed through thermochemical processes, such as pyrolysis, gasification and hydrothermal carbonization. In medium-temperature pyrolysis (up to 600 °C), the main product is biochar. This material has a number of applications, e.g. as aCO2 adsorbent, in wastewater treatment systems, water filtration, as well as in agriculture as a fertilizer. The purpose of the presented research is to study the physicochemical properties of biochar, obtained by pyrolysis of agricultural biomass waste. To obtain biochar, defatted rapeseed (rapeseed cake), corn cob residues, and walnut shells were used as feedstock. The pyrolysis process was carried out in a fixed bed oven at 600 ℃, under a nitrogen atmosphere with a flow rate of 100 ml/min and a sample residence time of 10 minutes. The study of physicochemical properties concerned both biomass and the biochar obtained from them by pyrolysis. The scope of the study included analysis of moisture, ash and volatile content, analysis of carbon, hydrogen and nitrogen content, analysis of hemicellulose, cellulose and lignin content, as well as structural and morphological analysis, using scanning electron microscopy (SEM) and bonding analysis using Fourier Transform Infrared Spectroscopy (FTIR). The pyrolysis process resulted in significant carbonization of the materials (increased carbon content): rapeseed cake(46% -> 62%), walnut shells(48% -> 87%), corn cobs (44% -> 85%). Structural analysis confirmed the release of volatile parts and the obtaining of porous materials with properties similar to activated carbons.

Funding: This research was fully funded by the National Science Center in Poland [grant number: 2020/39/B/ST8/00883], titled: "Comprehensive analysis of the effect of the presence of chlorine on the process of rapid co-pyrolysis of agricultural biomass and municipal waste."

Research supervisor of the paper:

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Wydział Energetyki i Paliw
Green Energy

Analysis of the use of heat pumps for heating purposes in residential buildings

The lecture discussed the issues of ensuring thermal comfort for single-family and multi-family buildings. In particular, the focus was on analyzing the profitability of investments in heat pumps and photovoltaic installations. The lecture made a critical assessment of the above-mentioned investments, paying attention to the most frequently made mistakes and the resulting ones possible negative consequences. The multi-faceted analysis took into account ecological issues, including: the issue of emissions, limiting the emission of pollutants into the natural environment; economic, taking into account prices for electricity, prices of other heat energy carriers, investment costs, legal issues, financing possibilities, technical issues such as: electricity consumption, efficiency, failure rate, etc. In the summary, it was noted that before installing a heat pump for heating purposes thermal modernization of the building should be carried out and actions should be taken to increase the efficiency of the use of both thermal and electrical energy.

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Nabla

Studenckie Koło Naukowe

Analysis of transport phenomena in the anode of an SOFC fuel cell

Fuel cells are devices that directly convert the chemical energy of fuels into electrical energy. They are characterized by high efficiency, significantly exceeding other methods of energy conversion. The parameters of the microstructure play a significantly role in the efficiency of fuel cells. The aim of the study is to analyze the transport phenomena in the anode of a Solid Oxide Fuel Cell (SOFC). The anode is modeled using a direct current electrical circuit. The study examines the change in current density on the anode, depending on the anode's thickness. To this end, two models are used (related to mesh currents and branch currents), followed by validation using theoretical models: for low and high current densities. The study also analyzes the change in activation overpotential and ohmic overpotential related to ionic conduction, with changing anode thickness.

Research supervisor of the paper:

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Caloria

Zero-waste bioethanol production

In the conducted research, a process of bioethanol production was carried out using two types of raw materials: molasses, which is a by-product in the sugar production process, and waste from the food industry, which was a selected group of candies. Since waste materials were used for fuel production, the produced bioethanol belongs to the third-generation biofuels group. As part of the experiment, an analysis of electricity and water consumption was conducted. The cost of producing 1 liter of bioethanol under laboratory conditions was estimated. Additionally, the sugar content before and after the fermentation process was determined. The distillation process was carried out in a distillation column with heating power and cooling intensity regulation. After the distillation process, the volume of produced biofuel and the content of pure ethanol were measured. The residue from distillation can be used as feedstock in a biogas plant in the biogas production process. Therefore, the entire bioethanol production process can be completely waste-free.

Research supervisor of the paper:

dr. inż. Monika Kuźnia

Karol **Pogoda**, I mgr
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Caloria

Conceptual design of a solar roof in a single-family house.

This paper addresses the issue of environmentally friendly solutions that can be applied to a single-family house. The European Union's requirements to meet standards of increased environmental care, energy security and reduced use of natural resources are driving us towards such technological solutions. Renewable sources are an excellent alternative to conventional applications, cause less harm to the environment and are sometimes a cheaper source of energy. This paper presents the author's concept of using solar roof tiles in a single-family house. The solution is described and analysed from a technological, ecological and financial point of view over 25 years of use. A comparative economic and ecological analysis was also performed, comparing it with conventional technologies used by households. The work was based mainly on sources from the scientific literature, websites related to the subject matter in question, together with the websites of the manufacturers of the technology in question.

Research supervisor of the paper:

dr hab. inż. Marcin Rywotycki,

Arkadiusz **Czader**, II mgr
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Caloria

Optimizing the shape of an air quality measurement chamber

Advances in manufacturing technologies, such as 3D printing, made it possible to create devices with geometries that are impossible or very difficult to achieve using traditional methods. These capabilities, combined with computer simulations, make it possible to design devices that meet very stringent requirements.

The project involved optimizing the shape of the measurement chamber using airflow simulation. For this purpose, a program implementing the Lattice Boltzmann method was created along with a second program to optimize the shape using the results obtained from the simulation.

The optimization resulted in a geometry suitable for designing a new version of the measurement chamber.

Research supervisor of the paper:

dr inż. Robert Straka

Jan **Kiełbania**, I inż.
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Caloria

Review of waste heat recovery methods from industrial processes

The topic of the presentation is a review of waste heat recovery methods from industrial processes. Recovering waste heat from industrial processes is a key element of the strategy to improve energy efficiency and reduce greenhouse gas emissions. There are many heat recovery methods that are successfully used in industry: heat exchangers, recuperators, heat recovery from cooling fluids and others. Heat recovery from industrial processes not only contributes to energy savings and cost reduction, but also reduces the negative impact of the industry on the environment. For this reason, the development and introduction of the mentioned technologies is a priority topic in the modern world. The presentation will describe selected waste heat recovery technologies. Their pros and cons, scheme of operation, places where they are used.

Research supervisor of the paper:

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Caloria

ELECTRIC CARS IN CONFRONTATION WITH REALITY

The analysis of literature and media reports on electric cars is a multi-faceted study, encompassing key areas of production, technological development, environmental impact, and transportation safety. The main objective of the work is to objectively present the real benefits and challenges associated with mass production of electric vehicles and to analyze the mechanism by which theory translates into practical achievements in this field.

In the context of production, it is important to understand the entire process, starting from the acquisition of raw materials necessary for battery construction, through component assembly, to the final production of cars. At the same time, it is necessary to monitor technological progress, identify key innovations, and their impact on vehicle parameters such as range and energy efficiency.

Environmental impact analysis encompasses not only carbon dioxide emissions but also other aspects such as natural resource consumption and impact on the local environment. Additionally, transportation safety analysis requires the examination of data related to road accidents and crash tests.

All these elements come together in a comprehensive analysis, which allows for the demonstration of both the potential benefits and the real challenges associated with the electrification of transportation. This enables the formulation of accurate recommendations for industry and political decision-makers, supporting further development of this promising sector.

Research supervisor of the paper:

dr inż. Monika Kuźnia

Rafał **Sypniweski**, III inż.
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Wydział Inżynierii Mechanicznej i Robotyki
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Akademia Górniczo-Hutnicza im. Stanisława Staszica w Krakowie
Wydział Inżynierii Mechanicznej i Robotyki
AGH Solar Boat

Numerical simulation of airflow with heat dissipation from electrical components in the solar-powered racing boat Celka.

The focus of the study is on simulating airflow within the space of electrical components generating heat during the boat's operation. The simulation is based on experimentally determined values of heat generated by electronic components in the solar-powered racing boat Celka. Values collected experimentally were assigned to a prepared simplified geometric model, followed by conducting a CFD simulation of airflow. Conclusions were then drawn based on the results.

Research supervisor of the paper:

dr inż. Krzysztof Sornek

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Wydział Energetyki i Paliw
Nova Energia

Thermal treatment of waste as an ecological way to manage it

The aim of this study was to assess the possibilities of municipal waste management system in Poland. Theoretical and legal issues were delineated, particularly concerning municipal waste, including landfilling and incineration. Statistical data were used to formulate three scenarios of increasing waste generation until the year 2040. Based on statutory methodology and the capabilities of incineration plants in Poland, theoretical energy and heat generations were estimated, along with corresponding financial gains. Data gathered from 39 landfilling sites allowed the estimation of the average price for municipal waste landfilling and enabling the calculation of the total cost of waste landfilling in the scenarios created. The cost of waste admission into incineration sites was also considered. The analysis concluded that waste incineration is a crucial element closing the waste management system. Not only is it economically viable, but it also helps to avoid significant environmental pollution.

Research supervisor of the paper:

dr hab. inż. Tadeusz Olkuski

Weronika **Słowik**, I mgr
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Wydział Inżynierii Metali i Informatyki Przemysłowej
Caloria

The use of renewable energy sources in air conditioning installations

The increase in energy prices results in high operating costs of air conditioning installations in single-family houses. However, there are opportunities to reduce these costs by using renewable energy sources. One way is to use the ground as a source of heat in winter and coolness in summer. The paper presents the results of tests on a ground glycol heat exchanger connected to an air conditioning installation. The system includes a GHE, an automation system, a ventilation unit and an air-glycol heat exchanger. The analysis was carried out for the winter and summer seasons. The air temperature was measured at the inlet and outlet of the AHU and heat exchanger. The volume flow of the flowing glycol and its temperature at the entrance and exit from the system were also recorded. The obtained results confirm the effectiveness of the designed system supporting the operation of a small air-conditioning installation.

Research supervisor of the paper:

dr hab. inż. Marcin Rywotycki

Section VII Renewable Energy, Nuclear Energy and Alternative Fuels

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AGH Solar Boat

CFD numerical analysis of airfoils considering the impact of angle of attack and wing twist on their efficiency and hydrodynamic properties.

Airfoils, an invention known since the 19th century, are among the most crucial structures discovered by humans. Besides their obvious presence in aircraft wings, airfoil profiles are also used in the design of fans, drone propellers and helicopter blades, and even in foiling motorboats. The physical principles of a wing are fundamentally simple: lift force is generated through pressure differences between the upper and lower surfaces of the wing. In this study, an investigation was conducted on the NACA 63-415 airfoil, which is part of the 6-digit NACA profiles. Numerical analysis was performed using Computational Fluid Dynamics (CFD) for both 2D and 3D geometries. Additionally, an analysis was conducted on how wings behave when the inlet flow is twisted horizontally at an angle relative to the leading edge of an airfoil. Numerical analysis using CFD covered simulations on 3D geometries, showing results of lift and drag for different angles and how the shape of the winglet affects it. The results of this study provide understanding of how forces acting on foils change, for example, vehicle turns. Winglets were analyzed to minimize energy losses caused by turbulent eddies. The aerodynamic properties were examined in relation to the wing's angle of attack.

Research supervisor of the paper:

dr inż Krzysztof Sornek

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CarbON

Analysis of various hydrogen storage methods using CHEMCAD software

The research focused on analyzing various forms of hydrogen storage to identify the most efficient storage method. Individual chemical compounds such as hydrogen in liquid and pressurized form, ammonia in liquid and pressurized form, as well as liquid ammonia, were selected for the study. Additionally, the possibilities of hydrogen storage in solid compounds were investigated, utilizing hydrides such as magnesium borohydride and aluminum-sodium hydride. The research was conducted using the CHEMCAD software. To compare the properties of liquid storage, the CHEMCAD program library was utilized, and the obtained results were compiled and analyzed

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Zrównoważonego Rozwoju Energetycznego Solaris

Analysis of the phenomenon of non-market redispatching of generation from weather-dependent RES sources

Weather-dependent RES sources encompassing wind (WF) and photovoltaic (PV) power plants account for a growing share of power generation in the national electric power system (NPS). In 2023, the installed electrical capacity of such sources amounted to nearly 24 GW. Therefore, the number of hours when there is an oversupply of electricity in the system is increasing, and the transmission system operator, due to the safety of the NPS operation, is forced to intentionally order the curtailment of generation from PV and WF installations. The analysis carried out in the paper for 2023 shows that on the days and hours when there was non-market redispatch of generation from RES, the total production from PV and WF accounted for about 60% of the demand. In order to estimate changes in the frequency of RES generation curtailment in the future, simulations of NPS development were carried out based on ENTSO-E scenarios. The results indicate that in the short term, the number of such events will increase significantly. In the long term, on the other hand, much will depend on the role of hydrogen in the decarbonization of the economy. If the scenarios of mass use of hydrogen come true, the phenomenon of curtailment of RES generation will not be a significant problem.

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AGH Eko-Energia

Research on the optical properties of materials to optimize the lamination method of PV cells for the solar car "Perła".

The presentation will refer to studies on the impact of the method of laminating fiberglass on the transmissivity of the sample. The aim of the work is to select the appropriate lamination technology for photovoltaic cells on the solar car "Perła". Several samples with different fiber arrangements and 3 types of finishing of the outer surface of the panels were prepared and later tested. Samples were made using the vacuum infusion method. That process allowed saving time and money due to their smaller surface area and lower price than photovoltaic cells. The research was conducted by members of the student research club with the help of Professor Barbara Swatowska. The results were analyzed using code in the C language, written by students. Particularly interesting results were observed for samples with a smooth surface finish, where short, high-energy electromagnetic waves were transmitted through the material far worse than waves of higher frequency. Further studies will be conducted to reduce this effect, such as using different epoxy resins, changing the lamination method to, for example, light RTM.

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Piorun

Biomass as a renewable energy source - use and sustainable development

The paper presents various aspects related to the use of biomass as an alternative energy source. Starting with the definition of biomass and its various forms, the processes of obtaining, processing and using biomass in energy production will be discussed. Particular emphasis will be placed on the economic, ecological and social analysis related to this process, taking into account both potential benefits and challenges. The report will also present the latest technologies used in the production of energy from biomass as well as current trends and development prospects for this sector. The aim of the paper is to increase awareness of the potential of biomass as a sustainable energy source and to encourage further research and investment in this area.

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FENEC

Electrolyzer powered by renewable energy sources to produce hydrogen for emission-free electric vehicles

Hydrogen obtained from renewable energy sources through the process of electrolysis is intended to serve as a carrier and storage medium for renewable energy to power vehicles. The paper presents the results of research on the electrochemical process of obtaining and purifying hydrogen through water electrolysis using a low-temperature PEM (Proton Exchange Membrane) electrolyzer with a polymer proton exchange membrane. Key aspects of this process, including media requirements and electrical energy demand for hydrogen production, are outlined. The results of experimental studies investigating the influence of the applied polymer membrane and Gas Diffusion Layer (GDL) made of carbon fibers on process efficiency under various conditions are presented. These findings are highly beneficial for optimizing the operational parameters of the electrolyzer to be powered by electricity from PV (Photovoltaic) panel installations. The "green hydrogen" thus obtained will be utilized to power hybrid electric drives with fuel cells in electric vehicles, such as H2 rickshaws. The paper aims to present and identify directions for further research on the efficiency of the water electrolysis process for hydrogen production in the context of sustainable development and emission-free economy.

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CarbON

Modeling hydrogen separation processes

The presentation provided a comprehensive analysis of pressure swing adsorption processes in the context of hydrogen separation and purification, offering a promising pathway for emissions reduction in the energy and transportation sectors. The particular focus was on adsorption from gas mixtures, including coke oven gas, as a prospective technology. Advanced software tools such as Aspen Adsorption™ were utilized for simulation and process optimization. A key aspect was the precise selection of adsorbents and operating parameters, which significantly influenced achieving satisfactory results. Additionally, a technological process model analysis was conducted, with particular emphasis on the hydrogen purification stage, allowing for a better understanding of the process.

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Hydrogenium

Tuning electrode materials with in situ exsolved nanocatalysts for symmetrical Solid Oxide Cells

In nowadays rapidly changing world, the necessity to develop renewable energy sources is increasingly recognized as one of the best ways to reduce greenhouse gas emissions and achieve energy independence. Symmetrical Solid Oxide Cell (SOC) technology is a very promising solution to overcome this problem. Symmetrical SOCs are capable of efficiently converting and storing energy, depending on the current demand. However, materials for both anode and cathode should fulfil specific criteria, such as high mixed ionic-electronic conductivity, and structural stability in hydrogen and oxygen atmosphere.

In this work, $Sm_{0.9}Ba_{0.9}Mn_{1.8-x}Fe_x(Co,Ni)_{0.2}O_{6-\delta}$ double perovskite oxides with in situ exsolved nanocatalysts have been designed as stable electrode materials for symmetrical SOCs. The obtained results allow us to conclude that the developed materials could potentially popularize the application of SOCs in the energy transformation.

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AGH Solar Boat

Optimization of the geometry of hydrofoil tips in terms of hydrodynamic resistance and lift force using CFD - calculations using SAS and k-omega SST GEKO computational models

The topic of hydrowings is very broad. Thanks to 2D or 2.5D simulations, we can determine the profile characteristics in any fluid at low computational cost, but if we want to use the profile in a hydrofoil, 3D simulations must also be performed. In my research, I analyzed several different hydrowing tips for hydrodynamic properties. The test parameters concerned the extraction of a complex profile with a chord of 100 mm and a length of 350 mm, which corresponds to the estimated dimensions of the hydrowings of the Celka solar racing boat. Thanks to the results, it is possible to select optimal wings for the above hydrofoil. This procedure allows you to minimize energy consumption during long-distance races.

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Nova Energia

Perspectives of Energy Transition in Poland with an Emphasis on Environmental, Economic and Technical Aspects

In this paper four paths of energy transition in Poland were compared within selected aspects. Perspectives of reducing human, environmental and economic cost of power generation were main motivations. Research analysed Polish Energy Policy by 2040, its unapproved update, back-to-coal and zero-nuclear scenarios. These scenarios differed in available power capacities and energy production. Current policies are outdated and insufficient, since wind and solar power capacities in 2023 almost exceeded levels expected for 2035. In scenarios with a high pace of coal phase-out emissions of CO2, SO2, and NOx are notably reduced. CO2 emissions per energy unit can decrease from 779 gCO2/kWh in 2022 to 188 gCO2/kWh in 2040. Rapid transformation scenarios had significantly lower cost of buying allowances in EU ETS. Without creating other capacities, power shortages may occur if Poland's nuclear energy program proves unsuccessful. According to analysed scenarios, power gap might happen in late 2030s. Calculations and data visualisations were conducted in Python using custom scripts.

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AGH Solar Boat

Design and numerical analysis of cooling of the electric accumulator of a solar boat using URANS and SAS models

Nowadays, electric energy obtained from renewable energy sources is increasingly widely used. Energy is stored in complex, isolated batteries aimed at ensuring high efficiency and safety against overheating or mechanical damage. The weight is also a key aspect, important e.g. in cars or electric boats. Computational Fluid Dynamics (CFD) analysis is a key tool used to study and optimize flow structures, including batteries. In this study, the focus was on the analysis of the battery of the solar electric boat Celka of the AGH Solar Boat scientific club. This battery, being a key element of the boat, is responsible for collecting and storing energy from photovoltaic panels located on the deck of the boat with an area of 6m2, which is then used for propulsion. Both 2D and 3D analyses were applied to fully understand the behavior of the battery under various conditions. Iterative numerical refinement of the battery geometry was carried out to increase its performance and energy efficiency. The results were compared with the previous battery model, which allowed identifying areas for improvement. In the CFD analysis, turbulence models based on URANS i.e. k-omega GEKO were used. Additionally, for a deeper understanding, a model from the SAS family showing turbulence inside the battery was used in the final analysis. The received data led to the creation of a high-quality battery design for a solar racing boat. Based on the conducted research, knowledge and experience were gained for future analyses, including the planned new battery operating at a higher basic voltage.

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AGH Eko-Energia

Design of a composite battery casing to "Perła" vehicle

During the lecture, the process of designing the battery housing of the "Perła" vehicle will be presented, starting from the design assumptions and the limited space of the battery compartment. The structure of one of the five packages in the 4S4P system will be presented, the main features of the structure and the method of assembly will be highlighted. Then, the topic of battery cooling will be discussed and a simulation of selecting the thickness of the heat sinks will be presented, as well as the technological process of producing the heat sink using specially designed stamping pliers will be discussed. The paper will then present the construction of the entire housing for five battery packs and the battery control system, and composite forms used to produce the details will be presented. After discussing the entire project, a second, twin battery design for seven packs in 3S5P systems consisting of other cells will be presented, which will ultimately be used in the "Perła" vehicle project.

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New-Tech

dapting a spark-ignition internal combustion engine to work on bio-ethanol

The presentation will showcase the benefits of powering a combustion engine with bioethanol from economic, environmental, and performance perspectives. Firstly, economic advantages will be discussed, such as potential fuel savings and raw material price stability. Next, the focus will shift to environmental benefits, including reduced emissions of harmful substances and the impact on climate change. Finally, improvements in engine performance due to bioethanol utilization will be presented, encompassing increased power and performance. Using the example of modifying the gasoline engine of a Volvo 740 car, specific adaptations necessary to achieve the described benefits will be discussed, including modifications to the fuel and electrical systems. Additionally, the costs of adaptation will be analyzed during the presentation, including the prices of parts and necessary accessories, to provide a comprehensive overview of the economic, environmental, and performance aspects of powering an engine with bioethanol.

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Nabla

Studenckie Koło Naukowe

Artificial Neural Networks as Efficient Models of Proton Exchange Membrane Fuel Cells

Utilization of machine learning methodologies, particularly artificial neural net-works (ANNs), presents a good approach to accurately model physical systems. Such pre-dictive simulations offer the ability to predict system performance across diverse operational conditions without the need of use mathematical descriptions. This approach contrast with traditional, time-consuming approaches reliant on partial differential equations. ANN methodology is used to obtain the characteristics of proton exchange membrane fuel cells (PEMFCs). PEMFCs are low temperature devices which convert chemical energy into electricity. Utilizing data gained from computational fluid dynamics simulations of PEMFCs, was explored various data collection techniques and network architectures to check their impact on predictive fidelity. Conclusions show that the ANN-based framework enables rapid prediction of current-voltage characteristics, achieving accuracy levels surpassing 90%. Practical of machine learning model implications were discussed, accenting its utility in optimizing PEMFC operational parameters.

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Energetyków Jądrowych Uranium

Thorium fuel cycle - implementation attempts using the example of the Indian nuclear energy program

The presentation addresses the issue of using thorium-232 as a fertile material in nuclear reactors as an alternative to technologies utilizing uranium-235. The basic assumptions and advantages of the thorium fuel cycle, involving the transmutation of thorium-232 into fissile uranium-233, will be presented. Attempts to implement the thorium fuel cycle in practice will be discussed using the example of the Indian nuclear energy program. This program is based on the thorium cycle and is divided into three phases. In the first phase, Pressurized Heavy Water Reactors (PHWRs) are to be used for plutonium production. In the second phase, fast reactors with a plutonium core and a thorium-uranium blanket produce even more plutonium and uranium-233. In the final phase, Advanced Heavy Water Reactors (AHWRs) with a plutonium-thorium core are planned to produce more fissile material than they consume.

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Creative

Algorithms of a proprietary eye tracking device allowing for the implementation of application control

The aim of the work is to analyze the construction of an eye movement tracking device and to create a recognition system that enables application control. It has been shown that this system can significantly facilitate communication for people with disabilities, improving their quality of life. The heart of this technology consists of image processing and machine learning algorithms that accurately detect and track the position and movements of the eyeball. These advanced algorithms allow for a quick and precise response of the system to the user's eye movements, which is key for smooth application control. The work also focuses on optimizing algorithms to reduce delays and improve tracking accuracy. Techniques for calibrating the system have been presented, which adjust it to the individual needs of the user, ensuring exceptional accuracy.

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Industrial Data Science

Personable identifiable information data detection in student essays through NLP techniques.

The area of data anonymization is a very common source of problems in many data science fields of study. Protecting personally identifiable (PII) information might even be one of the key aspects of initial considerations when planning some projects. One of such projects might be the preparation and publication of a student writing dataset.

Before said dataset publication the creators are tasked with anonymizing the data in each and every essay that would allow someone to identify the essay's author. Usually this task is done manually, which in turn is very time consuming. To significantly shorten the time needed to achieve said anonymization a NLP (Natural Language Processing) system should be proposed.

To that end we will compare state of the art techniques used for NER (Named Entity Recognition) tasks, such as BERT, DeBERTa and RoBERTa neural net architectures. In this comparison we'll search for the most effective solution in classifying PII. This work is part of a competition organised by Vanderbilt University in Nashville, Tennessee.

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Nie dotyczy (Student innej Uczelni)
Bit

Molecular Fingerprints in Chemoinformatics and Graph Preprocessing

Molecular fingerprints are algorithms commonly used to vectorize graphs of chemical molecules as part of preprocessing in machine learning solutions. Machine learning on graphs is a non-trivial task and an important problem in modern data science. An easy way to perform this task is by encoding the graph into a vector consisting of values of certain descriptors. Molecular fingerprints are algorithms designed to handle this type of preprocessing. Even simple models, that incorporate them, can yield results comparable to state-of-the-art neural network solutions. We would like to present some popular fingerprint algorithms and their uses in chemoinformatics and machine learning. The talk was inspired by our project, in which we implemented a library for efficiently computing such fingerprints.

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AGH Drone Engineering

SLAM Methodology in the Context of Map Building Using Autonomous Drone Sensors: Practical Applications, Challenges, and Perspectives

The paper deals with the method of map building using autonomous drone sensors, using SLAM (Simultaneous Localization and Mapping) methodology. There will be detailed explanations of what this methodology is, how it works, and practical examples of its application will be presented. One of them will be an example from international competitions, where as the Drone Engineering scientific club we integrated a software using SLAM to process information from the ROSbot2r robot lidar by Husarion. In addition, the paper will include an analysis of challenges and problems that may occur during the implementation of SLAM methodology in practical applications, as well as potential solutions to these problems. The impact of SLAM methodology on the development of mobile robot technology will also be discussed. The paper will conclude with predictions for the future, discussing the potential directions of development of SLAM methodology and its impact on future generations of autonomous drones. Looking ahead, the paper will also discuss the possibilities and limitations of the SLAM methodology in the context of the growing role of drones in various economic sectors.

Research supervisor of the paper:

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61th Conference of the AGH University of Science and Technology Student Research Groups
May 9, 2024

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Glider

Comparison and Use of Open LLM Models in the Linux Bash Environment for User Assistance

Thanks to the ability of Large Language Models (LLM) to generate code and instructions, they are used, among others, in tools that improve the work of programmers, relieving them from simple modifications or writing simple fragments of code from scratch. The aim of this project is to create a similar tool for Linux terminal users, both beginners and experienced, in performing tasks related to, for example, the use of CLI applications or system administration. To achieve this, an application was created for convenient querying of the model and executing returned instructions, as well as a testing framework using them. It uses containers to test generated instructions in a controlled environment, thanks to which it was possible to perform automated tests comparing the quality of instructions returned by available open LLMs depending on the set parameters.

During the presentation, the prepared tools will be presented along with the obtained preliminary results.

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61th Conference of the AGH University of Science and Technology Student Research Groups
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Industrial Data Science

Parallel heuristics for the traveling salesman problem in combinatorial optimization

This paper examines the use of parallel heuristics to solve the Traveling Salesman Problem (TSP), a key issue in combinatorial optimization. It focuses on implementing an Island Genetic Algorithm, which is made parallel through the use of the Message Passing Interface (MPI). This approach aims to improve the speed and quality of solutions. The study also considers the use of Compute Unified Device Architecture (CUDA) to potentially enhance performance further by utilizing GPU computing. By applying these parallel computing methods, the research explores their effectiveness in addressing the TSP, providing insights into how these techniques can be used in computational problems.

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AGH Code Industry - CoIn

Unity ML Self-driving Agent

The presentation discusses the Racing Cart AI project, which focuses on creating an unbeatable artificial intelligence (AI) in the game “Racing Cart.” The game was developed as part of scientific activities within the “AGH Code Industry” group. In this game, players maneuver a small vehicle through a complex map, avoiding obstacles and utilizing drifting techniques and advanced controls. The project leverages the Unity ML Agents environment, which allows training agents using various machine learning techniques, including reinforcement learning, in any custom-defined environment. The presentation will cover methods, possibilities, and challenges related to training such a model, specifically in the context of the Racing Cart AI project

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Bit

Application of machine learning to support pen & paper RPG game design

In recent years one can observe continuous and dynamic development of the pen & paper RPG market. One of the problems that the industry is facing is the need to design new opponents and to determine the scale of challenge they pose to players. The traditional way of establishing this figure requires many hours of practical tests. Currently there is no automatic way to estimate the level.

The prediction of the scale of challenge can be reduced to ordinal regression. As part of this thesis several machine learning models with different sets of properties were tested in order to create a solution that would estimate the level of the designed monster in a fast and precise way.

Additionally, with the use of explainable AI and counterfactual examples the authors developed suggestions on how to modify monster's properties to increase or decrease its level to desired value.

The result of this thesis is a web application that allows designing monsters using the functionalities described above.

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AGH Code Industry - CoIn

Utilizing Random Level Generation in Creating a Horror Game

In recent years, there has been a significant increase in interest in horror games. This terrifying form of entertainment proves to be a way to unwind from negative emotions. Despite such high interest, there is a shortage of games that combine the scary aspect of "Horror" with random level generation, which allows for unique experiences with each session played.

The aim of the project is to utilize random generation as the main mechanism responsible for building the prepared space for player exploration. The created levels have corridors, some of which are dead ends, and some loop, providing cyclic paths. The multitude of possible combinations of generated corridors ensures that the player always receives a different layout to explore. Rooms are also generated, with the generation process responsible for furnishing the rooms and corridors.

These objectives have been achieved through the integrated collision system offered by the Unity engine and pathfinding algorithms, which are the basic determinants of corridor placement. Optimization aspects of the generator itself and the resources needed for smooth gameplay have also been taken into account, including the creation of a system limiting the number of lights in the game.

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AGH Algo

Detecting AI-Generated Images

With the rapid developments in artificial intelligence technologies, the proliferation of AI-generated content has become a growing concern. The ability to detect AI-generated images plays an important role in safeguarding against misinformation, fraudulent activities, and can have potential ethical implications. Morover, such detection has a paramount importance in developping new generative models, because it allows to avoid training new model on previously generated data. This article provides an overview of the methods and challenges associated with detecting AI-generated content. Presenting not only solutions based on Deep Learning, but it also compares them with a more classical approach based on feature engineering and simpler machine learning models such as Linear Discriminant Analysis or Random Forest.

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New-Tech

Trajectory planning for a mobile robot based on image from a stereo camera

Path planning has numerous applications, including logistics, public transportation, aviation, and navigation applications. Our work, utilizing images from the ZED 2 stereo vision camera, enables trajectory planning and obstacle avoidance for a mobile robot. It leverages the OpenCV library for camera calibration, depth map calculations, 3D space reconstruction, and optimal pathfinding. The process involves camera parameter correction, obstacle identification, followed by trajectory determination using a suitable pathfinding algorithm. The final path is projected onto a 2D image for visualization. The entire project facilitates complex motion planning operations for robotic vehicles in three-dimensional environments.

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Using Soft Margin in the Support Vector Machine Method for Various Applied Applications

The task of data classification, as one of the Data Mining tasks, is used in various fields of activity. The widely known Support Vector Machine (SVM) method is used to define linear class boundaries in a certain feature space during the training phase and classifies new objects according to the same features, providing the largest standard margin between classes. The application of this method in various applied fields demonstrates interesting and user-understandable important results. The decision-making process regarding new objects, whose features somehow violate the previously established classification rules (exceeding the established margin width), uses the concept of a "soft margin". The soft-margin SVM method minimizes the number of errors during training by adjusting the margin width. The solution to such an optimization task is of a compromising nature: it establishes a balance between the margin width and the number of points that need to be moved to maintain this width. Examples of the application of the soft-margin SVM method in some important applied areas are provided.

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AGH Space Systems

"Healthcare in the IoT Era: Design and Implementation of a Health Monitoring System"

The paper discusses the design concept of an IoT device used to collect health data such as pulse, body temperature and physical activity. At the beginning, the vision and general idea are presented - thanks to it it is possible to observe and control the most important parameters. Thanks to fall detection, it is useful to have the option of informing selected people about a disturbing event. Then, the design process of an ergonomic wearable device and the integration of sensors with the device are presented. Nowadays, the aspect of economic power supply is also important. Communication with the mobile application on the phone is a key aspect of the project, including the use of Bluetooth Low Energy (BLE) technology or communication via Wi-Fi. Thanks to the collected data, the system can inform the user about disturbing parameters (thanks to the developed algorithm). Finally, the importance of testing, calibrating and maintaining the system to ensure its effectiveness and measurement accuracy is also highlighted.

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Ekonometryk

Analysis of Demand for diverse diet

Demand analysis is a complex process aimed at understanding consumption dynamics in the context of changes in commodity prices and consumer incomes. However, its scope can also be extended to examine the need for a diverse diet, identifying factors significantly influencing the quantity and assortment of consumed goods. The aim of this study is to determine the factors that statistically significantly affect the diversity of diet among households in Poland. Unit data from the Household Budget Survey (HBS) conducted by the Central Statistical Office in 2022 were used for empirical analysis. Based on these data, two indicators describing the diversity of consumed goods - quantity and the Berridge index - were constructed to explain variables describing the households under consideration. The results obtained from the estimation of the Least Squares Method (LSM) model indicate that the level of dietary diversity is a result of the variability of commodity prices and consumer incomes, as well as other characteristics influencing dietary preferences. These findings partially confirm the results obtained in previous studies on households.

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Spatial analysis of labor markets across districts in the Voivodeship of Lesser Poland

The Lesser Poland Voivodeship, although not the largest in the country, boasts a remarkably diverse labor market shaped by its unique geographical characteristics and various local factors influencing job markets across its districts. This paper aims to highlight the results of research conducted on labor markets within the Lesser Poland Voivodeship. The analysis utilized the data from the Local Data Bank of Statistics Poland. For said data, methods from multivariate statistics, specifically linear ordering and cluster analysis were applied. Consequently, synthetic variable was created, which was used to construct a ranking that reflects the state of each district's job market. Furthermore, territorial units were grouped to determine the similarity among local labor markets within Lesser Poland. The results of this study have not only a scientific value but also offer valuable insights for district policymakers aiming to develop effective strategies for local labor markets.

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AGH Solar Boat

Autonomous control system of the solar-powered research boat

This thesis presents the development and implementation of an autonomous control system designed for a solar-powered research vessel. The research vessel serves as a platform for studying various aspects of marine environments, including environmental monitoring, data collection, and scientific research. The autonomous control system integrates advanced navigation, sensing, and communication technologies to enable the vessel to operate efficiently and independently. Key components of the system include GPS navigation, obstacle detection and avoidance, and remote communication capabilities. The thesis outlines the design, implementation, and testing of each component and its integration into a cohesive autonomous control system. The autonomous control system presented in this thesis represents a significant advancement in the field of marine robotics and has the potential to enhance the capabilities of solar-powered research vessels for scientific exploration and environmental monitoring.

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Study of High-Volume Return Premium on the Warsaw Stock Exchange: Analysis of Investment Strategy Profitability

The presented study focuses on analyzing the high-volume return premium on the Warsaw Stock Exchange (GPW) and the profitability of an investment strategy based on this phenomenon. The study utilizes data from selected companies from the WIG20 and mWIG40 indices. The investment strategy involves purchasing stocks of companies on the day they experience unusually high trading volumes compared to a reference period and then selling them within a short time horizon. Additionally, the impact of various factors such as company size and industry on the profitability of this strategy is examined. The study also considers different variations of the strategy, such as an additional condition related to return rate, different lengths of reference periods, or different holding periods for stocks in the portfolio. The results of the analysis provide key insights into the effectiveness of investment strategies based on high-volume return premiums and the factors influencing their performance in the stock market.

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AGH Solar Plane

Lesion detection in CT imaging via deep learning-driven volumetric segmentation.

The research described in the paper focuses on utilizing artificial intelligence algorithms to support veterinary medicine. Emphasis is placed on the segmentation of heterogeneous tumor changes in dogs of different breeds. Within these studies, the Residual UNet architecture was utilized, based on convolutional neural networks and containing additional blocks supporting gradient propagation. The entire process of data processing, implementation, and the use of tools necessary for working with medical data, specifically 3D images obtained using a tomograph, has been described. The research results were discussed in detail, and further project development possibilities were proposed. The research was conducted using computational resources from PLGrid under computational grant No. PLG/2023/016239. The research is part of the author's engineering thesis.

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Creative

Integration and development of software for controlling the dieless drawing machine

The project involved the integration and development of software for a device to perform dieless drawing process. Within this project, the integration of two applications was realized: one controlling the dieless drawing process and the other conducting static tensile test. As a result, a unified, comprehensive software was created. Subsequently, the part of the software controlling the static tensile test was improved. The entire software was implemented in Python using the PyQt framework. The implemented functionalities enabled:

- conducting multiple tensile tests within a single application run,

- automation of creating stress-strain and force-elongation graphs,

- determination of basic mechanical properties,

- performing pre-tensioning of the sample,

- generating a report from the conducted tensile tests.

Additionally, an algorithm in the Arduino programming language was implemented to automate the movement of the heating system during the dieless drawing process.

Finally, all implemented solutions were tested on a machine located at the Faculty of Metal Engineering and Industrial Computer Science.

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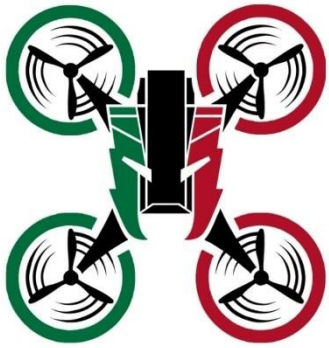
AGH Drone Engineering



Drone and mobile robot cooperation

The paper presents a novel approach to land search that uses the cooperation of an unmanned aerial vehicle (BSP) and a mobile robot. Using SLAM (Simultaneous Localization and Mapping) technology. The solution integrates sensor technology solutions, autonomous systems and wireless technology.

The system uses advanced route planning and control algorithms to ensure optimal efficiency and effectiveness of search operations.

The solution is also scalable and flexible, allowing it to adapt to a variety of scenarios and field conditions.

The paper also discusses the prospects for further development of the system, including the potential for integration with other technologies, such as industrial sensors and thermal imaging cameras, to further enhance its effectiveness and versatility. The system will also allow for the integration of more BSPs and robots in the future.

The solution can bring improvements in the fields of safety, rescue and environmental protection. With this approach, using modern technology, it is possible to effectively monitor difficult-to-access terrain and respond to emergency situations.

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Hexa

High resolution affordable spectroscope with dedicated mobile application to analyse obtained spectrum.

Optical spectroscopy is one of the fundamental fields of physics. School students start learning about the spectra of various elements in their physics classes at an early stage of education. With current technology, experiments on light dispersion shouldn't be a challenge anymore. However, we still lack easily accessible yet good solutions in this area. To promote science among students, we worked on creating an affordable and easy-to-make paper spectroscope.

The primary goal of the project is to develop a spectroscope that is accessible without requiring significant financial investment, based on a mobile phone camera. We've designed the spectroscope using a diffraction grating and a thin slit. Additionally, we've developed a mobile application with an analysis algorithm capable of classifying the spectrum. However, the algorithm encounters issues with spectra containing peaks in the red region due to the ambiguity in recording these light waves by the phone's camera apparatus.

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Glider

Modelling and simulation of crude oil spreading on a sea surface - comparison of methods

Modeling the spread of oil is an important part of developing plans and methods to deal with the consequences of oil spills on the environment. A cellular automaton-based model, a model based on the Lagrangian transport model, and a hybrid model combining the two previous models have been implemented.

An essential part of this project is describing the process of obtaining and preparing input data. Tests conducted on the models and collected metrics can help in future choices of modeling methods for phenomena related to fluid flow research. The project has demonstrated the potential of oil spread models in studying possible oil leak trajectories. The process of creating oil spread models has revealed the need to base their implementation on theoretical and practical formulas created by the scientific community.

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Creative

Assessment of the feasibility of developing a digital representation model of bone structure in discrete computational space

The treatment of thoracic defects, including the so-called "pigeon chest" and "funnel chest", is associated with highly invasive surgical procedures using a dedicated implant system. In these approaches, it is impossible to preliminarily analyze the interaction of the patient's bone with the system before the surgery. On the other hand, proper selection of the implant size and its mounting to the patient's ribs is crucial for the success of further treatment. Therefore, to solve this issue, advanced numerical models that allow direct mapping of the structure of human bone and its subsequent interaction with implants can be used. A combination of the finite element method (FE) and the cellular automata method (CA) was used to develop the approach. This combination allows the use of CA to create an accurate digital representation of the bone structure, which can then be used for FE modelling of its behavior under loading conditions. The first part of this research was focused on developing and implementing an algorithm for generating a three-dimensional model of the digital microstructure of bone based on the CA method. The model is based on a connection of random points inside the computational domain to obtain the spongy tissue's structure and generate expanding cylinders along the bone's axis, mimicking the osteons' structure. Examples of digital models generated for bone structure for subsequent FE simulations will be presented in the second part of the presentation.

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Creative

Development and implementation of a model generation algorithm for digital representation of the fuel cell microstructure.

Fuel cells play a key role in the Green Deal policy as they help provide clean and efficient energy. Their relevance stems from their ability to generate electricity and heat with minimal harmful emissions, supporting the goals of combating climate change. The properties of this type of element are a direct result of the structure at the material microstructure level. Therefore, digital mapping of such a composition opens up a wide range of possibilities in terms of computer-aided design of manufacturing new cells with specific parameters.

The work will focus on methods of generating digital microstructure models for a selected type of material used in fuel cells. An exemplary microstructure of different areas in fuel cell will be described, serving as the basis for the presented model. Subsequently, a developed digital microstructure generator will be introduced, enabling the adjustment of cell component sizes such as anode, cathode, electrode, and transitional zones between them. Discrete modelling methods will be employed for digital microstructure generation including cellular automata or Monte Carlo. The obtained digital microstructures will then be modified to achieve desired operational properties, particularly open porosity at specified volume fractions.

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Creative

Design, construction and implementation of a phototrap

The aim of the project was to develop, implement, and construct a camera trap – a device that captures images under specific conditions.

The project involved creating an efficient device based on the Raspberry Pi platform and an HD camera with infrared sensors capable of capturing images in various lighting conditions upon detecting significant movement or the presence of people or animals in the monitored area. To achieve this goal, a script was developed to analyze images and save captured photos on the device. Subsequently, the saved photos were transferred to Firebase Storage, a service enabling photo storage for further use. Additionally, a cross-platform application with authentication was created to allow easy browsing of saved images both on the website and in the mobile application. To enable field use of the device, a housing was designed using a 3D model and then printed using a 3D printer. Furthermore, to ensure uninterrupted device operation, solar panels and a power bank were utilized. The designed camera trap has potential applications, for example, in monitoring wildlife.

Research supervisor of the paper:

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61th Conference of the AGH University of Science and Technology Student Research Groups
May 9, 2024

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AGH Solar Boat

Optimization of the Position of Hydrofoil Rotation Axis in the Context of Solar Boat Flight.

In the context of progress in zero-emission maritime transport, an innovative approach to enhancing the energy efficiency of boats is crucial. Hydrofoils represent such a solution, with their efficiency closely tied to flight stability. This paper focuses on optimizing the position of the hydrofoil pivot axis, aiming to improve the flight efficiency of solar boats.

Computational Fluid Dynamics (CFD) simulations were employed to model fluid flow around the foil profile, providing information on the location of the center of pressure along the chord. The study covers the entire range of angles of attack at which the foil operates. Subsequently, the obtained results were utilized to optimize the pivot axis position to minimize forces on the foil mountings.

The outcome of this approach enables stable flight with minimal power consumption by the servo mechanisms controlling the angle of attack of the hydrofoils. It also helps reduce stresses on the mounting elements, resulting in better durability of the entire assembly.

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Glider

A Comparative Study of Agent-Based Modeling Platforms

In recent years, a variety of new frameworks streamlining the process of agent-based modeling has emerged. These frameworks serve different purposes and each offers a unique set of features. To provide a practical resource for both learners and academics, this review evaluates the performance of various ABM frameworks through a series of bench-mark simulations. By comparing the distinct functionalities offered by these tools, we aim to assist in the selection of an appropriate ABM toolkit for developing system models. This review presents a concise overview of seven popular agent-based modeling tools aiming to inspire further exploration and investigation into this subject.

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AGH Solar Boat

The utilization of coupled numerical simulations and the ensuing potential in analyzing the propulsion system of the solar-powered racing boat Celka.

The objective of my research was to utilize coupled CFD (Computational Fluid Dynamics) simulation with FEM (Finite Element Method) structural simulation of the propulsion system of a solar-powered racing boat, along with the ensuing possibilities for further project development and the validation of current assumptions. For analysis purposes, a geometric model tailored for CFD analysis was prepared, which was conducted using ANSYS Fluent software, followed by coupling the results, such as pressure distribution on surfaces, with the structural analysis module in ANSYS Mechanical software. Utilizing FEM, structural analysis was performed, and based on the analysis results, conclusions were drawn regarding further work on the project and the possibilities provided by coupled numerical simulations.

Research supervisor of the paper:

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Hefajstos

Analysis of microstructure and manufacturing process of XX century sword blade

The aim of the research is to understand the manufacturing process, properties, and analyze the microstructure and chemical composition of historical sword blades. The material taken under the study comes from a blade of XX century officer's sword, which was forged out of pattern welded Damascus steel. The blade was made in the area of the current Germany, probably in Sollingen. Samples was taken from the tip and the area nearby the tang of the sword. Samples were analyzed using optical microscopy, moreover the hardness was measured. These studies enabled the reconstruction of the forging processes and heat treatment of the examined sword.

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Hexagon

Analysis of the microstructure and mechanical properties of 6082 aluminum alloy subjected to interrupted aging

Due to their unique properties combining low weight with high strength, aluminum alloys are a key structural material used in many branches of industry. Recent research endeavors have revealed promising avenues for enhancing their strength characteristics, notably through non-conventional heat treatment methods such as Interrupted Aging. Our research work focuses on determining the impact of the interrupted aging process in the T6I4 variant on the microstructure and hardness of 6082 aluminum alloy. In addition, the microstructure, and mechanical properties of 6082 alloy aged in the conventional T6 variant were carried out for comparative purposes. The experiment encompasses the hardness measurements of the material using the Vickers method, as well as microstructure observations by means of scanning transmission electron microscope (STEM). In order to analyze the mechanical properties, the hardness of the 6082 alloy were carried out for the solution treated samples (530°C/30 min.), aged to the T6 temper (180°C/from 0.5 to 196h) and aged to the T6I4 state in two variants (180°C/10min + 65°C/from 0.5 to 196h) and (180°C/1h + 65°C/from 0.5 to 196h). Results demonstrated that the interrupted heat treatment process in the T6I4 variant yielded comparable hardness levels to those achieved through conventional aging to the T6 state. Furthermore, it exhibited the ability to sustain high hardness levels even during prolonged annealing periods. These findings offer valuable insights into the efficacy of interrupted aging processes applied to the 6082 aluminum alloy, shedding light on their potential for enhancing material performance and durability.

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Analysis of the microstructure and mechanical properties of titanium with different purity levels

Titanium is one of the basic building blocks of our planet, classified as the ninth most abundant element in the Earth's crust. Humanity has been using titanium industrially since around the 18th century, but the capability of titanium was only discovered with the development of aviation and cosmonautics. Titanium, with a density of 4.51g/cm3, is considered as the heaviest of the light metals. What is surprising about titanium is its extremely high strength in relation to its weight. The factor determining the strength properties of the alloy is related to its purity. Due to differences in chemical compositions, the yield strength of titanium alloys is extended from approximately 170MPa in the case of Grade 1 alloys to even over 900MPa in the case of Grade 5 alloys. Titanium exists in two allotropic forms. At a temperature of 882°C, Tiα to Tiβ is transformed, which results in a change of the crystallographic lattice from hexagonal (HCP) to body centered cubic (BCC). The allotropic transformation temperature is strongly dependent on the purity of the alloy. Impurities and alloying additions may be of natural origin from minerals and rocks containing titanium or may be introduced into the alloy as a result of industrial processes. For example, oxygen, nitrogen or carbon lead to an increase in the allotropic transformation temperature, but deteriorate the strength properties, while silicon and iron lower the allotropic transformation temperature. Appropriate control of admixtures can lead to obtaining the desired properties of the alloy in such a way that it becomes as industrially useful as possible. Titanium is mainly used in the aviation and space industries, and also works well in medical applications, IT, the arms industry, the chemical industry and jewelry.

Our research work discusses the effect of impurity level on the microstructure and strength parameters of titanium (Ti). The research experiment was carried out for grade 2 and grade 4 technical titanium characterized by various levels of impurities in the form of iron and interstitial elements of the types C, N, O and H. The work includes the characterization of the microstructure, texture and mechanical properties determined in tensile tests and hardness tests.

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Analysis of the temperature effect on the microstructure and mechanical properties of 2017 aluminum alloy

Low density, high mechanical properties, good corrosion resistance, and relatively easy mechanical processing make aluminum and its alloys a key material in today's global market. Many metallic materials, including those based on Al, are facing increasingly higher demands in terms of carrying higher loads, processing in unconventional production techniques as well as resistance to external environmental factors. Temperature, in particular, plays a crucial role in influencing the mechanical properties and thermal stability at given operating conditions. Many structural elements based on Al alloys operate at elevated temperatures, thus it is important to determine their mechanical properties at the possibly wide temperature range.

At the presented work, the effect of temperature on the microstructure and mechanical properties of 2027 aluminum alloy was carried out. The research experiment covering the plastic deformation process was carried out for the alloy at the supersaturated state and T4 and T6 temper at the temperature range of 20oC to 300oC. Based on the received results, the characteristic strength parameters of the tested materials were determined, which were further correlated with the microstructural observations of as-deformed samples (SEM and STEM). By synthesizing the obtained data, a comprehensive structure-property relationship for the 2017 alloy was established across both room and elevated temperatures.

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Metalurgii Surówki i Stali

Optimization of LPBF process parameters for aluminum alloy Al7SiMg for thin-walled biomimetic structures

The aim of the research is to produce biomimetic structures with enhanced compressive strength or energy-absorbing properties using 3D printing with Laser Powder Bed Fusion (LPBF) method. The objective of the study is to optimize printing parameters for the Al7SiMg alloy, such as scanning speed, laser beam power, and distance between tracks, to manufacture thin-walled structures. The raw material subjected to analysis is gas-atomized spherical aluminum powder. Test prints of thin-walled structures were made at various printing parameters, which were then examined for porosity occurrence and dimensional accuracy. The microstructure of the printed samples was also analyzed. Data were compared and an optimal set of parameters for printing thin-walled structures with wall thicknesses up to 150 µm was selected.

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AluminaTi

Structural and mechanical evaluation of the TIG weldability of rapid solidified 6082 alloy

An important issue in today's economy is the development and production of light metal alloys with unique properties, combining high strength with low specific weight. In the literature, much attention is paid to Al alloys with a fine-graine microstructure, where the primary strengthening mechanism is based on the introduction of a large number of grain boundaries into the microstructure. In this respect, many methods are known to reduce the grain size (e.g. SPD techniques), although in most of them the main technological problem is the final size of the finished product. From this perspective, an attractive production process is the method based on rapid solidification (RS) carried out by casting on a wheel (melt-spinning) and plastic consolidation in the extrusion process. In this work, attempts were made to weld the rapidly crystallized 6082 alloy using the TIG method. Tensile tests and microstructural tests were carried out. For comparative purposes, alloy 6082 was produced under the conditions of classic casting and hot extrusion, and then welded joints were made.

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Hexagon

Influence of thermo-plastic treatment conditions on the hardness of the Al 2014 alloy

Heat-treated, high-strength aluminum alloys are commonly used construction materials. Their properties largely depend on the conditions of the heat or thermoplastic treatment used. This group of materials includes the Al 2014 alloy, for which the influence of thermoplastic treatment conditions on hardness was investigated in this study.

Samples of this alloy were saturated from a temperature of 505°C and stretched, giving them a deformation of 0%, 5%, 10%, 15%. Samples after such treatment were subjected to calorimetric tests, which show that the application of deformation affects the disintegration process of the supersaturated alloy.

In the next stage, the supersaturated and deformed samples with different work hardness were artificially aged at 170°C and 200°C for various times ranging from 0 to 64 hours and their hardness was tested using the Vickers method. The results of these tests are presented in charts presenting the influence of the amount of deformation after supersaturation, aging temperature and aging time on the hardness of the Al 2014 alloy. These studies show that with the increase in deformation after supersaturation, the hardness of the 2014 alloy increases, but this effect persists only in the initial stages aging, i.e. up to approximately 4 hours for an aging temperature of 170oC and approximately 1 hour. for an aging temperature of 200oC. Samples aged at 170oC obtain a maximum hardness value of ~163 HV after approximately 19 hours of aging. Aging at 200oC results in lower hardness values ~152 HV, but after a much shorter time, i.e. after about 4 hours.

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Effect of annealing on mechanical properties and martensitic transformation in Ni-Mn-Ga alloys obtained by rapid crystallization method

The main objective of this study was to carry out an in-depth analysis of the properties of Ni-Mn-Ga alloy-based materials obtained by the melt spinning method. This method produces material in the form of thin strips with a thickness of several tens of micrometres. In 2021, the so-called magnetically induced bending effect was demonstrated for the first time in Ni-Mn-Ga-based alloys obtained by the melt spinning method. This phenomenon resembles the bending behaviour of a ferromagnetic iron wire in a magnetic field. In this case, the bending effect is produced by a magnetic moment. In contrast to iron wire, which undergoes a significant degree of elastic deformation, it has been shown that magnetic shape memory alloys can undergo some plastic deformation during deflection. Although, in typical applications of this type of material e.g. in transducers or actuators, the effect of magnetically induced bending may be undesirable, leading to friction and reduced cycle life, it may prove beneficial for new functional applications e.g. in biosimilar drive mechanisms. In this context, material in the form of with ribbons an aspect ratio of more than 100 may prove to be extremely attractive due to the specificity of the tape geometry, as well as the ease and scalability of the rotating roll casting technique itself. From this point of view, the analysis of the structure and morphology of this type of material subjected to a cyclic bending effect induced by an external magnetic field, as well as external loads of a mechanical character, is an important issue for further experimental use, which is the main objective of this work. The material produced by this method is characterised by a strong anisotropy of the microstructure along the cross-section. The research therefore includes an analysis of the mechanical and magnetic properties in strongly anisotropic materials from a microstructural point of view. Another research objective was to analyse the effect of heat treatment of cast strips and the influence of this treatment on their properties. It was shown that the heat treatment strongly modifies the microstructure, the internal stresses of the obtained tapes and will also increase the degree of atomic ordering. An attempt has been made to distinguish the effect of the healing phenomenon from the subsequent recrystallisation stage. As a result of the analysis, it will be possible to optimise the heat treatment applied in order to maximise the material's performance.

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New-Tech

Trajectory planning for a mobile robot based on image from a stereo camera

Path planning has numerous applications, including logistics, public transportation, aviation, and navigation applications. Our work, utilizing images from the ZED 2 stereo vision camera, enables trajectory planning and obstacle avoidance for a mobile robot. It leverages the OpenCV library in Python for camera calibration, depth map calculations, 3D space reconstruction, and optimal pathfinding. The process involves camera parameter correction, obstacle identification, followed by trajectory determination using a suitable pathfinding algorithm. The final path is projected onto a 2D image for visualization. The entire project facilitates complex motion planning operations for robotic vehicles in three-dimensional environments.

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Determination of relationship between hardness and yield point as well as ultimate tensile strength of 2014 Al alloy.

Aluminium alloys, especially heat-treated high-strength alloys, are widely used as structural elements applied in many industries. One of them is an alloy marked Al 2014, whose main alloy additions are copper (approx. 4.4 wt. %), silicon (approx. 0.8 wt. %), manganese (approx. 0.6 wt. %) and magnesium (approx. 0.5 wt. %). It is required that structural elements made of this material have specific strength properties. The parameters of strength properties (UTS and YP) are usually determined in a static tensile test, in which preparing standardized samples and performing measurements is relatively more difficult and expensive compared to Vickers hardness (HV) measurements. Moreover, the Vickers hardness (HV) method is characterized by low impressions on the tested sample surface and is therefore often classified as non-destructive testing.

It was observed that there is a correlation between hardness (HV) and tensile strength (UTS), as well as hardness (HV) and the yield point (YP). Based on the equations describing these correlations, it is possible to determine approximate values of UTS and YP based on hardness measurements (HV), without the need to perform a tensile test.

Therefore, the aim of this work is to determine the relationship between Vickers hardness (HV) and tensile strength (UTS) and yield point (YP) of the precipitation-hardened Al 2014 alloy. The material for testing was subjected to supersaturation from a temperature of 505 °C and aging at temperatures of 170 °C and 200 °C for 0, 0.5, 1, 2, 4, 8, 20, 32, 68, 128 hours. The heat-treated samples were subjected to hardness measurements using the Vickers method as well as static tensile tests. Based on the obtained results,

a proportional relationship between hardness and ultimate tensile strength and the yield point were demonstrated, and rectilinear equations were determined. These equations can be used to predict (with some approximation) the strength properties of Al 2014 alloy based on its hardness, without the need of perform the tensile tests of standardized samples.

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Section XI Welding Engineering

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Metaloznawców

Analysis of the microstructure of welded joints in BMX-type bicycle frame

The analysis of welded joints was carried out on a used, steel BMX-type bicycle frame. As a result of the discovery of a crack along the log on the frame's gusset the frame was designated for testing. The analysis of the welds is aimed at discovering the cause of the crack in the frame under study as well as finding other potential places where the crack could have appeard. The analysis was carried out based on: Macroscopic and microscopic observations of welded joints; Vickers hardness tests. Metallographic specimens taken from selected welded joints were subjected to analysis. During microscopic observation, special attention was paid to the weld, the heat-affected zone as well as the base material close to the welded joint, and the location of the fracture of the aforementioned reinforcement. Combining the results of microscopic studies and hardness tests allowed the conclusions presented in the presentation.

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Metaloznawców

How to combine it? Bulk metallic glasses - chapter II

In recent years, metallic glasses have been gaining increasing popularity, becoming a competitive solution to other advanced materials. The unique properties stemming from their amorphous structure (mechanical, physical, or chemical) make them increasingly introduced to the market. An area of research that was neglected until recently and is now gaining more interest is the joining of metallic glasses. Fragmentary information and an unexplored topic have prompted action in this direction.

The study presents a comparison of the results of joints welded by the following methods:

Electron beam welding of alloys Zr50Cu40Al10. Joints were made at an electron beam traverse speed of 5 [m/min] and the following current intensities: 10/9/8/7 [mA].

Laser welding of alloy Zr50Cu40Al10. Joints were made at a laser beam traverse speed of 6 [m/min] and the following beam powers: 400/500/600/700/800/900/1000 [W].

Arc furnace welding of alloy Zr50Cu40Al10. Joints were made at a constant speed of 2 [s] and the following current intensities: 30/40/50 [A].

Laser and electron beam welding were carried out at the Upper Silesian Institute of Technology: Łukasiewicz. Microstructural analysis was performed using light microscopy (LM) and electron microscopy (SEM, EDS). X-ray diffraction (XRD) was used to identify phases and the structure of the native material.

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AGH Drone Engineering

Composite Materials in 3D Printing: Opportunities, Potential Uses, Challenges

The innovative 3D printing method, based on composite filaments, offers new possibilities for creating prints with defined properties. An example is the combination of PLA and TPU, both materials do not mix during extrusion, which leads to the formation of microstructure in the print. TPU, as a more flexible material, enclosed in a PLA shell, exhibits significant absorption of external forces, potentially increasing impact resistance by up to 100% compared to pure PLA. In addition, such a composite is characterized by ease of printing, which is a significant advantage over other materials with similar mechanical properties. The process of manufacturing such a filament is feasible on a small scale, requiring only two types of materials and a standard 3D printer. The method is based on iterative printing of layers of the materials used, allowing controlled deposition of the core inside the coating. The resulting composite filament could represent a significant step forward in the development of 3D printing technology, opening the way to the production of prints with complex mechanical and functional properties.

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Era Inżyniera

Microstructure and selected properties of the welded joint of P355GH steel

The work examined a welded joint of P355GH steel. The joint was made using the TIG method in argon shielding. Selected strength properties were tested on the welded joint, and the microstructure of the welded joint was analyzed. The conducted tests constitute the preliminary part of the welding technological instruction.

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AGH Solar Boat

The influence of chemical composition modification of the Inconel 740 Ni-based superalloy on the weldability during the GTAW repair process

The continuous evolution of materials designed for high-temperature applications has contributed significantly to the ongoing advancements in the energy sector. These materials are crucial for fabricating components of power boilers or steam superheaters. One such group of materials is Ni-based alloys that are marketed under the brand name Inconel. These alloys are well-known for their stable microstructure, exceptional heat strength, and resistance. However, they are relatively expensive, which has led to a strategy of regular repairs instead of direct replacement of elements in complex boiler systems to reduce operational costs.

This study aimed to investigate the influence of modifying the chemical composition of the cast Inconel 740 superalloy on its susceptibility to cracking during repair with the Inconel 625 alloy. This process is intended to extend the lifespan of high-temperature installations without the need for complete dismantling and replacement. Manual welding was carried out on six variants of cast alloy 740 with varying chemical compositions (Al and Ta concentration). During technological trials of arc welding using the GTAW method, the material exhibited a tendency to overheat and significant thick fluidity, making it challenging to apply filler material to the surface. Microstructure examination was carried out using light microscopy and scanning electron microscopy, revealing three typical areas in the clad joint: base material, heat-affected zone, and the overlay weld. Observations using light microscopy showed microcracks in three of the six tested variants, and the probable cause may be the increased brittleness of the base material. The cracks occurred only in the heat-affected zone, which may indicate that they are liquation cracks caused by constitutional liquation of the strengthening phases. However, no cracks or discontinuities were detected in the Inconel 625 superalloy welds, which is attributed to its higher plasticity and susceptibility to welding deformations. Based on the obtained test results, it was concluded that inappropriate modification of the chemical composition of superalloy 740 may lead to the formation of hot cracks in the heat-affected zone during repair.

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Metaloznawców

The study deals with the effect of gas type on the weld

The study deals with the effect of gas type on the weld. The weld was applied to a sheet of s235 steel. Metallographic anastomoses were made from previously cut samples, which were examined for microstructure and hardness to show the microstructure, the heat affected zone and possible irregularities. The results were compared and conclusions were obtained.

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Metaloznawców

Use of a buffer layer in a welded joint with a different chemical composition

In the welded joint of two steels with different chemical compositions, a nickel-based alloy acting as a buffer layer was used. The weld was also made of an alloy that did not act as a buffer, and a combination of both alloys. Metallographic samples were made and then examined for: microstructure, macrostructure and hardness. The results were compared and conclusions were drawn. Examples of applications of welded joints using buffer layers in industry are presented.

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Section XII Physical Metallurgy and Surface Engineering

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Powierzchnia

Aluminum Aging Secrets - how time influence on the properties of aluminum alloy joints?

Aluminum Aging Secrets - how time influence on the properties of aluminum alloy joints? Ilona Batko

The phenomenon of aging is well known. Both people and animals age. Products or goods losing their freshness over time and views or concepts that lose their relevance also undergo aging [1]. Aging also affects certain metal alloys, such as aluminum alloys from the 2xxx (Al-Cu), 6xxx (Al-Mg-Si), and 7xxx (Al-Zn-Mg) series. These alloys are strengthened by precipitation as a result of heat treatment consisted of solution treatment, quenching and aging. Aluminum alloys can undergo natural or artificial aging. Natural aging occurs at room temperature, while artificial aging is carried out at elevated temperatures [2].

The aim of the study was to determine the effect of natural aging time on the mechanical properties of joints between aluminum alloy from the 7xxx series (7075) and alloy from the 5xxx series (5083). Since the 7075 alloy is difficult to weld using conventional welding technologies, friction stir welding (FSW) was used to perform the joints. In the FSW process, the joint is obtained by mixing plasticized material. Since the process occurs without melting the workpiece, it is possible to achieve a defect-free joint without typical welding defects [2-3].

Hardness tests using the Vickers method and tensile tests were conducted on joint samples after 9 years of joining and compared with properties determined after the welding process. Four joints (carried out in two configurations and with different welding parameters) were tested. An increase in hardness was observed on the side where the 7075 alloy was located. Natural aging caused changes in the tensile strength, yield strength, and elongation of the joints.

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Metaloznawców

Analysis and characterization of ferrosilicon made from recycled silicon and steel scrap

Ferrosilicon (FeSi) is a compound or alloy of Iron and Silicon. They are used extensively in steelmaking. Ferrosilicon is the most consumed ferroalloy. It is used for alloying, nucleating, and deoxidizing. It is produced in electric arc furnaces based on the carbothermic reduction of silica (quartz) and iron oxide. Recently there have been efforts to use recycled silicon for the production of FeSi to reduce the use of carbonaceous reducing agents. In this work the microstructure of different grades of FeSi made from recycled silicon is analysed using optical microscopy and scanning electron microscopy (SEM). The composition of the FeSi is analysed using the EDS coupled with the SEM. It is observed that the composition of the FeSi is not uniform throughout the sample. Si rich phases exist in the FeSi phase. Several intermetallic compounds are also identified in the FeSi sample which lead to the formation of precipitates along the grain boundaries.

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Metaloznawców

Analysis of causes of damage to flywheel gear rims

The research project concerns the wear analysis of flywheel gear rims, which play a key role in the starting system of agricultural tractors. These wreaths directly interacted with the starter gears. They came from machines of different horsepower, i.e. about 60 KM and 110 KM. Abnormal and uneven tribological wear of the teeth on the periphery of the rims was observed on the lateral surfaces. In order to determine the causes of this type of wear, a study and detailed analysis of the deterioration in these areas was carried out. The purpose of the study was to determine the causes of this type of excessive degradation. The analysis included areological and metallographic studies. Hardness measurements were also taken in sensitive areas and diffraction studies were carried out. Numerous traces of tooth surface degradation, such as scratches, seizures and material intakes, typical of this type of wear, were observed on the test specimen. Changes in metallographic structure and differences in hardness values indicated the heat treatment performed. Observation within the wear edges showed areas of plastic deformation and flowing of the material, which indicate insufficient strength or the occurrence of improper operation.

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Metaloznawców

Study of the phase sequence of a smectic liquid crystal compound using complementary methods

The main objective was to study the phase sequence of a liquid crystal while cooling and heating the substance at different rates. Two complementary methods were selected: differential scanning calorimetry (DSC) and polarizing microscopy (POM).

The tested substance was (2S)-octan-2-yl 4-{4-[4-(2-fluoro-4-{[5-(2,2,3,3,4,4,4-heptafluorobutoxy)pentyl]oxy}benzoyloxy)benzoyloxy]phenyl}benzoate – (CK2).

Calorimetric measurements were performed using a differential calorimeter Netzsch DSC214 for substances CK2 in the temperature range -30÷220˚C, during heating and cooling of the substance.

Results DSC presented using thermograms DSC obtained during cooling and heating of the sample CK2 for different temperature change cycles. Thanks to heat flow measurements using the method DSC phase transformations in the tested substance were identified during the heating and cooling process.

Observations for polarizing microscopy were made using a polarizing microscope LeicaDM2700 in a wide temperature range, during heating and cooling. Measurements of both processes were made at the rate of temperature change: 2, 7, 10, 20, 30, 40 and 50K/min.

Results POM shown in the photos, in which assessed the influence of temperature and speed on the state of microstructure. Temperature range of microscopic observations during heating and cooling for substances CK2 was 140^{o}C÷210^{o}C. During heating a phase was identified SmA* to Iz, and during cooling SmC*-SmC*A.

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Hefajstos

Selection of steel for forging dies – analysis of properties of selected grades considering wear mechanisms

Abstract: The paper focuses on the analysis of wear mechanisms of hot forging dies and the comparison of mechanical properties of three selected steel grades: X37CrMoV5-1, Unimax, and Vidar Superior. The aim of the research is to determine the suitability of the selected grades for use as die inserts. Based on available literature, wear mechanisms of forging tools (plastic deformation, cracking, abrasion) and the associated steel properties were identified. Studies were conducted to determine the wear resistance of selected grades, including hardness tests, fracture evaluations, microstructure analysis, and abrasion tests. The research results were compared with available literature data. Conclusions regarding the suitability of each steel grade in forging die processes were formulated.

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Powierzchnia

Flight towards Leonardo da Vinci's dreams - the role of Ni-based superalloys in the development of aviation

Leonardo da Vinci had a vision of conquering space, which became a reality in the 20th century with the advent of air transportation, making it a key sector. The exponential increase in passenger volumes and military demands brought about unprecedented challenges for engineers, who had to come up with solutions to overcome the limitations of contemporary materials. This led to the development of Ni-based superalloys, which have become the most important alloys in the aerospace industry due to their remarkable creep and corrosion resistance properties. These materials are now essential in manufacturing vital components of turbojet engines, which directly affect their efficiency and safety. While forged elements were used in the early stages of the industry, manufacturing methods have evolved, and precision casting is now the preferred method. Directionally solidified alloys are the most effective materials for this process, as they have elongated grains with desirable crystallographic orientation in their microstructure.

The research work focuses on examining the effect of heat treatment on the microstructure and properties of the MAR-M247 superalloy, with a specific emphasis on the γ' precipitates. The study involves analyzing the microstructure constituents and assessing the effect of heat treatment on their stability. Various techniques such as light microscopy, scanning electron microscopy, dispersive X-ray spectroscopy, and hardness measurements were used to conduct the analysis. The study results reveal that the alloy being tested has a typical dendritic structure with numerous strengthening precipitates such as the γ' phase, MC and M3C2 carbides, M5B3 borides, and Ni7(Hf,Zr)2 phase precipitates. The process of solution heat-treatment caused partial dissolution of the γ–γ' eutectic and the secondary γ' precipitates. The hardness measurements indicate that the material's hardness increases by approximately 40-60HV after heat treatment compared to as-cast condition.

The research presented in this work significantly contributes to our understanding of the properties of the MAR-M247 superalloy. The findings shed light on the influence of heat treatment on the superalloy's microstructure, which could help optimize production processes and develop new and innovative applications of this material. This is particularly important for the aviation industry, where Ni-based superalloys play a critical role in realizing Leonardo da Vinci's dream of flying. The research opens the door to further developments and innovations in aviation technology.

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Metaloznawców

Medium Entropy Materials for High Temperature Applications

This work presents the findings from a study of medium entropy materials tailored for high temperature applications. The research includes an investigation of alloy design, phase formation analysis over a wide temperature range and microstructure, as well as an exploration of their processing and solidification. This will pave the way for potential applications of these materials.

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Era Inżyniera

Copper Cu+ and its unusal antimicrobial properties.

Presentation of the use of copper for antimicrobial purposes in health care facilities, public transport and on touch surfaces. Presentation of the mechanisms of elimination of microorganisms by copper ions as well as the effectiveness of their action on bacteria and viruses (including the SARS-CoV-2 virus)

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Era Inżyniera

Microstructural analysis and mechanical properties of ductile Iron used for railway anchors

The main objective of the research was the characterization of cast Fe alloys used, among others, for railway anchors. On the Polish and world markets, special ductile iron is used for the production of anchors, which provides high tensile strength of the material while ensuring high impact strength.

Cast iron railway anchors type SB are intended for use in the railway surface as a component of the spring fastening system for reinforced concrete foundations. It is one of the most modern types of fasteners used on railway and tram lines. They are characterized by quick, simple installation, shock absorption from rolling stock and electrical insulation limiting traction stray currents to a minimum. The SB spring fastening provides good electrical insulation of the rails from the track surface and absorbs vibrations as a result of which the service life of the track is extended and the train runs are quieter.

The following research techniques were used: microstructural and macrostructural analysis and hardness measurements. The final result of these studies was the characterization and analysis of cast iron railway anchors from various market representatives in the Polish and foreign railway industry.

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Metaloznawców

The microstructure and properties of Ni-Ti shape memory alloys produced by suction casting method

The Ni-Ti alloys, also known as nitinols, belong to a subgroup of smart materials called shape memory alloys. Such materials can remember their original shape and, after deformation, under the influence of external stimuli such as temperature, magnetic field, or radiation, they have the ability to return to the previously memorized shape. These capabilities are provided to these materials by the reversible martensitic transformation and enormous elasticity.

This study presents the results of research on two such alloys (60%Ni-40%Ti and 54.5%Ni-45.5%Ti), which were produced using a unique suction casting method. The research included analysis of microstructure and chemical composition as well as hardness measurements. Additionally, dilatometric studies were conducted on cast samples to evaluate the magnitude of dilatation effects accompanying phase transformations in these materials.

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Metaloznawców

Designing a stepped mold for the suction casting process of bulk metallic glasses

In this project, efforts were made to design a stepped mould for determining the critical diameter of bulk metallic glasses in the suction casting process. As part of the research, three variants of the stepped mould were designed in SolidWorks CAD. Thermo-Calc Software was used to calculate material property data. The designed moulds and the data obtained were then implemented into MAGMASOFT, where simulations of the casting process were carried out.

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Powierzchnia

316L steel with laser tuning: new properties through innovative modification

The human body is an extremely demanding organism, so for materials used in medicine, special attention is paid not only to biocompatibility, but also to strength, corrosion resistance and flexibility. 316L steel is used not only in surgical instruments but also in orthopedic implants, dental devices, cardiac devices and fastening devices.

An amazingly developing technique is laser surface treatment, characterized by unparalleled precision, contactlessness and high productivity with high energy efficiency. It uses concentrated beams of laser light to modify the surface properties of not only metals but also ceramics, plastics and organic materials.

The applications of 316L steel are wide-ranging. The paper focuses on the biomedical aspect of the steel for applications including surgical instruments or, for example, in bone fusion implants. The steel surface used for the study was machined using a TC-300 fiber laser with an output power of 300W and a wavelength of 1064 nm with a variable scanning speed parameter of 3000, 5000, 7000 mm/s.

The surface morphology was examined by scanning electron microscopy (SEM). The surface was homogeneous and indicated that the laser beam was uniformly applied to the steel surface. The most dense arrangement of laser-treated surface "lines" was observed for a sample processed at 3000 mm/s.

The surface roughness was measured with an optical profilometer and varied from 700 nm to 1 um. The test also showed that the surface was uniform.

The wettability of the surface was measured with a goniometer using the standing drop method. The measurement showed a change in the nature of the laser-treated surfaces to hydrophobic, where the wettability angle was about 100^{o}.

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Metaloznawców

Strengthening with TRIP effect of composites on matrix of bulk metallic glasses

Over the past few years, an increase in interest in metallic glasses can be seen. The main reason for this is their unique physical, chemical and mechanical properties, such as high hardness, strength and good corrosion resistance, which makes them an attractive material for many industrial sectors. Unfortunately, the low plastic properties of metallic glasses, especially high brittleness, limit their potential applications. However, the presence of crystalline precipitates in the matrix of these materials seems to offer the prospect of solving the aforementioned problems. The crystalline phase in such composites significantly reduces brittleness while increasing ductility, to which the transformation-induced plasticity (TRIP) mechanism contributes significantly. The purpose of this study was to compare the effect of the degree of glass transition on the mechanical properties of metallic glass composites.

The Cu48Zr45Al7 alloy was produced in an electric arc furnace and then cast using the suction casting technique. The microstructure and chemical composition of the castings were examined using a scanning electron microscope. The amorphous-crystalline structure was confirmed using X-ray phase analysis. Mechanical properties were examined by static compression test and Vickers hardness. The breakthroughs were again subjected to observation on a scanning microscope using a SE detector.

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Powierzchnia

Influence of laser surface modification of S355 constructional steel on corrosion resistance.

The purpose of this study is to investigate the corrosion resistance of S355 structural steel subjected to a high-frequency laser beam using different laser powers. An S200 fiber laser with an output power of 200W was used to treat the steel surface. The laser treatment experiment used 3 different laser beam powers: 100, 150, 200 W, with a scanning frequency of 10 kHz. Then corrosion resistance measurements were performed. A 3.5% NaCl solution was used as the corrosion medium. For the measurement, a traditional three-electrode system was used, consisting of a platinum counter-electrode, a reference electrode made of Ag/AgCl and a working electrode, which is the test sample. For the untreated sample and the 200W sample, three measurements were carried out: open circuit potential (OCP), linear sweep voltammetry (LSV) and electrochemical impedance spectroscopy (EIS).

The OCP test showed that for the laser-treated and untreated sample, the potentials stabilize after about 6 hours. For the untreated sample, we record larger potential differences of about 0.1V, indicating more intense corrosion on the surface.

The EIS measurement showed an increase in impedance for the laser-treated sample, indicating improved corrosion resistance. The LSV test also showed that for the laser-treated sample, the current density values relative to the reference sample were higher for the entire measurement.

This confirmed the increase in resistance of the sample after laser treatment.

For all samples, the plateau region is weakly developed and practically immediately transitions to the trans-passive region, i.e., the active dilation of the sample. The weakly developed region is due to the low content of alloying additives in this type of steel.

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Metaloznawców

The effect of cooling rate on the activation energy of crystallization in bulk metallic glasses.

The presentation focuses on analyzing the influence of cooling rate during the casting of bulk metallic glasses on the activation energy of crystallization upon heating. Alloys were cast using suction casting and melt spinning techniques to achieve different cooling rates, followed by analysis using differential scanning calorimetry (DSC). The activation energy was determined using the Kissinger's method based on thermal profiles obtained at 20 K/min, 40 K/min, and 80 K/min. The microstructure of the castings was observed using scanning electron microscopy (SEM).

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Metaloznawców

Manufacture and analysis of combinations of hydrophobic and hydrophilic fibers with beads for efficient fog water harvesting

Fog is a source of water, especially where basic water sources are not available. Polymeric fibers, in the form of mats, can catch water droplets from fog. Therefore, the aim of our research is to produce hydrophobic-hydrophilic polymer fiber mats, where the hydrophilic properties attract the water droplets and the hydrophobic properties remove them faster, thus increasing the efficiency of the collectors.

Fibers were produced by electrospinning using a coaxial nozzle to obtain hydrophobic polyurethane (TPU) fibers containing hydrophilic cellulose acetate (CA) beads. The morphology of the obtained material was analyzed using scanning electron microscopy (SEM) and its wetting properties. The mechanical properties of the obtained mat were checked using a tensile modulus, and fog water collection tests were carried out. Spectroscopic studies (FTIR) confirmed the presence of both polymers in the TPU-CA mat. The combination of hydrophobic and hydrophilic polymers increased the number of droplets captured and the rate at which they flowed off the mat, allowing it to collect larger amounts of water than standard mats made from a single polymer type.

The study was conducted within funding from the REKTOR'S GRANT No. 63 / GRANT /2023 and infrastructure Faculty of Metals Engineering and Industrial Computer Science.

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Powierzchnia

Green corrosion inhibitors – potential application of coffee grounds as a corrosion inhibitor for steel in a corrosive environment

Corrosion is a process of gradual metal degradation due to its interaction with the surrounding environment. Corrosion poses a constant problem, often difficult to completely elimination. One of the many methods of preventing metal corrosion is the use of inhibitors. These are substances that, when introduced in small concentrations into a corrosive environment, effectively reduce the corrosion rate. The effectiveness of inhibitors largely depends on the pH of the environment. Some are only effective in neutral solutions, while in acidic electrolytes, they do not affect the corrosion rate or even increase it. There are several different classifications of inhibitors, taking into account their chemical composition (organic or inorganic inhibitors), corrosive environment, or mechanism of action.

Corrosion inhibitors are often synthetic compounds that exhibit good anticorrosive properties, but most of them are highly toxic to both humans and the environment. Therefore, an important concept in metal corrosion protection is the search for natural products as corrosion preventive agents. Green corrosion inhibitors are biodegradable and do not contain heavy metals or other toxic compounds. Studies on the corrosion protection of steel have shown the positive effects of green inhibitors such as tamarind, alma, pomegranate juice, tea leaves, eucalyptus oil, henna extract, aloe leaves, mango or orange peels.

The aim of this study is to use spend coffee grounds as a corrosion inhibitor for carbon steel. To utilize coffee grounds as an inhibitor, an oil extract must be produced from them. The extract studied in this work was produced from u coffee grounds from LaCava Limy bru using the Soxhlet process. The effect of the corrosion inhibitor on corrosion processes were determination by electrochemical tests (linear polarization), which were conducted on S355 steel in a 1 mol HCl solution with various concentrations of the inhibitor.

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Section XIII Casting, Metallurgy and Recycling

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Alchemist

ALCHEMIST

The concept of creating a replica of an ancient cannon using reverse engineering techniques

The concept of creating a replica of an ancient cannon using reverse engineering techniques has already gone through the stage of selecting and scanning the cannon at the Wawel Royal Castle – State Art Collection. Additionally, a cannon model is currently being created based on the point cloud obtained by the Revopoint POP 2 scanner in Solid Works software. The next stage involves simulations of casting processes in Magma Soft, Flow&Solid, Nova Flow&Solid, Anycasting software, as well as 3D printing of the casting model, core making, casting mold technology, cannon casting, welding, and mechanical processing. This project not only utilizes advanced engineering technologies but also integrates historical knowledge with modern production methods, contributing to interdisciplinary collaboration among students and their development in the field of engineering sciences.

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AGH Solar Boat

Design of a proprietary casting process for the aluminum propeller blades of the "Celka" solar racing boat.

The process of producing blades for the propeller of the Celka solar racing boat has so far involved milling forms in an MDF board and then, after sanding the form with 2500-grit paper, carbon fiber soaked in epoxy resin is placed in it, and the whole thing is then closed and heated to harden the resin. This process had many drawbacks. For example, it required a long grinding process, which extended the manufacturing process to about 7 working days. There were often problems such as a milling machine failure or the blade sticking, which resulted in the mold being destroyed when the composite was removed. Thanks to the new technology, it is possible to shorten this process to 3 days and it is also possible to produce products in parallel. The process requires using a 3D printer using SLA technology, molding silicone, wax and heat-resistant plaster. Once the mold is created, casting can begin. The production process of aluminum blades will be much cheaper than those made of carbon fiber and allows the number of contact hours to be reduced to a minimum. The process is still in the testing phase, but improving and speeding it up is easy to implement.

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Artefakt

Technology design and realization of a sabre handle from copper alloy casting

The beginning of the paper describes the various stages of creating a 3D model of a saber handle, i.e. from conceptual sketches of the handle, through the creation of a 3D model, to construction drawings. Then the calculations of the gating system are presented, and the casting technology is developed. A large part of the paper was devoted to describing the simulations performed for the pouring and solidification process. After analyzing the results of the first simulation, it was necessary to change the technology by adding a feeder. Subsequently, two more simulations were carried out for different ways of feeding the metal into the mold cavity and the optimal way of pouring the mold was selected. In the next stage, models were made, core box, so that the casting mold could be made. Finally, the process of pouring the casting mold with brass was carried out and the casting of the saber handle was made.

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AGH Rapid Prototyping

Development of the 3D Printing Laboratory's activities - analysis of the potential of using 3D printing in the casting process.

The paper presents the results of the project completed as part of the "Rozkręć koło z ArcelorMittal Poland 2023" competition, which aimed to estimate the limiting factors of 3D FDM printing regarding the geometric accuracy of the produced casting models. The advantages and disadvantages of using additive technologies were analyzed, focusing on the dimensional accuracy, the applicability of selected materials, and the impact of surface roughness on the process of producing sand molds. There was reported the project contribution to the development of the 3D Printing Laboratory managed by the Students' Scientific Group AGH Rapid Prototyping, as well as to the improvement of the quality of printed elements and increase of the laboratory's processing and manufacturing capacity.

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Zgarek

Selected sensors in microprocessor-based monitoring of environmental air parameters

The presentation showcased selected digital sensors for measuring environmental air parameters in industrial production halls. The operating principles and technical characteristics of these sensors were discussed, along with the permissible ranges of measured parameters. A prototype air parameter monitoring device was presented, based on the Arduino MKR1010 WiFi microprocessor module, collaborating with mobile applications or computers via Bluetooth technology. Examples of measurement results presentation were demonstrated, as well as plans for further development of the developed device.

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Zgarek

Production of a cannon based on a real object located in the Wawel Royal Castle - State Art Collection.

The overall approach to creating a cannon based on a real object located in the Wawel Royal Castle – State Art Collection is an initiative stemming from the project titled "Recreation of a Historical Artifact Miniature" as part of the 2024 Rector's Grant competition. In light of this, contact was established with the authorities at the museum on Wawel Royal Castle, resulting in two meetings. During the first meeting, a cannon meeting the necessary conditions for accurate scanning was selected. The second visit involved the process of reverse engineering - scanning, utilizing the Revopoint POP 2 scanner. Additionally, Revo Scan 5.4.6 software was used for initial scan processing. Further steps include the current processing of the object in Solid Works for the purpose of the structural-technological design project. A group of students from two Scientific Circles, Zgarek and Alchemist, from the areas of red and black, focused their efforts on conducting the reverse engineering process. The project's implementation will provide students from the Zgarek and Alchemist circles with practical experience in reverse engineering and modern production technologies, while also contributing to the promotion of technical sciences and Poland's cultural heritage.

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The use of simulation software to develop a project of casting an eletric motor housing, using high pressure die casting technology

The present work focuses on preparation the design of casting an electric motor housing, and particularly on the use of simulation tools, during the design of the manufacturing process of the part, using high pressure die casting (HPDC) technology.

The study will present the technical solutions used in the development, the geometry of the part as well as the entire system, adapted to casting in "HPDC" technology, as well as the parameters of the pressure machine casting process. It will also be presented an analysis of the results of calculations, carried out in the Nova Flow&Solid CV v6.65 simulation program, which allow assessing the quality of the part, as well as the efficiency of the entire process before the start of high-volume production.

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Applications of conducting polymers

A polymer composite has been produced involving two polymers (polyolefin-conductive polymer). Ultimately, this composite is intended for use as filament in 3D printing technology. A literature review was conducted on polymers, their structure, properties, and applications, with particular emphasis on conductive polymers and their methods of synthesis and characterization. 3D printing technologies were also characterized. The focus was mainly on the technology in which the produced composite could be applied. In the research part, a series of tests were carried out to compare the properties of the composite with those of the original polymers. Flammability ("flame test") was determined, and solubility studies were conducted in selected solvents. Subsequently, thermal analysis in an oxygen atmosphere (TG-DTG) was performed to examine the thermal decomposition behavior of the composite (thermal stability, decomposition temperature). Finally, the conductivity of the composite was measured to determine its ability to conduct electricity and its efficiency.

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Section XIV Metal Forming and Modern Manufacturing Processes

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Hefajstos

Analysis of the drop hammer forging process including dies connected by shrink fitting

The project is related to the analysis of the use of removable insert in hammer die forging processes. Using die models and parameters of the industrial forging process, computer simulations were performed in the QForm program. Based on the distributions of effective stress, mean stress, elastic strain, tool wear models and fracture criteria, an area was selected for the insert application in the die. An insert was designed for the selected area of the tool and thermal fitting parameters were determined. In order to determine the influence of the insert fit value on the obtained results, two variants of insert insertion into the dies were used. The obtained results allowed for the assessment of the usefulness of the insert as an additional tool in the matrix.

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Hefajstos

Analysis of the forging process of a model forging in the context of prediction of failure of the die

The purpose of this study was to analyze forging process of a model forging with an elongated shape, during which total die failure occurred due to the formation of cracks. Technical documentation of the finished forging, process parameters, and results from finite element method (FEM) simulations of the currently used dies were provided by the company. After conducting the analysis, a solution to the problem was proposed in the form of a modified geometry of the final die. Creating a geometric model of the forging based on the technical drawing and die models was carried out using SolidWorks software. All forging process models were created in the QForm software, which allows for simulating phenomena occurring during plastic processing processes. Several models were prepared, from which two were selected that seemed to meet expectations. In the first, the shape of the preliminary die was completely changed, but the results were slightly worse than those obtained by the company. The second model gived satisfactory stress results, staying below the material's yield strength, from which the dies were made. This was sufficient to conclude that the given die geometry is appropriate for producing tools with reduced risk of cracking.

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Promat

3D printing and Co-Cr alloy micromodifications - the new generation of digital dentistry

For centuries, the community has been struggling with dental problems in conjunction with the patient's individual jaw anatomy. The task of modern prosthodontics laboratories is not only to treat, but also often to replace missing teeth with prostheses that meet both the expectations of the patient's psychological and physical comfort, but also visual qualities, the durability of the piece or its biocompatibility in the specific environment of the oral cavity.

The advent of 3D printing technology in the prosthetic sector makes it possible to accurately reproduce a specific case of a patient's missing teeth, without generating material waste. Due to its precision and accuracy, the technique of Selective Metal Powder Fusion (from Direct Metal Laser Sintering) is increasingly being used. This method is similar to SLS (Selective Laser Sintering), differing in that the powdered material is not sintered, but completely remelted. This form of fabrication of the prosthetic component allows for further processing without changing the dimensions of the printed part. The scientific research that was carried out within the framework of the presented work consisted in the evaluation of the influence of the variation of the 3D printing parameter and heat treatment on the properties of dental Co-Cr alloy with W and Mo micro-additives. The metallic specimens used for the study were made in the dental laboratory by a dental technician using DMLS technology from Co-Cr-W-Mo Adorbond CC metallic powder from Ador with variable 3D printing parameter - layer thickness of 20 µm and 30 µm, respectively. The samples were then heat treated (annealed at 1150^{o}C for 1 h). The paper compares and discusses the results of hardness tests, as well as microstructural analysis using light microscopy (LM) and scanning electron microscopy (SEM) along with EDS analysis from the microarrays for four samples: produced with print layer thicknesses of 20 and 30 µm before and after heat treatment. Changes were found in the hardness of the Co-Cr-W-Mo alloy specimens and in the microstructure of the alloy, as a result of the presence of carbide phase precipitates and changes in their chemical composition.

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Creative

SINGLE-POINT INCREMENTAL FORMING OF THIN METALLIC SHEETS USING A SCARA-TYPE ROBOTIC ARM

With the dynamic development of modern industry, there is a growing demand for unconventional products made from steel alloys, aluminum, and copper. This trend is particularly evident in the case of thin-walled products with complex shapes, used in architecture, the automotive industry, and aerospace, among others. Consequently, economic aspects of production play a crucial role here, and the use of standard stamping methods is often impossible to implement. Therefore, the main objective of this work is to develop an automated robotic laboratory station for rapid prototyping and research on the development of forming technologies for low-batch production of sheet metal products. The research is based on the single-point incremental forming (SPIF) technology with the use of the Dobot M1 Pro robotic arm. The first part of this work presents the process of manufacturing the forming tools and adapting a robot tool holder to realize SPIF. Then, the development stages of algorithms to generate the toolpath and create a communication protocol between an implemented user-friendly software interface and the robotic arm are discussed. Particular attention is focused to the effective adaptation of libraries that enable communication with the robot. Finally, results from a series of operational tests on the developed stand, including forming different materials and shapes of final products, are shown and discussed. The work was summarized with the idea of transferring the created approach to an industrial robotic arm.

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Promat

Design of a device that converts PET plastic obtained from recycled bottles into filament for 3D printing

The conducted project was aimed at designing and creating the device for cutting and converting PET bottles into filament for 3D printing. The work involved determining the optimal process parameters for effective production and conducting printing tests using the produced filament. The scope of the project included the design of a model and the subsequent creation of a physical structure of a complex device for the production of 3D printing filament from used PET bottles. The project's goal was to design a structure in which as many components as possible could be produced using 3D printing technology. The design of the device consists of two integrated stations, allowing a direct connection between the bottle cutting phase and the processing of the bottle into filament and coiling the material onto a spool.

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Metalurgii Surówki i Stali

Steel 316L - Inconel 625 gradient material additively manufactured by the LPBF process - fabrication and characterization of the microstructure, chemical composition and hardness

The purpose of this study was to design a 316L steel - Inconel 625 gradient material and produce it using the LPBF process, and to investigate its microstructure, chemical composition, and hardness. The bulk density, flowability and grain shape of the of 316L steel and Inconel 625 superalloy powders used to produce the gradient material were determined. In order to establish the best LPBF process parameters that would allow production of a gradient material without pores and/or cracks, a set of test specimens was created. The porosity of the samples was calculated, and the optimal parameters to achieve the lowest possible porosity were determined. A chemical composition gradient was designed for a combination of 316L steel and Inconel 625. Another set of samples was produced, using additive manufacturing and the previously determined optimal LPBF process parameters. The microstructure of the resulting gradient material was examined with a scanning electron microscope. Microanalysis of the chemical composition of the different zones of the gradient transition was performed using the characteristic energy-dispersive spectrometry method. Hardness testing of the obtained gradient material was also carried out. It was found that the material obtained though the additive manufacturing process is characterized by low porosity, fine-grained microstructure, a smooth gradient of the chemical composition and hardness ranging from that of the 316L steel to that of the Inconel 625.

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Promat

Development of parameters for 3D printing of AlSi7Mg alloys obtained by ultrasonic atomization from metal chips

The main objective of the work was to make a powder for the process of selective laser remelting by atomization of a molding obtained from AlSi7Mg alloy chips, qualitative analysis of the obtained powder, and then selection of parameters for 3D printing. In order to obtain powder from aluminum chips, the feedstock was subjected to cleaning before the densification process. Then, the chips thus prepared were subjected to SEM-EDS analysis. The compaction of the chips was carried out on a hydraulic press, in closed dies and at room temperature. The resulting molding was subjected to ultrasonic atomization. The resulting powder was tested for its applicability in 3D printing by imaging and EDS analysis using a scanning electron microscope.

Research supervisor of the paper:

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Metalurgii Surówki i Stali

Development of 3D printing process parameters for manufacturing geometrically complex sword heads

3D printing technologies, also known as additive manufacturing, allow the manufacturing of objects layer by layer. These methods have found application in the low-volume production of components with complex shapes. An important aspect is the ability to create parts with advanced geometries that were previously difficult to achieve with traditional methods.

The research conducted concerns the process parameters and laser strategii for Laser Powder Bed Fusion (LPBF) for the manufacture of sword heads with complex geometries. 3D models of various head geometries were created in Solidworks and then manufactured using the LPBF process. A mixed powder of 316L steel and Inconel 625 was used. After LPBF, the porosity, microstructure and chemical composition of the fabricated elements were examined using scanning electron microscopy.

Research supervisor of the paper:

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Creative

Software development of a device for the dieless drawing process and implementation of a multi-stage brass wire drawing process

The project involved improving the software of the device for dieless drawing process. Software development focused on automating the drawing process as well as conducting static tensile test. Within the static tensile test, the following functionalities were added:

- the ability to pre-stress the sample to a value chosen by the user,

- the ability to perform multiple tensile tests within a single application run responsible for controlling machine processes,

- automation of creating a stress-strain graph along with real-time updating in the user GUI,

- automation of creating a force-elongation graph after the test is completed,

- calculation of the Young's modulus for the stretched sample along with its visualization as a line on the stress-strain graph,

- generating a report summarizing the conducted tests.

Additionally, the issue of measuring sample strain occurring during the tests was resolved. After adding the new functionalities, a series of static tensile tests were conducted to verify the implemented solutions.

Within the dieless drawing process, the movement of the heating system was automated, allowing for the realization of a multi-pass drawing process without the interference of the machine operator. Finally, a set of tests was performed on a brass wire to test the implemented solution.

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Effect of LPBF 3D printing process parameters on the microstructure and relative density of Ti6Al4V alloy

The research presented here focuses on analyzing the effects of Laser Powder Bed Fusion (LPBF) 3D printing parameters on the microstructure and relative density of Ti6Al4V alloy. The research plan included the analysis of samples from 17 variants of combinations of laser power and scanning speed, which are two key parameters of 3D printing in the metal. The methodology adopted included preparation of metallographic samples, observation of the microstructure and determination of porosity using Leica Application Suite software and the PhaseExpert subroutine for image analysis and determination of phase percentages and microstructure components. The results made it possible to identify the optimal combination of process parameters for the material under study. This analysis is important for the effective use of 3D printing technology in the production of Ti6Al4V alloy parts, keeping in mind both the quality of the microstructure and the density of the material.

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The use of carbon fiber as a heating element in composite molds

The report will concern the issue of heating composites. The introduction will discuss issues related to various types of solutions, including: technology of laminating carbon fibers in the mold, installation of heating panels, construction of a mold heating system using pipes distributing hot water through it and the use of a heating furnace. The main element of the report will be the presentation of the authorial technique of the previously mentioned method of laminating carbon fibers serving as mold heaters and the problems encountered during testing. The main complications associated with this technology include: : selection of a controller controlling the heaters, taking out the connections outside the form, calculating the resistance and power dissipated on the heaters. At the end of the report, photos from thermal imaging cameras will be presented showing the obtained results

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Machine-learning algorithm for evaluating company net worth

The objective of the project is to create a machine-learning model to estimate a company's net worth based on selected financial statistics. The model could serve in practice as a helpful metric for evaluating a company's worth during a buyout or sale.

The model would base its operation on a machine learning algorithm trained on a preselected dataset representing bankruptcy data from the Taiwan Economic Journal (https://www.kaggle.com/datasets/fedesoriano/company-bankruptcy-prediction). It would be a regression model that would return a valuation as output and take selected company statistics as input. The keras library and tensorflow will be used to prepare the machine learning algorithm.

The idea is innovative because it uses machine learning techniques instead of classical methods that base their operation on financial analysis. In addition, the model will be versatile because, learning from data from many different markets, it will be able to estimate various companies with their characteristic business models. Using data from the bankruptcy analysis set, the model would also be able to take into account risk factors that purely financial data might miss.

The project also plans to create charts to assess the quality of the estimation performed by the algorithm, as well as the course of the learning process and its testing.

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Technical analisys of listed stock companies performed by survival analisys

The main goal of the project is to perform a technical analysis for the stock companies listed. Firstly, the selected companies will be grouped depending on their sectors of operation, including the stock exchange they find themselves on. Next, survival analysis will be conducted with each group. This is a set of statistical methods related to time analysis passed until a specific, previously-defined event occurs. Data analysis will be performed using the Cox proportional-hazards model. This is one of the methods used for survival analysis, estimating the risk factor represented through the frequency of a given event from one group to another.

This method will allow us to determine which industry sectors companies are most likely to achieve a certain increase in value in, during any given timeframe, compared to other companies from other sectors of the economy. The events defined for the Cox proportional-hazards model's implementation will be increases in the prices of a given company's share thresholds, over the previous 5 years, or since the company's listing on the stock exchange (in cases where it joins a particular stock exchange within this period).

This analysis will be conducted independently for companies listed on the three following stock exchanges:

- New York Stock Exchange
- London Stock Exchange
- GPW Main Market in Warsaw

Risk coefficients related to given share price increases will be calculated for each selected group. Next, results related to the same economic sectors from different stock exchanges will also be compared. This study will allow to determine whether certain trends are independent of a given stock exchange, as well as how the same sectors fare against each other depending on geographical location.

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Music organizing application

The aim of the project is to create a tool for recognizing and automatically completing information about audio files based on the audio track. It will provide the ability to organize files by selected category - music genre, band, album or year of release. It will take the form of a desktop application written in Python to ensure the best possible cross-platform compatibility.

The application will use the crowdsourced and open-source Acoustid database, which combines a digital fingerprint of music files along with their corresponding metadata. It will provide accurate, up-to-date and reliable data. Several modes of operation are assumed, overwriting all existing file information, completing only missing data or just single fields.

The system of overwriting metadata and names will allow granular control over implemented functionalities to avoid accidental deletion of information of interest.

The application will have several independent data organization systems and a history of changes made:

- updating names based on fingerprints or existing residual metadata, in case the song does not yet exist in the database,
- updating metadata on the basis of fingerprints or the band/song name contained in the file name,
- preparing a directory structure according to the category, music genre, band, album or year of release that interests the user.

It is also planned to add a function for saving information in the local database which songs have been changed by the application to avoid unnecessary duplication of scans for already arranged files.

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Real-time sign language translation application

The goal of the project is to develop a mobile application using React Native, TensorFlow and Keras to provide real-time sign language to text translation in different languages. The model will be trained based on analyzed data, optimized for accuracy and adapted to different communication situations. The mobile application will offer gesture recognition, dynamic translation and seamless integration of the model into the user interface. The system includes a backend hosting an API to communicate with the model and a visual layer for user interaction.

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VR application in phobia treatment

The aim of the project is to create an application using a virtual reality environment. The application will be adapted for use with the Oculus Quest 2 set. The Unity environment using the C# language will be used to implement the project. The created software will provide an easily customizable environment that will allow users to face their phobias such as:

- arachnophobia,

- nyctophobia,

- claustrophobia,

- fear of heights.

There will be boards prepared for each type of phobia with varying degrees of advancement and the intensity of phobia triggers. The user will be able to move around them and interactively influence the game environment. The project will design a progression system that will enable the user to gradually come to terms with their fears in order to support people affected by phobias in overcoming them. Data can be saved in the user's profile to determine and visualize progress.

The system will be tested on a group of people affected by particular phobias. Tests will be conducted to see if users are getting used to their fears, for which purpose the user's heart rate will be tested (using an external sports armband). In addition, a short interview will be conducted with each respondent regarding general feelings about the system. Only those who do not indicate previous problems with simulator sickness will be invited to the study.

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Dermtektyw - skin disease classification app

The project aims to build a mobile application which will allow for the recognition and classification of selected skin diseases by using a camera and machine learning techniques. Images of abnormal skin will be obtained from the widely available Dermnet dataset. The set will be properly adjusted - among the several available diseases, only the most popular ones will be selected to increase the accuracy of recognition. Based on the found dataset, a suitable algorithm will be trained, most likely utilizing convolutional neural networks. In case of an uncertain classification, the user will receive other guidance on dealing with the potential disease or will be referred to a specialist they can consult.

The application will be built using the React Native framework, enabling it to run on both Android and iOS devices. This will make it available to a larger number of users than choosing a single native platform. Due to the chosen framework, the application's functionalities will be written in JavaScript. Python programming language along with AI-supporting libraries such as TensorFlow or Keras will be used to create and train the machine learning model. Thanks to the tfjs library, the trained model can later be imported into the React Native application and used for image classification.

The designed system will stand out from other solutions with a specifically created image classification algorithm, tested for the given problem and compared with other popular methods of classification in terms of accuracy. Additionally, it has been confirmed that there is no application offering the functionalities of the project in the App Store that would be widely available and provided in Polish.

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E-GPS - Navigation System For Electric Cars

The aim of the project is to create navigation for electric car drivers, which determines routes taking into account charging stations. The solution is currently highly desirable due to ongoing intense discussions about the range of electric cars and their use in longer trips. Currently, many people struggle with route planning in Google Maps and using the proposed solution will provide them with significant time and stress savings. The proposed application aims to facilitate this task by determining routes based on driver preferences such as charging time, total route length and current road conditions, including air temperature and traffic intensity.

The developed system will utilize previously prepared APIs, which will help verify the status of electric chargers and their properties. Based on the received data, the proprietary algorithm will calculate paths considering the collected user information about the car battery capacity, average energy consumption, driver preferences, and external factors. Routes will be determined using optimization software.

The project also includes creating a simple and intuitive graphical interface to make it user-friendly on smartphones, tablets or on-board computer monitors of electric cars.

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Implementation of an interactive compiler in a mobile application

The project aims to develop an interactive compiler for mobile devices accessible through the Telegram mobile application. The server-side of the application will run on a Raspberry Pi microcomputer, utilizing Kubernetes and Docker for scalable information processing. The application's user interface will allow language selection and provide compilation results and error feedback. Additionally, users will have access to artificial intelligence functions based on the LLM model. Leveraging ChatGPT 3.5 will enhance coding and resource optimization. In case of errors, users will receive corrective instructions. Integration with Telegram will facilitate convenient access and swift code exchange. The project innovatively combines mobile technology, cloud processing, and artificial intelligence, enabling users to test ideas without the need for traditional programming environments or computers.

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Implementation of the ML model for data extraction from receipts

The application aims to help the user manage expenses by reading, analysing and organising data automatically from receipts. The main functionality of the application will be the ability to upload an image of the receipt, for the relevant information to be extracted using an OCR and machine learning model.

The model will be trained on a large and diverse dataset, enabiling it to learn to recognise different receipt formats. Using text processing techniques, the model will automatically identify and extract relevant information from the receipt, such as product name, quantities purchased and unit prices.

The process of the application will be as follows:

1. The user uploads a photo of the receipt to the app.

2. The application uses an OCR model to read the text from receipt. The resulting text is then processed by an implemented machine learning model – analysis and data extraction is performed.

3. The information obtained (such as products names, quantities and prices) is presented to the user in an easy-to-read format.

4. The users has the option of confirming or editing the data.

5. (optional) The user can view, manage and analyse their expenditure through various functions such as reports, expenditure categories, etc.

The application will be written in Python. One of the open-source OCR models (e.g. Tesseract) will be used to read the text from the receipt. A machine learning model will be created based on the Tensorflow library.

Thanks to the functionalities implemented, users will be able to track their expenses quickl and efficiently, avoiding manual data entry and thus save time. The application aims to increase users fincancial awareness and help them manage their budget effectively.

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Intelligent Alarm System Using Home Assistant and Azure Cognitive Services

The goal of the project is to create an advanced, yet user-friendly alarm system accessible on the open-source platform Home Assistant, supported by the latest vision technologies from Azure Cognitive Services. One way to manage a smart home is through software like Home Assistant, which, due to its continuous operation, is installed on energy-efficient terminals with low power, and incapable of processing video signal from cameras due to a lack of computational performance. The proposed solution, by utilizing the external API of Azure, will be able to conduct image analysis without burdening local resources, thus allowing for rapid and effective intruder identification. The main task is to reduce the number of unnecessary requests to the Azure service, which is very important from both a cost and a system performance perspective. In the project, a 24 GHz radar will be used, which activates the camera and sends a request to Azure only in the event of potential intruder detection. This strategy may optimize the number of requests with high precision, so as not to exceed Azure's free query limit while ensuring the effectiveness of the alarm system.

The development of the project will include the design and implementation of custom integration in Home Assistant, configuration connecting to Azure Cognitive Services, and integration with radar systems. The scope of the project will include the creation of documentation to facilitate further expansion of the system by other Home Assistant users according to the principles of open-source software.

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Wireless LAN Controller

Main goal of the presented project is creating a software implementation of Wireless LAN Controller(WLC) and Wireless Access Point(AP). Controller should enable configuration of multiple access points using the command line interface(CLI) or web interface through a browser.

Implementation utilises Scapy module for Python programming language and Hostapd package for Linux operating systems.

In order to ensure safe and effective communication between the WLC and APs, a dedicated protocol will be developed. The protocol will allow tracking state of the devices, handling control events on the network and encapsulating user data so that the 802.11 traffic can be converted into Ethernet frames and forwarded further. To mitigate MITM(Man-in-the-Middle) attacks, control and client data traffic between devices will be secured using the Datagram Transport Layer Security protocol.

Finally, load balancing and optimisation of client roaming will be achieved by creating a reinforcement learning agent, to make BSS(Basic Service Set) Transition decisions within the ESS(Extended Service Set), so that they can be applied using the AP control interface.

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Artificial intelligence model recognizing potential phishing based on hyperlink syntax analysis

The aim of the project is to create and train an artificial intelligence model using supervised learning, the purpose of which will be to analyze a hyperlink in order to detect whether it is a potential attack vector related to an attempt to persuade the victim to trust a fake entity and to go to crafted resources (e.g., a website) created to obtain sensitive data of the attacked entity. The prepared model will solve a binary classification problem based on a given input that is a hyperlink in the form of a caption.

Publicly available labeled datasets that contain hyperlinks in text form and information about them will be used to train the model. The data will be analyzed and processed accordingly before being sent to the algorithm created earlier.

Various neural network architectures and machine learning algorithms will be tested to solve the problem. Using the Pandas, Matplotlib and Numpy libraries, the data will be properly prepared and cleaned for use in teaching models. The potential models will then be implemented with TensorFlow (neural network) and Scikit-learn (classical classification algorithms). In addition, the Matplotlib library will enable graphical visualization of the results obtained and the process of learning the models. As the final product, which will consist of a model (function) taking a hyperlink as input and returning as output the probability of whether a link is potentially dangerous, the model with the best result obtained during testing will be selected.

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Design and implementation of dynamic content classification module and parent incident handling platform

The project will consist of two parts. The first is the design and implementation of an algorithm to detect harmful and inappropriate content from among the data sent to it, enabling categorization using tags. This element of the system will be realized on the basis of "fine-tuning" of existing classification methodologies and artificial intelligence models, in terms of content reaching the youngest on the Internet. The project will focus on algorithms designed to analyze text and images, so that in the future it can dynamically detect harmful content and blur it. The idea here is to detect images, videos and even toxic comments or posts in places such as posts or online forums.

The second part of the project is the implementation of a platform, which will support the ability to integrate with other elements of the system, thus being the link, between 'local' sources of alerts on agents installed on devices along with the person handling these incidents (the parent). The user controlling the platform, will have the ability to analyze the collected information and, based on his preferences, will be able to decide what to block. Another functionality of the platform, will also be the ability to set automatic "sensitivity" of detection, thus taking care of the privacy of children depending on their age.

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Design and implementation of a proxy module and agent to protect children from harmful internet content

The aim of the project is to create a proxy module for intercepting and securing Internet content. The mitmproxy framework will be used for development, which is an open-source set of libraries for capturing traffic. The developed modules will allow you to export content that is potentially harmful to the youngest Internet users. The proxy will be connected to an agent that is used in professional IT infrastructure monitoring systems. Unfortunately, there is no open-source software of this kind available, so a custom solution will be developed as part of the project. The project will enable dynamic detection of harmful content and its blurring. This involves detecting images, videos and even toxic comments or posts on platforms such as social media or forums.

The project will constitute one of two parts of a larger system designed to detect threats on computers and mobile devices used by children. We are talking about threats here, i.e. fake news, patostreams, hate, violence, illegal content presenting violence, hostility or hatred, content inciting self-harm or sexual deviations. The system is to be intended for parents who decide to protect their children by using the developed system to detect and respond to the above-mentioned incidents early enough. Thanks to this, the Internet will be a safe place for children, without causing permanent damage to their health. Market analysis has shown that there is currently no such comprehensive solution focusing on children's safety on the Internet.

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Intrusion detection system for small businesses and home users

The aim of the project is to create and implement an effective intrusion detection system dedicated for small businesses and home users. This project aims to provide protection against cyber threats, which can have serious consequences for data security and network infrastructure. By continuously monitoring network traffic and quickly responding to potential threats, the intrusion detection system allows to minimize the risk of attacks and data loss. Additionally, the project aims to facilitate users with safe and effective network security management, even with limited resources and budget.

The intrusion detection solution for small businesses offers several significant advantages. Firstly, its simplicity and ease of implementation mean that even people without advanced technical knowledge can effectively secure their network. Unlike some of the solutions available on the market, the proposed system does not require complicated configuration or advanced infrastructure. Moreover, thanks to the use of the latest intrusion detection technologies, the system offers effective protection against various types of attacks, while minimizing the number of false alarms.

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Interactive Compiler Testing in a Mobile Application

The aim of the project is to test the capabilities of a compiler for mobile devices accessible through the Telegram mobile application. The hardware part of the project, running on a Raspberry Pi microcomputer, will undergo performance tests to assess the platform's ability to serve as the application server. Testing will involve measuring the time it takes to process code, analyzing its correctness and cleanliness using a language model, compilation, program execution, and potential corrections made by the intelligent compiler. Additionally, the project aims to examine the compiler's performance in terms of mobility and flexibility, specifically its ability to work efficiently on various types of mobile devices. The ultimate goal is to provide users of the Telegram application with a tool that not only ensures fast and accurate code compilation but is also optimized for limited mobile device resources. Furthermore, the project involves collecting data on the compiler's resource consumption and its impact on overall performance, allowing for the identification of optimization areas and adjustments to enable more efficient compiler operation, thus enhancing the user experience associated with mobile programming.

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USB MANAGEMENT SWITCH

The aim of this project is to create a tool that allows for the management of connected devices via WebUI. It would consist of USB ports, which would enable its connection via serial ports to switches, routers and other devices.

The project assumes preparation of a complete solution adapted for use in laboratory/server room. The work will include preparation of appropriate software and a physical prototype consisting of:

- A casing made using 3D printing
- Raspberry Pi
- USB ports and an Ethernet port
- An „epaper" display

The proposed solution would host a website that would allow the user to manage available ports and use terminals of connected devices. The WebUI would also offer a division of users into various levels of permissions, e.g. access only to specified ports specified for a given user.

Additionally, the display would also show specific and useful information for a network/device administrator.

The development of the necessary software assumes usage of:

- Python programming language
- Django framework, Django Channels extension
- HTML5, Javascript, CSS
- Boostrap5

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Using deep learning to automatically detect points in padel matches

In recent years, artificial intelligence (AI) and machine learning (ML) technologies have found applications in various fields of life, from medicine to entertainment. One interesting example of their use is in sports analysis and automation.

The presented project aims to create and then implement an advanced model based on TensorFlow and Keras technologies. Its main task is to analyze video material from padel matches, enabling the identification and classification of moments when points are scored by the participating teams.

The project utilizes advanced image processing techniques and machine learning, including Convolutional Neural Networks (CNNs) and transfer learning, to analyze video sequences. After converting the video into frames, the system identifies and tracks the movement of the ball and analyzes the position of players, using a trained model to detect key moments of the game. Integration of the YOLO model for ball and game scene detection is a key element in achieving this task.

The final goal is to create an application dedicated to amateur players that will use the trained model and provide real-time information about the current state of the match. This approach not only makes it much easier to manage match results, but also allows for greater focus on the game itself, eliminating the need to manually count points, which is especially useful in dynamic and fast games.

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Algorithm for risk management in the development of socially orientated systems considering falsified information environment

The rise in data volume and the broader evolution of social and market dynamics necessitate a re-evaluation of fundamental management principles, particularly in risk management. In contexts where outcomes are uncertain, such as in the development of socially oriented systems, predicting potential issues demands utilizing contemporary tools for data analysis. Standard frameworks often fail to ensure effectiveness during social upheavals fueled by misinformation campaigns aimed at discrediting business proposals. This study focuses on refining basic decision support models and creating a data reprocessing algorithm to enhance the precision and dependability of project activity forecasts. The suggested approach hinges on a text fake news detection algorithm employing hybrid neural networks and content analysis principles. The method prioritizes three components: the nature of the crisis, the target audience, and the business environment. Comparative experiments between simple autoregressive and neural network models and the proposed solution illustrate the superior efficiency of the latter in terms of accuracy and speed, facilitated by parallelization using MapReduce technology. These findings set the stage for real-world testing, aiming to broaden the scope of predictive capabilities and risk assessment for socially oriented initiatives.

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