# 60th Conference
## of the AGH University of Science and Technology
## Student Research Groups

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*CONFERENCE MATERIALS*

Narodowa Agencja Programu Erasmus+ i Europejskiego Korpusu Solidarności
Edukacja, Szkolenia, Młodzież
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**AGH Solar Plane**

# Neural controller for an Unmanned Aerial Vehicle control

Unmanned aerial vehicles and their use in autonomous missions have gained popularity in recent years. The neural flight controller project involved the creation of a device capable of controlling an aircraft model with a wingspan of two meters using artificial intelligence algorithms. The stated goal was to cover the route in the shape of the "Lazy Eight", between columns set eighty meters apart. For this purpose, a composite aircraft model with photovoltaic cells on its wings as an additional power source was constructed. In addition, an electronic flight controller module and a ground base station connected to a visualization and data processing application were designed and created. The control algorithm is based on a recurrent neural network that was trained on data collected during test flights. The controller successfully performed parts of the route, proving the effectiveness of neural networks for use in UAV control. The planned future development is the use of an LSTM network that would minimize the compounding of control errors over a longer period of time.

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**Azymut**

# Geotourist attractiveness and geoeducational value of the residual landforms – a case study of the Paprotna Hill (Wiśnicz Foothill, Lipnica Murowana municipality)

The sandstone-conglomerate rocky forms of the Carpathian Foothills show high landscape, aesthetic, and cognitive values. Few of such residual objects are located on the Paprotna hill in Lipnica Górna. The group of rockies includes the well-known monument of inanimate nature – Brodziński's Stones, as well as several less known, but equally interesting nearby outliers.

The geoeducational value of sandstone-conglomerate rocks is mainly related to the genesis of syn- and diagenetic sedimentary processes, the development of flysch formations and the variability of their lithological and sedimentological properties, as well as the genesis of epigenetic denudation processes, i.e. the selective character of weathering, erosion and transport of land waste, which developed under certain climatic conditions.

The deposits forming the tors are a lithostratigraphic subdivision of the Silesian Unit of the Outer Carpathians, called the Lower Istebna beds of the Late Cretaceous age (about 70 m.y.). These are sandstone-conglomeratic rocks of arcosic type. The primary sedimentary structures include: a massive structure, channels and wash-outs, numerous load casts, locally normal grading, and large-scale cross stratification. The presence of common amalgamation of beds and postdepositional water escape structures (dish structures) is also characteristic. Epigenetic structures that create a varied surface relief of the tors are, for example, arcade- or cellular structures.

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## Kalman rover - New mobile laboratory and other aspects of Science section activities

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 2023 University Rover Challenge have necessitated the introduction of a new, modular version of the mobile laboratory. In addition, the tasks of the Science team include geological mapping of the Red Planet's surface and continuous expansion of knowledge about it. Continuous evolution of the Science section allows supporting the team to get high places at international Mars rover competitions.

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# Kalman - planetary rover evolving through mechanical innovations

The topic of the presentation is to showcase the mechanical enhancements made to the key components of the Kalman planetary rover - project operated by AGH Space Systems science club. The presentation will focus on improvements made to the propulsion module, suspension, and manipulator with a gripper.

Leveraging on previous design and operational experience, the club developed a superior propulsion module that delivers significantly improved performance by obtaining a higher torque, reducing weight, and improving reliability. The rover's suspension was completely redesigned, resulting in a weight reduction of about 1 kg and improved shock absorption. The six-degree-of-freedom manipulator presented at the 59th HKSKN and tested at many international competitions was also improved with increased lifting capacity, refined functionality and durability. Although the gripper concept remained the same, the design was changed and expanded with additional sub-modules such as adjustable side cams and a quick-click system.

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# Algae cells - The possibilities of using photosynthesis to power microcontrollers in space missions.

The topic of the paper is presentation of the problems of using various species of algae to generate electricity in hostile extraterrestrial conditions. The dilemmas related to the preliminary stage of research, such as the selection of algae species to be tested, how to maintain them and conduct their monitoring, will be addressed. In addition, it is necessary to design a suitable apparatus to allow dynamic changes in such conditions as insolation and UV radiation levels and their effect on the obtained energy. The solutions presented will allow a series of studies on the usefulness of algae for generating electricity in a hostile environment. Finally, potential applications will be mentioned - positive results would allow the design of a module capable of powering microcontrollers in research probes deployed, for example, on the surface of the Red Planet.

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**AGH Drone Engineering**

# "Marking and targeting based on the air-dumped indicator – Drop&Lock system "

The idea of developing the Drop&Lock system originated in the AGH Drone Engineering Scientific Club, which focuses on practical applications of technology in unmanned vehicles. Based on their experience and collected data, the members of the Club decided to create a tool capable of physically marking targets located on the surface of the Earth using an unmanned aerial vehicle carrying a small cargo with a GPS locator, as well as a strobe emitting light. This seemingly primitive technology can be used when searching for people in mountains or other areas where rescuers or other active units are unable to quickly get close to a detected target or a flying drone is unable to stay in the air long enough to monitor the position of the target being tracked. The priority of the project is reliability and simplicity of design so that the system is intuitive and user-friendly and will be able to focus on the action to accomplish the mission.

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# Can We Dream of the Conquest of Space? The Influence of Isolation and Sunlight Deprivation on the Sleep of Members of Simulated Space Missions

The research paper is about a pilot research on sleep quality and related parameters among the crew members of analog space missions at the LunAres research station. As part of the study, the influence of physical activity and light of varying wavelengths on the analog astronauts' sleep quality was evaluated. The mission's characteristics and the facility itself enabled complete isolation from the outside world by guaranteeing lack of sunlight and limited access to the internet. Although the main goal of the project was to test tools for future missions and assess their reliability, a correlation between physical activity and sleep quality in the above mentioned conditions was confirmed. The authors identified many possible directions for further research, including the study of the impact of light of different wavelengths, the influence of physical activity, or interpersonal relationships and stressful social situations. The project can provide valuable information on the impact of social isolation and lack of natural light on the performance and sleep quality of astronauts, which could help to develop better measures of maintaining their psychological well being.

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**Bozon**

# Environmental monitoring using remote sensing on the example of Iceland's cryosphere.

The report concerns the processing of data collected during the IDUB 2022 Grant (action 12) SKNF Bozon, when a team of students went on a research trip in order to: collect samples of sediments, water and Icelandic mice in terms of testing the content of radionuclides and perform a series of measurements of methane concentrations released from under melting glaciers. The report will focus on methane research and its analysis with the use of remote sensing techniques using satellites and indicates the importance of using space industry technologies in environmental research.

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# Kalman rover - Design solutions leading to increased reliability of on-board electronics

The presentation will provide a general overview of the electronic subsystems of the "Kalman" planetary rover, as well as the presented solutions that affect the modularity and reliability of the robot. The construction, created by AGH Space Systems student engineering group over the last 6 years, has undergone many improvements, using the knowledge gained from the previous iterations of components.

Continuous operation of the rover exposes it to mechanical or electrostatic damage, therefore, modules that are easier to replace and have increased fault resistance have been developed. Solutions will be presented that protect the power subsystem, communication buses, and robot control modules from exceeding nominal operating conditions and malfunctions caused by operator errors.

Developed modules in the "miniRack" standard, which separates rover functionality into individual printed circuit boards, improves modularity and standardizes the robot configuration. After testing and verifying the performance during competitions held worldwide, the electronics team will present conclusions and results from the implementation of the solution over the past year.

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# Zawisza4000 - how the heart of Turbulence - Poland's first liquid-fuel student rocket - pulses

The aim of the presentation is to introduce an innovative solution in the field of rocket engines, which is Zawisza4000 - the first Polish liquid fuel rocket engine. The engine utilizes a movable piston inside a pressure vessel, which eliminates the need for an external tank of

neutral substance to increase the pressure of the propellants. The presentation discusses the operation of liquid fuel rocket engines and their ignition process. The results of previous research and tests will be presented, as well as the planned applications of Zawisza4000 in the Turbulencja rocket during the EUROC 2023 competition in Portugal in October of this year.

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# How to test a liquid fuel rocket? That is, the test cycle engine rocket engine of AGH Space Systems Scientific Group

Lecture explores ground test programme of "Zawisza400" rocket engine under development for Turbulence rocket built by AGH Space Systems Student Organisation. Explored here is motivation of testing and proper testing methodology. Proper test preparations and safety messures are touched on too. Later various ground tests such as leak checks, pressure readings, cold flow and hot fire tests are described. Then presented are necessary test conditions and methods of taking satisfactory measurements. Finally Research Group members will present collected data to show chellanges that can appear while obtaining proper test data.

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## Section II Acoustics, Biomechanics, Bioengineering and Ergonomics

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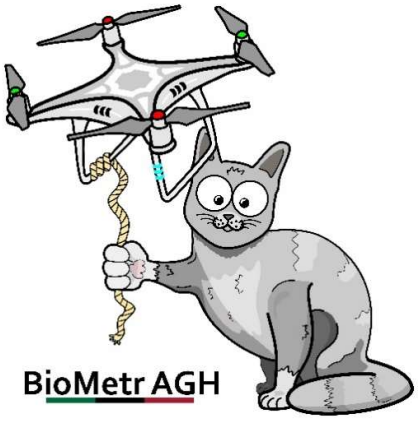
**BioMetr**




### Heartbeat monitoring based on speech signal

This research presents a new technique for monitoring heartbeat pulse using human speech signal and machine learning models. The main objective of the experiment, which consisted of reading a text and performing physical exercises, was to test the feasibility of pulse estimation from voice using regression-based machine learning algorithms. The voice data was obtained using a phone as well as a professional recorder to test the effect of recording quality on the final results, while the heartbeat pulse was obtained by using a pulse oximeter. The acquired data were then processed to obtain the averaged MFCC coefficients extracted from the voice and the corresponding pulse values. Estimation was carried out implementing linear regression models, RANSAC, SVR, decision trees and random forests. A check was also made on the results depending on the amount of data or a factor such as gender.

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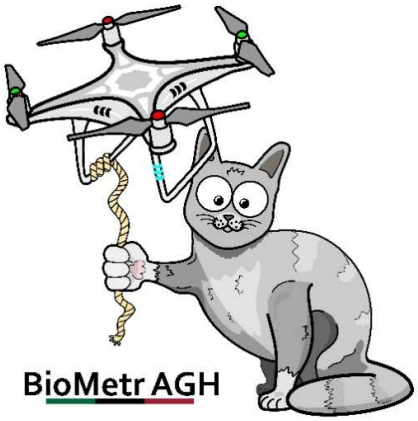


# Quantification, synthesis and processing of Chinese tones in the context of teaching to people who do not speak a tonal language.

This paper is concerned with tone analysis in the context of teaching a tonal language such as Chinese to non-tonal speakers. Tonal language is characterized by the fact that a word can have different meanings depending on the type of tone that is used during pronunciation. The most important parameter that characterizes each tone is the waveform of its fundamental frequency. The influence of correct tonality on the correct use of Chinese is presented, and the main differences in frequency ranges used in communication between tonal and non-tonal language are outlined. The fundamental frequencies for each tone are plotted, and attention is paid to the effects of changes in phonation on the spectra of the tone signal. For a method of teaching tonality called the speech shadowing, which is the most effective method used in Chinese language classes, the use of synthesized sounds from recordings of speakers pronouncing particular tones with altered phonation was proposed. By doing so, learners would be stimulated with pure sounds, where the only information contained would be the change in fundamental frequency of the tone, without the unnecessary distracting information that is contained in ordinary pronunciation recordings, such as the timbre of voice of the person being recorded, his or her age, gender, or possible noise level caused for example by the quality of the recording device. Based on the results found, it was suggested that such a method of sound stimulation could be used not only in the context of developing tonal language learning systems, but also in therapies improving hearing sensitivity and studies on changes in brain plasticity and mind development after stimulation with sounds from foreign speech.

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Koło Naukowe Akustyki Architektonicznej

# Analysis of sound directionality control methods using digital crossovers in loudspeaker set

Speaker crossover is bank of filters which divides loudspeaker input signal into individual drivers. Its main task is to ensure that every speaker in set is going to reproduce the frequency range it is adapted to. The negative effect of using classic crossover is presence of distortions off main loudspeaker axis, on which the measurements are made.

The main goal of project is analysis digital crossover design methods which premise improvement of loudspeaker off-axis directional characteristics. In this presentation there are presented chosen solutions with description of their implementation and the analysis of their advantages and disadvantages was performed. There are proposed comparing methods of discussed solutions in order to chose the most effective.

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Koło Naukowe Akustyki Architektonicznej

# Analysis of vibration measurement methods and vibroacoustic excitation selection in light type turntables

Vibroisolation is a series of activities that are aimed at reducing the transmission of vibrations. It is especially needed for delicate systems, for which even the smallest shocks are undesirable. Such objects include modern, lightweight turntables weighing no more than 10 kg. Vibration reduction is usually achieved by increasing the mass of the system, but this is not possible with the discussed devices. One of the possible methods of vibration isolation is the use of an anti-vibration platform. This paper will present a vibroacoustic analysis of the turntable based on vibration acceleration study and the results of measurements in the selection of vibroacoustic stimulation methods. In addition, the materials used to reduce vibrations and their impact on the effectiveness of vibration isolation will be discussed.

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# Analysis of scattering effects in the small room acoustics

Sound-diffusing panels are commonly used in the acoustic treatment of spaces. Temporal and directional scattering of a sound wave enable the elimination of acoustic defects and the maintenance of constant acoustic energy. Recent studies demonstrate that the efficacy of diffusers depends on their placement, design parameters and facing angles. In small-room acoustics, where Sabine's assumptions are not fulfilled, choosing the best placement of diffusing panels requires a different approach. At this point, the literature on scattering effects in small room acoustics was reviewed. The purpose of this project is to critically analyze the current state of knowledge and propose new studies in order to conduct experimental verification of panel placement and identify the best placement of diffusers in a small room.

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Koło Naukowe
Akustyki
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# Experimental verification of the possibility of improving the sound absorption coefficient of fibrous materials by combining them with activated carbon.

Activated carbon is a material that has undergone activation, a chemical treatment that increases its ability to adsorb. It is used in many fields such as medicine, pharmaceutical and food industries, water purification, air and soil cleaning. The use of this material in the context of acoustics is still poorly developed, and available publications usually do not provide comprehensive information on this subject. The aim of the research was to experimentally verify the possibility of using activated carbon in combination with fibrous, sound-absorbing materials. The measurement of the sound absorption coefficient was carried out in an impedance tube, according to the procedures described in the PN-EN ISO 10534:2003 standard. As part of the research, a selection of activated carbons was made, taking into account their diverse parameters. Various available fractions and types of activated carbon, available on the market, were analyzed in order to choose the best-matched materials for research purposes.

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**Komfort**

# Design and measurement validation of diffusing elements placement in a reverberation room.

Acoustic studies conducted at the Reverberation Chamber Complex have for a long time indicated a problem with insufficient homogeneity of the acoustic field in the receiving chamber. Attempts have been made to improve dispersion, but the results are not fully satisfactory.

The main problem in measuring acoustic isolation from airborne sound is the measurement of the acoustic power radiated through the barrier, in practice realized by measuring the sound pressure level and acoustic absorption in the receiving chamber. It is assumed that there is a diffusion field in the reverberation chamber, which is characterized by spatial homogeneity of acoustic energy density and reverberation time throughout the acoustic field. In contrast, large changes in the sound pressure level in the reverberation chamber indicate the significant presence of standing waves. In PN-EN ISO 354:2005, we find that the sound field in a reverberation chamber used for sound absorption measurements should be sufficiently dispersed. Satisfactory dispersion can be achieved by using fixed hanging dispersion elements or rotating vanes.

The purpose of this project is to carry out a comprehensive acoustic adaptation, which will consist of the following stages:

- making acoustic measurements in the room in the current state in order to tune the acoustic model,

- execution of the acoustic model of the room,

- performing calculations to determine the optimal amount and distribution of scattering materials in the chamber,

- fixing of scattering materials,

- execution of verification measurements

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**Mechatronics**

### How to make an electric bolide autonomous?

During the presentation, the construction of an autonomous system for the Formula Student electric car will be discussed. The presentation answers the question "How to make an electric car autonomous?". The presentation will present the architecture of the autonomous system along with an overview of all the necessary components that enable autonomous driving. A ready-made solution will be presented, which was included in the car in 2022 and made it possible to build the first autonomous car in Poland in accordance with the Formula One regulations last season.

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**AGH Marines**

# "Design and implementation of a sealing system for an AUV robot".

The multi-modular Autonomous Underwater Vehicle (AUV) allows for both inspection and exploration tasks characterised by difficult accessibility, occurring at great depths. The primary concern of this type of design is to ensure watertightness during manoeuvres at given depths. The system consists of electronic modules arranged on a constructed aluminium frame. These are connected to each other by external wire lines, which, in order to ensure a high level of watertightness and guarantee that none of the electronic components (such as the on-board computer, control microcontroller or battery) are damaged by flooding, must be protected by suitable connectors or cable glands. As this is a niche area in the current market, access to this type of solution is difficult. The design being carried out is invented to meet all of the above requirements. The solution allows an impermeable cable bundle transition from the wet zone to the dry zone (the space where the electronic systems are located). The project was designed using Autodesk Inventor Professional.

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**Industrial Data Science**

## Localization of an inspection robot in a warehouse using computer vision algorithms

One of the modules of the Digital Twin project carried out in the Industrial Data Science research circle implementing a system for localizing an inspection robot based on an image from a warehouse monitoring system will be presented.The presentation will cover the general purpose of using Digital Twin solutions in industry, the goals of the module implementation and the algorithms used and their learning process. Directions for further development will also be discussed.

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**AGH Drone Engineering**

# Detection and Cataloging System for Diseased Trees

This paper focuses on using unmanned aerial vehicles to monitor trees and plant conditions in areas with limited accessibility or time-consuming travel. The device utilizes modern technologies such as neural networks and vision systems to identify and classify potentially diseased trees.

In addition to using trained neural networks, the unmanned vehicle has access to a dynamic database, allowing it to present located diseased trees and record the location of each potential case. This method can be used to clearly and concisely inform the relevant authorities of the forest's condition and present a factual problem. This technology can speed up and facilitate the process of detecting and treating diseased trees, which can help maintain the health of forest ecosystems.

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**Eko-Energia**

# The process of selecting a drive unit for an automobile

In the presentation, I aim to demonstrate the complex process of selecting a drive system for an electric vehicle. I base my approach on criteria such as vehicle type, load, speed, and operating environment. In the following part of the presentation, I present calculations for the power and torque requirements for our project, as well as graphic visualizations of the calculated power and torque requirements in different scenarios to facilitate interpretation and show the dependencies between parameters. Finally, I present examples of offers for engines available on the market, which differ in technical parameters, price, and availability. Based on this, I also discuss another engine parameter, which is efficiency, and its importance for our project. Summarizing the key aspects of selecting a drive system for a vehicle allows for precise determination of requirements and the selection of the appropriate engine, which is crucial for ensuring the reliability and efficiency of the vehicle.

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**Avader**

## Use of detection-segmentation convolutional neural networks in autonomous vehicle perception

Object detection and segmentation are two core modules of an autonomous vehicle perception system.The most commonly used algorithms are based on deep neural networks, which guarantee high efficiency but require high-performance computing platforms.In the case of autonomous vehicles, it is necessary to use embedded platforms with limited computing power.In this presentation, we focus on finding the appropriate architecture of networks for such systems.\We concentrate on so-called detection-segmentation networks.We compared the performance of three different architectures described in the literature: MultiTask V3, HybridNets, and YOLOP.We conducted experiments on a custom dataset consisting of approximately 500 images of the drivable area and lane markings, and 250 images of road objects.MultiTask V3 proved to be the best, achieving 99% mAP50 for detection, 97% MIoU for drivable area segmentation, and 91% MIoU for lane segmentation, as well as 124 fps on the RTX 3060 graphics card.

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**Sensor**

# Autonomous monitoring and predicting malfunctions system for 6-axis industrial robots' drives.

The scientific study examined the impact of loading on a collaborative industrial robot. The experiments involved measuring the current intensity and temperature and analyzing the results to identify possible overloads in the mechanisms and propulsion of the robot. It was identified that an increase in loading leads to an increase in current intensity and temperature, which can result in damage to the robot's mechanisms and propulsion. Data is collected from the robot's sensors and then using deep learning technology utilized for showing the ways to minimize the risk of overloading by selecting appropriate loads and implementing regular maintenance of the device.

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**Sensor**

# Mobile autonomous patrol robot FieldGuard

The scientific research on a mobile patrol robot AMV FieldGuard presents the design and implementation of a monitoring system that detects movement and the presence of an intruder in a given space. The goal of the project is to create a mobile AMV robot equipped with a camera and motion sensors that can navigate through a room and scan it for humans. The system will monitor movement in the room and detect a human body in real-time. Python language, OpenCV library, and image processing algorithms were used to develop the system architecture. The research presents the results of performance tests and the accuracy of change detection in the room. The proposed solution's implementation could have applications in various fields, including warehouses, logistics centers, and even homes, where tracking movement and detecting humans is useful.

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**New-Tech**

# Vibration analysis of a 3D-printed cycloidal gear

Vibration analysis of cycloidal gears and vibration prevention are important issues in the field of mechanical engineering. Cycloidal gears are used in many different applications, including industrial machines, industrial robots, and medical devices.

Vibration analysis of cycloidal gears involves identifying sources of vibrations and determining their characteristics. As a result of the conducted research, sources of vibrations can be identified and strategies for their reduction can be developed. Vibration analysis of cycloidal gears includes spectral analysis, time-frequency analysis, vibration analysis, as well as verification of the impact of using other control methods (e.g., micro-stepping control) on vibration generation.

A 3D-printed cycloidal gear was used in the research. The gear is intended for use in moving a robot arm. The aim of the research is to analyze vibrations, which will be used to develop a control system that minimizes robot vibrations, which will have a positive impact on its accuracy and lifespan. An active vibration monitoring system will be developed, which will use an Arduino microcontroller. This system will monitor and warn of the occurrence of vibrations with a dangerous amplitude. To properly implement this system, research will be conducted comparing the accuracy of measurement using the developed Arduino-based system and the professional Digiducer 333d01 sensor.

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**New-Tech**

# The use of a mobile robot for inspection of sewage pipes.

The occurrence of failures in water or sewage pipelines can be a serious problem due to the complexity of the issue and the costs associated with repairs. A solution may be the use of various types of robots/manipulators for inspection and repairs, which can enter the interior of the installation without the need for physical entry into the pipe (e.g. with an excavator). Such a solution provides a diagnosis of the problem (e.g. providing additional information) and in some cases allows for the repair (e.g. unblocking the pipe) of the installation without the need for additional, heavy equipment. However, using such a solution can create a problem related to moving on relatively flat sections, or adapting the robot's geometry to the variable diameter of the pipe.

We would like to present the concept and construction of a prototype robot that allows for movement on inclined pipes. We have used variable drive geometry, which allows for an appropriate coefficient of friction during work in an inclined pipeline. The construction solutions used and the results of the tests of the prototype are presented. This solution can effectively reduce the need for heavy equipment to monitor the quality of water supplies and sewage systems. We would like to present the potential benefits of using mobile inspection robots to reduce the negative impact of human activity on the environment (in accordance with the principles of sustainable development).

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**Avader**

# Vehicle tracking in an urban environment using an autonomous drone

Nowadays unmanned aerial vehicles, also known as drones, are very popular. Both within the scientific community and the commercial sector, research on flying vehicles is constantly being conducted due to their high potential for development of various applications, i.e. infrastructure inspection or geodetic data collection. For this reason, many different competitions are held, creating the right conditions for modeling and testing new solutions, and thus stimulating teams from around the world to work in that research area. In this paper, an example of a simple solution is presented, which is an introduction to the first part of the UAV Chase Challenge Competition. The project includes a software model designed in the ROS operating environment. As part of its implementation, the control module of the four rotors and the flight stabilization was made, as well as an application containing a simple vision track for detection and tracking the designated target. To visualize the environment and measure the distance, a depth camera with a resolution of 1280 x 960 and a frame rate of 30 Hz was used, placed on the front of the drone, facing forward. The model was simulated and tested in the Gazebo 11 environment, on the Linux Ubuntu 20.04 operating system.

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# Pedestrian detection using event cameras.

Pedestrian detection is an important issue in advanced driver assistance systems (ADAS), autonomous vehicles and advanced automated video surveillance systems (AVSS). Traditional frame cameras are used in such solutions, but they do not work properly for insufficiently lit environments, large variability of lighting on the scene and the presence of fast moving objects with respect to the sensor. Event cameras can also be used to implement such systems. Due to their characteristics (low latency and high dynamic range) event-based sensors can detect people quickly and under adverse lighting conditions. In this work two network architectures were analyzed and implemented: Event-based Asynchronous Sparse Convolutional Network and the YOLOv7 detector. Both models were trained and tested on selected sequences from the Prophesee 1 Megapixel Automotive Detection Dataset. The results obtained from the Event-based Asynchronous Sparse Convolutional Network, despite the change of various model parameters and techniques for slicing the input image into smaller fragments, were unsatisfactory. The best result obtained during testing was 0.033 in the AP metric (Average Precision). Another approach based on the YOLOv7 detector and a two-dimensional representation of events in the form of SAE (Surface of Active Events) was also proposed. A significantly better performance of 0.9476 AP was obtained for this model. The implemented detector works correctly for single objects, but due to YOLO limitations, some pedestrians occurring in larger groups remain undetected.

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# Multi-camera drone motion capture system

With the increasing popularity of unmanned aerial vehicles (UAVs) commonly know as drones, more and more algorithms are being developed to control and plan their flight. In order to be able to evaluate such algorithms in real-world conditions , it is necessary to have a system that allows tracking their position in space.

Motion capture systems allow this task. They consist of multiple cameras that, by detecting special markers (passive or active), are able to estimate the position of the tracked object in 3D space. They are characterized by the use of high-frequency, near-infrared (IR) cameras. This makes it possible to determine the position of the drone in space, as well as to command the position using feedback. However, for such a system to function properly, it is necessary to calibrate it beforehand.

The paper will present the system, created by members of the AVADER Scientific Circle thanks tofunding from the Grant Rektora - IDUB competition, and describe how to calibrate it. For this purpose, a special calibration marker was created and software was developed to allow automatic calibration.

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# Event data processing using graph convolutional networks.

An event camera is a new type of vision sensor inspired by the principle of the human eye. Compared to standard vision cameras, which synchronously measure the intensity of light at each pixel, event cameras record changes in light intensity for each pixel independently. The result is an asynchronous sequence of data, called events.

Due to their distinctive nature, event data in its original form cannot be processed using traditional vision-based methods. First approaches to solving this problem involved converting events to dense, two-dimensional representations such as histograms. However, this approach leads to the loss of the advantages of event cameras, such as the large time span and the sparseness of the data. Therefore, current research in event cameras focuses on processing data in spatial form.

The presentation will describe a method for processing event data using graph convolutional networks. The event-based graph generation, the construction and working principle of convolutional graph layers will be described and first results in a classification task will be presented.

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**Piorun**

### Multi-criteria comparative analysis of selected light sources

Modern requirements for ensuring high energy efficiency and reducing energy consumption by electrical devices, due to the requirement to reduce global CO2 emissions, mean that the possibilities of using low-energy light sources in lighting systems are also analyzed and implemented. Currently, a wide range of electric light sources is available on the market. The development of technology has resulted in the fact that these sources are characterized not only by different construction, but also by different photometric parameters. During the project, a comparative analysis was carried out for specific light sources in terms of selected parameters, such as: current drawn from the network, power and power factor, illuminance, luminous flux and luminous efficiency.

The final goal of the conducted research was a comparative analysis of individual parameters of electrical light sources based on measurements of individual light sources, and then comparing the obtained results with the data provided by the manufacturers.

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**Piorun**

STUDENCKIE KOŁO NAUKOWE PIORUN

# Designing the insulation system for the busbars of the GIS switchgear

The use of high voltages in the transmission and distribution of electricity with simultaneous limitations in the area available for locating substations and power switchgears results in the use of switching devices insulated with SF6 sulfur hexafluoride. The aim of the presented project is to indicate and analyze various aspects and requirements for the design of busbar insulation systems for such switchgears. The paper presents the principles and problems of dimensioning the current path system in SF6 insulation. The presented analyzes and calculations are aimed at the optimal selection of the size of the switchgear and the insulation system due to the criteria of electrical, mechanical and thermal strength.

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**Piorun**

STUDENCKIE KOŁO NAUKOWE PIORUN

# Possibilities and limitations of using hydrogen in power engineering and industry

Possibilities and limitations of using hydrogen in power engineering and industry

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STUDENCKIE KOŁO NAUKOWE PIORUN

# Technical and economic analysis of the building security system on the example of a video monitoring system and an access control system based on solutions from different manufacturers

The currently designed and implemented building security systems contain various solutions for individual subsystems in terms of the technology used and their degree of sophistication. Important and at the same time quite commonly used access security solutions are: video monitoring systems (including infrared) and electronic access control systems. The completed project included the analysis of:
a) currently applicable standards and guidelines for the design of building security systems;
b) commercially available technical solutions for security systems from different manufacturers;
c) principles and practices of designing the above-mentioned systems, taking into account technical and economic aspects.

Examples of installation solutions for the above-mentioned building security subsystems will also be presented.

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STUDENCKIE KOŁO NAUKOWE PIORUN

# Market analysis and prospects for electric vehicles of public transport

Legal regulations of the European Union and the related growing requirements in the field of reducing CO2 emissions, by increasing the share of renewable energy in the energy mix, result in a constantly increasing number of industrial, municipal and consumer applications in which electricity is used. The aim of the presented project was to review and analyze the market of electric vehicles for public transport. In particular, attention was paid to the latest technological solutions used in this type of vehicles. The path of development of this sector of electric vehicles will also be discussed, together with an indication of the basic advantages and disadvantages of the development of mobile technologies in this market segment.

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**Piorun**

STUDENCKIE KOŁO NAUKOWE PIORUN

# Technical problems of locating distributed generation sources in MV distribution networks

In recent years, there has been an intensive increase in distributed generation sources in the Polish power system. Such sources are installed at all voltage levels, starting from small prosumer installations at low voltage and ending with large photovoltaic or wind power plants connected to the system at high voltage. The location of such sources, with unstable operation characteristics, may cause some technical problems for the owner of the network to which the connection is made.

This paper presents the issue of medium-voltage (MV) distribution network operation in conditions of high generation from renewable energy sources (RES). The subject of the requirements set by the Distribution System Operator (DSO) in the criteria regarding the impact of connecting generation units on the MV network was discussed. Attention was also focused on the methods of improving the operation of the distribution network (e.g. through network reconfiguration, the use of energy storage facilities), aimed at improving the quality parameters of electricity in the distribution network.

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STUDENCKIE KOŁO NAUKOWE PIORUN

# Memristor measurement stand in Laboratory of Electrotechnics

Students under the project "Investigation of properties and characterization of memristors - design, construction and verification of a measurement stand" are tasked with creating a teaching stand to bring memristor elements closer to students within the framework of teaching classes in the Department of Electrical Engineering and Electrical Power Engineering at AGH University of Kraków. Grant funds were used to purchase the memristor elements under study, a computer and a measurement card. The presentation will include a proposal for a complete exercise with instructions describing the complete course of the exercise. During the conference, live measurement of the memristor hysteresis loop and simulation in LTSpice software will be presented. The mentioned stand will also be used in scientific work at the Academy.

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STUDENCKIE KOŁO NAUKOWE PIORUN

# Programming of memristor circuits

The study focuses on investigating the potential use of memristors as RRAM memory cells. SDC (self-directed-channel) memristors with different doping types were used in the research. The possibility of using memristors as multi-bit memory cells was also considered, whereby the memory capacity of such cells is increased several-fold compared to memory based on single-bit DRAM cells. The study also involved tests that examined the process of changing the element under the influence of a programmed pulse, as well as the time retention of the memristor state. The necessary measurements were carried out using National Instruments equipment supported by the nidaqmx library of the Python programming language, which was also used for data processing and analysis.

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STUDENCKIE KOŁO NAUKOWE PIORUN

# Memristor, the fourth element of circuit theory - theory and application

In the presentation the memristor element will be presented as the fourth element of circuit theory, in principle as well as in practice. The presentation includes mathematical foundation, which determines whether an element could be classified in a group of memristive devices. The terms memristance and memductance will be defined. These relations complete the connection between other circuit theory elements. Moreover, the usage of memristors in modern electronics will be described. In the following part, the presentation shows how the memristor can be used to create an „instant" computer, revolutionizing the approach to the modern computer architecture. We will also demonstrate the aspect of utilizing memristor as non-volatile memory cells. At the end, a question is posed – what is neuromorphic data analysis and whether a computer could replace the human mind?

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# Voltage control in a power distribution network highly saturated with photovoltaic generation

Plans regarding the increase in the share of distributed generation based on renewable energy sources lead or will lead to a high saturation of distribution networks with this type of energy generation sources. For this reason, it is necessary to develop methods and algorithms for controlling the operation of such networks in advance, using simulation tools with capabilities adequate for the implementation of this task.

The aim of the presented project is to develop an optimal voltage regulation strategy in a MV distribution network with a high saturation of photovoltaic (PV) installations. The scope of works performed includes:

- a synthetic review of the state of knowledge on voltage regulation systems used in distribution networks;

- development of a voltage regulation strategy, taking into account the grid load and generation volume in the connected PV sources;

- simulation testing of the effectiveness of the proposed solution for the network model built with the use of a specialized tool (PowerFactory software package);

- conducting analyzes of the obtained simulation results and determining the resulting conclusions.

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STUDENCKIE KOŁO NAUKOWE PIORUN

# Blumlein generator - history, design, construction and applications

In many areas of science and technology, it is necessary to use electrical impulses of high energy and very short duration, in the order of single nano- or sub-nanoseconds (which also means their very wide frequency spectrum). The device that can generate such impulses is the Blumlein generator. It is a generator that uses the properties of the transmission line in the idea of operation. In the basic topology, it contains two transmission lines, configured in such a topology that it is possible to shape a voltage pulse with a very small width on the load resistor. In more developed versions, it contains a larger number of transmission lines, which allows to increase the peak value of the impulse voltage and increase the generator power.

The aim of the project is to build a laboratory version of the Blumlein generator, intended for a test and measurement stand in a student laboratory. The conference presentation will present the history of the first construction of the generator, related to the person of its inventor (Alan Blumlein, 1903-1942), the basic design of this device and its multi-stage versions. The results of work on the construction of a laboratory version of the generator will also be presented.

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**Piorun**

# Multi-criteria comparative analysis of selected light sources

The objective of the study is a comparative analysis of individual parameters of selected light sources, which is based on measurements and then making a comparison between the obtained results and data available from manufacturers of individual light sources. Nowadays, there is a wide selection of electrical light sources. Due to a development of technology, these sources are different not only because of their structure, but also of their photometric parameters. A comparative analysis was carried out for selected electrical light sources with regard to parameters as: current consumed from the electrical grid, power, illumination, luminous flux and luminous efficacy.

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STUDENCKIE KOŁO NAUKOWE PIORUN

# Voltage control in a power distribution network highly saturated with photovoltaic generation

The aim of this paper is to develop an optimal voltage regulation strategy in a network with high saturation of photovoltaic installations. The paper will include:

- a review of the state of knowledge on voltage regulation systems used in distribution networks,

- the development of a voltage regulation strategy taking into account the state of network loading and generation from connected sources,

- simulation testing of the effectiveness of the proposed solution in a computational model created using specialized tools,

- conclusions from the conducted analyses.

Research supervisor of the paper:
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# Discussion on civil aviation to become co2 free

Environmental pollution problems are becoming more and more global. CO2 emissions are one of the main sources of pollutants in the atmosphere. One significant source of emissions is aviation. On average, emissions increase by 3% every year. What are the possible solutions?

At first glance, aviation might follow the same path as road transport. There is no surprise by seen an electric car on road any more. They are modern, battery capacities are increasing all the time, journeys are becoming longer. Charging times are steadily decreasing. Why not use the same methods in aircraft construction? Electric aircraft already exist today, but this technology is unfortunately not flawless. Batteries are heavy and unlike kerosine they do not reduce the weight of the aircraft over the course of the flight. Charging such batteries will take a considerable amount of time. The batteries themselves are also likely to be lithium-ion. They have a tendency to spontaneously combust. The plane itself will use a propeller to create thrust. Such airplane would be much slower than jet plane. However, the electric motor will be the advantage, because it is simple to construct. The simpler the design, the greater the reliability.

Some believe that by 2050, aviation could reduce CO2 emissions to zero. There is a prospect, but a lot of work needs to be done to ensure that such flights are safe, regular and efficient.

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# Assessment of the wind potential of the Chernihiv region

ASSESSMENT OF THE WIND POTENTIAL OF THE CHERNIHIV REGION

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Durytskyi Mykola, candidate for higher education with the degree of Doctor of Philosophy, 1 year of study

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Currently, the average height of installation of powerful wind turbines on the territory of Ukraine is about 120 meters, so the characteristics of the movement of air masses at such heights are of the greatest interest [1].

The most important characteristic that determines the energy value of the wind is its speed. Due to various meteorological factors, as well as unevenness of the earth's surface, the wind constantly changes its speed and direction. In preparation for the design and subsequent construction of wind farms, studies of air masses at different heights (the so-called wind potential), from 50 to 120 meters, are carried out within one to two years. In normal conditions, all parameters are recorded at stationary weather stations at a height of about 10 meters from the surface of the earth [2].

There are 7 weather stations in the Chernihiv region, the data from which are sent to the Chernihiv Regional Center for Hydrometeorology, where I received the data shown in Table 1.

Table 1 - Weather station data for 2021 at a height of 10 meters

| Parameter | Parameter value for a calendar month | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| Average wind speed, m/s | | 2,9 | 2,7 | 3,2 | 2,6 | 2,5 | 2,6 | 1,6 | 2,1 | 2,3 | 2,1 | 3 | 2,8 |
| Direction | W | NW | NW | W | SW | N | NE | W | SW | W | W | W | |

The wind speed at the cutting heights is described using a logarithmic or power law (formulae (1)-(2)). Moreover, average wind speeds at high altitudes are more accurately approximated by a power-law function, and in the ground layer (15-25 m high) by a logarithmic function [3].

(1)

(2)

where is the: – wind speed at the required height; – known wind speed at height (in our case it is 10m); – a parameter that depends on the type of surface around the weather station; – is a degree index that depends on the type of surface around the weather station.

There are three main classifications of surfaces around the weather station:

- type A - open coasts of seas, lakes and reservoirs, deserts, steppes, forest-steppes, tundra;

– type B – urban areas, forest areas, as well as other areas are evenly covered with obstacles, the height of which is less than 15 meters;

- type C - urban areas with buildings higher than 25 meters.

Since weather stations are usually located in urban areas, mostly in areas built with one-story buildings, it can be assumed that the surface around the weather station belongs to type B, for which . Using formula (2), expected average monthly wind speeds at a height of 120-130 meters were calculated. The results of the calculations are summarized in Table 2.

Table 2 – Expected wind speeds at heights of 120, 125 and 130 meters

| Height, m | Value of average wind speed in m/s per calendar month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 120 | 5,01 | 4,66 | 5,53 | 4,49 | 4,32 | 4,49 | 2,76 | 3,63 | 3,97 | 3,63 | 5,18 | 4,84 |
| 125 | 5,05 | 4,71 | 5,58 | 4,53 | 4,36 | 4,53 | 2,79 | 3,66 | 4,01 | 3,66 | 5,23 | 4,88 |
| 130 | 5,10 | 4,75 | 5,63 | 4,57 | 4,40 | 4,57 | 2,81 | 3,69 | 4,04 | 3,69 | 5,27 | 4,92 |

Table 2 shows that wind speeds in the surface layer and at heights of more than 100 meters are very different. Analyzing the data obtained at the weather stations of the Chernihiv region, it may seem that the wind potential is not enough, but after calculating the values, we can see at the height of the wind turbine rotor that the average speed is sufficient for their operation. To obtain more accurate results, it is necessary to obtain by rewriting the formula (2). This can be done knowing the wind speed at heights greater than 10 meters.(3)

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### Solar car – and what is next? Prospects and possibilities of alternative fuel vehicles.

This presentation explores the topic of alternate fuel vehicles and their potential as a solution to current environmental and economic challenges. Alternate fuel vehicles, such as electric, hydrogen fuel cell, and biofuel-powered vehicles, offer a cleaner, more sustainable, and potentially more cost-effective alternative.

The presentation examines the advantages and limitations of each type of alternate fuel vehicle, discusses the role of government, and the challenges that need to be addressed in order to achieve a transition towards a low-carbon transportation system. Furthermore, it shows present alternative fuel vehicles as well as these that are currently being developed. The presentation fucuses on technological advancements, environmental impact, needed infrastructure, and consumer interest, while using detailed data.

The presentation states that alternate fuel vehicles have a promising future and significant potential to transform the transportation sector. It argues that these vehicles have the potential to play a significant role in reducing greenhouse gas emissions and improving air quality, while also offering economic benefits and energy security.

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# Process of selecting cells for an electric car

The presentation presents the process of selecting batteries for an electric car using an extensive spreadsheet. 6 previously selected cells of different construction (cylindrical and pouch), capacity and characteristics, produced by different manufacturers, are tested. This process takes into account the assumed parameters of the designed vehicle and the conditions of its use during the planned competition. Conclusions are constructed on the basis of a comparison of weights, dimensions, costs and ranges of a given battery for various average vehicle speeds. All results take into account the parameters and features of the selected battery management system (BMS). In addition to the theoretical comparison of the 6 mentioned cells, the paper also presents the results of testing the capacity of several cells from each of them. During their tests, their thermal properties were also checked. The plan for subsequent resistance tests is also described.

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# Variant analysis of the lightweight electric vehicle's undertray shape

The paper presents the results of variant analysis of the diffuser's shape in the EV "Perła". The comparison was conducted for eight, two-dimensional variants of the car's undertray, each of their sections differed in key dimensions. The vehicle's body remained unchanged in each of the cases. During the simulations' preparation, a good-quality mesh with an inflation layer was created around each of the car's profiles. All the variants were analysed in a steady-state simulation, with air velocity on the inlet equal to 20 m/s. The criteria for geometry selection were pressure decrease and velocity increase under the vehicle. The results have shown that there is a possibility of an over two times increase in the streamflow's velocity in the throat. In the back area of the car's undertray for each case, the increased turbulence kinetic energy was observed. It is recommended to put strakes in that region to redirect emerging vortices. In the designed car, the geometry case providing the biggest pressure decrease in the diffuser's area will be implemented.

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# Waste Management In Poland: Current State And Future Prospects.

This research paper examines the current state of waste generation and management in Poland and its appearance against the statistics of this topic in the European Union. The study involved a comprehensive review of literature and analysis of data from various sources, among others Eurostat, Central Statistical Office, web pages of waste incineration plants and articles that discuss waste management in Poland. The hierarchy of waste management is presented, and its final step – waste incineration is discussed in detail. The processes taking place in a waste incineration plant are described and the parameters of Polish waste incineration plants are shown, some of them estimated and calculated basing on other. The abilities of systems of thermal decomposition of waste in Poland are approximated and the role of cement industry in waste management in Poland is discussed. Prospects of development of the systems are presented.

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# Planning a municipality's energy transition using geospatial data

The paper presents an optimization model that can be used to support the energy transition process of municipalities. The model was developed using the GAMS algebraic modeling language. It uses geospatial data in the form of the BDOT10k vector database of topographic objects, containing, among other things, the spatial location of buildings along with their basic characteristics. This data is processed accordingly using Quantum GIS software tools. The model operates at the level of individual buildings, selecting for each of them the cost-optimal combination of thermomodernization option and heat source. It is possible to introduce constraints in the form of available financial resources for energy transformation of the municipality, e.g. replacement of heat sources or thermomodernization of buildings.

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# Medical applications of infrared thermography

The thermal imaging camera is used in many areas of the industry. It is also used in medicine. Hippocrates and Galileo already pointed out temperature differences on the surface of the body caused by inflammation. Applications of thermography can play an auxiliary role in X-ray, mammography, ultrasound and computed tomography examinations. The thermal imaging camera can detect a number of anomalies and the early stages of malignant tumors. The observed temperature differences may indicate inflammation or ischemia. It is worth noting that thermovision is also widely used in forensic medicine, e.g. determining the time of death with greater accuracy than previous methods. The work presents the principle of operation and characterizes the thermal imaging camera used for research. Medical areas where the thermal imaging camera is a promising diagnostic tool are presented.

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## Investigating the feasibility of using TEG generators to recover waste heat from industrial processes

Electricity performs a large role in everyday life and is also the basis for other applications. Nowadays, the best-known challenges faced by humankind include the depletion of fossil resources, continuously growing electricity consumption, global warming, and environmental problems. Work is being done on how to obtain energy from alternative sources. In recent decades, the development and improvement of industry, transport systems and people's lifestyle in general are based primarily on transforming the chemical energy of fossil fuels into thermal, mechanical, and electrical forms. The thermal energy is a waste product of every generation of energy and every production process. Recovery of waste heat is one of the most promising methods of improving the energy efficiency of many production processes and power equipment. Thanks to the implementation of waste heat recovery systems, it will be possible to limit the emissions of CO2 and to reduce the consumption of fossil fuels. The assumed outcome of the project will be to carry out physical experiments to assess the feasibility of using TEG generators to recover waste heat from industrial processes.

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## The use of mineral waste in the production process of composite insulation materials

The most frequently used insulating materials used to insulate buildings or attics are materials based on mineral wool or glass wool. Despite their wide use, there is no rational way to reuse them. The presented work presents the method of using these wastes as a modifier in the production of rigid polyurethane foams (PUR). Before using them in the foam production process, they were initially prepared by thermal treatment in muffle furnace and then grinding in a ball mill. As part of the research, 3 types of materials were produced: PUR foam without the addition of a filler (as a reference) and PUR composites with the addition of 10% and 20% of properly prepared mineral waste. The produced PUR materials were widely analyzed. Among other analysis, the cellular structure was analyzed using a scanning electron microscope, the content of carbon, hydrogen and nitrogen as well as the heat of combustion were determined. The produced composites can be a prospective insulating material.

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# Simulation of air flow in the chamber used to measure concentration of particulate matter

With the development of industry and technology, there is a growing need to study the quality of the air we breathe, which is a more complicated task than one might think. Measurement devices can behave very differently on different operating conditions. The quality of measurement can be affected by temperature, pressure, air humidity, level of measured parameter, air speed and air flow character. The project involved the simulation of airflow in a measurement chamber used to measure concentration of PM2.5 particulate matter. For this purpose, a program implementing the Lattice Boltzmann Method on the D3Q27 lattice and cumulant based kernel was written. Analysis of the results shows two vortices inside the chamber. This information can be used to design the geometry of new chamber versions which get rid of these vortices. It might lead to improved chamber measurement quality.

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# Research and optimization of the design of the cogging electric machine

In new designs of electric machines designed for use in mobile drives, other coefficients are more important than in classic solutions used in industry. Much more importance is attached to the power density, understood as the ratio of the achieved power to a unit of volume and weight. Research conducted on machines with a transverse field led to the development of the concept of using a core commonly known from alternating current machines with a radial field in this construction. The cogging machine is a new design of the permanent magnet machine that combines the advantages of the transverse flux machine (TFM) while eliminating its disadvantages. Analytical and finite element method (FEM) tests were performed for the machine with the proposed construction. They show that the average value of the torque generated by the cogging machine is about 25% higher than the TFM torque of a traditional design and three times higher than the torque of an induction machine of the same size. The promising results of these studies prompted the development of an optimal design and the creation of this machine.

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# Improving the eco-friendliness of a product: the use of eco-design and the Life Cycle Assessment (LCA) method.

For today's consumer, the environmental impact of a product is increasingly important. In response to this need and the Green Deal goals set by the European Union, manufacturers are applying eco-design principles to create more sustainable and energy-efficient products with closed life cycles that fit into the concept of a closed-loop economy.

The Life Cycle Assessment (LCA) method is used to assess the environmental impact of a product at all stages of its life cycle, providing information and recommendations to minimize that impact. During the presentation, the LCA method and eco-design will be presented in detail, along with the challenges faced by these methods. In addition, a case study of environmental optimization of an air separation oxygen production unit based on the pressure swing adsorption (PSA) method will be conducted.

The presentation will help understand how manufacturers can use the LCA method and eco-design to create products with less environmental impact while meeting the growing consumer demands for sustainable production.

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# The concept of Life Cycle Thinking in the aspect of sustainable development

Today, the idea of sustainability is a key element for the development of economic and social progress. The purpose of this presentation is to introduce the concept of Life Cycle Thinking (LCT), which involves applying a holistic way of thinking about the environmental impact of products, processes and services. The application of LCT thinking, includes consideration of the economic, environmental and social interactions between the analyzed systems and the environment and society in terms of their entire life cycle.

The speech will also present methods for enabling Sustainable Life Cycle Assessment (SLCA) analysis. SLCA is the most comprehensive tool for performing a multi-faceted assessment that takes into account both environmental, social and economic aspects. The results of SLCA analysis influence the ability to develop pro-environmental strategies, improve eco-efficiency, optimize economic costs, or carry out more socially responsible activities.

SLCA allows for documented sustainable operations and information on environmental and social impacts, leading to the ability to make more conscious decisions.

"Funding of Students Scientific Association projects under the IDUB program - Support for Students scientific Association" (Activity 12)

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**AGH Solar Boat**

AGH SOLAR BOAT TEAM

# The system for controlling and monitoring the operational parameters of the photovoltaic installation in a solar boat

In the present times, there is a continuous increase in the share of photovoltaics in industry, along with the development of PV panels. Solar panels are becoming increasingly cheaper, and their efficiency is rising, which, along with high-performance batteries, is finding increasing applications in devices and vehicles without access to power grids. An example of such an application is the solar boat, the main project of the AGH Solar Boat student research group.

The paper describes the construction of a photovoltaic installation in a racing solar boat. The construction of an original system for diagnosing the chains of PV panels will be discussed, as well as the application of a converter with the MPPT algorithm (Maximum Power Point Tracking) required in the photovoltaic installation, also known as a charge controller.

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# Issues in modern science groups

Global COVID-19 pandemic resulted in enormous changes in modern world. Some of those including: reorganisation of work form, education, studying and also differences in the workflow of scientific groups. In this paper a comparison was carried out between the state of scientific groups from before the lockdown and changes in work organisation that followed and current state in terms of activity and willingness to act of members, which decline was noticed. The comparison was carried out thanks to information, opinions and statements of members that experienced the changes first-hand. Additionally, noted changes were compared to those noticed on a larger scale and described in scientific papers. Possible causes of current situation were debated. Finally feasible solutions for improving current situation and mitigating the problems were considered.

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# Ways to look for savings in making fiber composites for the HALYNA wind turbine model

The paper for the conference will address the topic of finding savings in making fiber composites for the HALYNA wind turbine model, which is a design project of the AGH Eko-Energia research circle. At the beginning of the presentation at the conference, the lamination methods used during the construction of the turbine and the composite parts produced by the mentioned methods will be presented. This will be followed by a set of costs for the materials used in the lamination processes if the recommended original parts were used, and a comparison to the set of costs that the wheel incurred with replacement parts during the development of the project.

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# Comparison of available methods for lamination of photovoltaic panels.

The paper will deal with the lamination of photovoltaic panels and will focus in particular on the solutions available today. It will introduce the various steps involved in this process. The materials used for this will be highlighted with particular emphasis on explaining the properties of each. After a theoretical discussion of the application of each layer of laminate, the factors that influence the production of the desired panels by the various laminating methods will be listed. The paper will be enriched with a summary of the obtained power generation modules and a comparison of their strength properties. The aim of the paper is also to propose the use of fully laminated photovoltaic panels in a variety of fields, focusing mainly on the subject of projects carried out in the Eko-Energy research group.

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# Ultrafast method for hydrogen leakage measurement using thermography, computational topology and machine learning

The use of hydrogen technologies may be the answer to the energy transition problem. Hydrogen has many characteristics that qualify it as a potentially safe fuel – it disperses rapidly in the atmosphere and is non-toxic. However, there are properties of hydrogen that require additional safety measures to allow its widespread use. Hydrogen molecules are small in size and can penetrate the structure of a material making it brittle – so leaks can occur. Furthermore, hydrogen has a wide range of flammable concentrations in air and a relatively low minimum ignition energy. Consequently, care must be taken to ensure proper ventilation and leakage detection. A novel method for detecting hydrogen leaks is presented. The procedure involves using the convectional cooling of the area around the leak due to the rapid, turbulent flow of gas through the small defect area. The effect is recorded with an IR camera. Subsequently, the image is segmented and converted into a persistence graph using topological analysis. The role of the artificial neural network is to identify the leak and its type. This allows rapid, accurate and remote identification of leaks.

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# Sustainable development in the wind energy industry - recycling of plastics used in wind turbines.

The development of renewable energy sources is nowadays one of the main issue in the energy industry, taking into account environmental and economic aspects. One of the more promising and effective ways to bring closer the zero-emission energy production is the use of wind energy for this purpose. It is widely known that the very generation of electricity by wind turbines is harmless to the environment, but many controversies arouse the turbine manufacturing process itself and the construction materials used. The report deals with methods and innovations in the field of recycling plastic materials (including composite materials), which are currently used in the construction of wind turbines. The problem will be discussed on the example of conventional wind turbines as well as innovative turbines "WINDY" and "HALYNA" constructed fully and independently by the Eko-Energia team. Ways to process or reuse plastics will be presented in order to turn to more sustainable production, thus minimizing the impact of equipment used in order to produce renewable energy sources on the environment.

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# Matter Organic Non-glycerol - a study of the substance and an assessment of the potential to produce soap from it

This paper focuses on the study of Matter Organic Non-glycerol (MONG). This substance is a waste product from the purification of technical glycerine to distilled glycerine.

Three thermogravimetric analyses of the substance in different atmospheres were carried out, allowing the approximate composition of MONG and its behaviour in different atmospheres to be determined.

In this paper, attempts were made and described to use MONG as a substrate in the production of soaps by saponification reactions of fats with sodium hydroxide.

Analysis of the substance and the resulting soap was carried out by examining, among other things, pH, saponification number and acid number.

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# In search of lithium in the Bystre thrust-sheet in the Bieszczady Mountains - the LiSEARCH project

Due to the global demand for lithium, Scientific Association of Geological and Computer Cartography "AZYMUT" conducted research aimed at determining the genesis and the range of its elevated levels in the underground waters of the Bystre thrust-sheet. The project "Detailed reconnaissance of the structural composition of the Bystre thrust-sheet in the area of occurrence of geochemical anomalies for the identification of potential lithium deposits in the Outer Carpathians" was initiated, and named the LiSEARCH acronym.

Preparations included the analysis of the LiDAR terrain model, workshops in the use of ArcGIS PRO software, and field exercises in geochemical measurements.

Previous activities focused on the reconnaissance of the area's tectonics. During the first trip, structural studies were carried out in the valleys of the Rabski and Jabłonka streams, rock samples, slickensides, mineralogical and water samples were collected.

Further research is planned for the summer season of this year.

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# "Hybrid electric bicycle powered by green hydrogen for urban transportation"

In order to reduce the so-called "low emission" in cities, the transportation sector is seeking alternative power sources for vehicles. This paper outlines the concepts and projects of hybrid power sources based on hydrogen fuel cells as a power source for electric bikes within the projects carried out by KN FENEC. The hydrogen for fueling will come from renewable energy sources such as PV or biogas obtained electrochemically. It will be used to power the electric hybrid bike or hydrogen fuel cell-powered rickshaw, enabling the transportation of people, goods, and packages in urban areas. The paper will illustrate the construction of a hybrid electric drive with a hydrogen fuel cell, the benefits and challenges associated with its implementation, economic issues, and a comparison of the achievements of the tested units with those equipped with conventional power sources. The presentation will also address the method of obtaining so-called "green" hydrogen using renewable energy sources, as well as forecasts for the development of this technology in transportation.

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## An adsorption cooling systems analysis

In the work there were mentioned topics related to adsorption cooling systems, which are using activated carbons as adsorption material, working in pairs with some other refrigerants. In particular, there were presented the cycles, which consist of: adsorption and desorption and there were explained the mechanism of their processes. In the work there were also analyzed some different adsorption systems, starting with basic passive systems, which doesn't require neither electrical nor mechanical energy delivered to the system – the only provided energy is the heat of solar radiation. Next, there were shown hybrid systems, which are using both sorption processes and conventional devices, such as heaters or mechanical compressors. There were highlighted two methods of hybridization: connecting adsorbents with electrical heaters and connecting thermal compression, through desoprtion, with mechanical compression. In the work there were also indicated some features, which should be characterized by suitable adsorption material and refrigerant. In conclusions there were analyzed some research results conducted on adsorption cooling systems, with an indication on the system, which would have significant potential of practical application in nations of East Europe.

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## Status and prospects for development of photovoltaic systems

Photovoltaic cells are claimed to be the future of sustainable energy development, facing still increasing electrical energy demand and successive moving away from the use of fossil fuels. Since many years there have been some research conducted, focusing on improving and production of new types of photovoltaic cells. In this paper there were analyzed actual state and perspectives of energy development, basing on using photovoltaic cells on a bigger scale. A significant attention was paid to economic considerations of using them in different regions of the world and some perspectives of developing systems mentioned above as one of an acquiring clean energy forms. In particular, there was also the question of photovoltaic cells production development opportunities taken into account and the problem related with this case. In addition, there were presented previous biggest achievements and examples of operating photovoltaic installations, both on a small and large scale. There were also shown both the systems supplying single devices and the systems, which are main energy supplying units for whole cities.

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# Mobile air quality testing system linked to an autonomous solar unmanned aircraft

Recently, environmental protection has become a very important area of scientific development. The Students Association AGH Solar Plane is constantly looking for more technical solutions to help improve the environment. As part of the project, a fully composite solar unmanned aerial vehicle called Foton was built, which is ideally suited for long-term flights. Taking advantage of this property, a system was created to study air quality.

As part of the team's activities, a measurement module consisting of two sensors Next PM and SDC30 was created, whose readings provide information on the concentration of PM1, PM2.5, PM10, CO2, as well as temperature and humidity values. In addition to sensor data, the system collects GPS position information, taken from the Pixhawk Orange Cube flight controller, via the Mavlink communication protocol. A Raspberry Pi Pico microcontroller was chosen as the computational unit, performing every second recording of the received data to an SD card, thus enabling its subsequent analysis. An application was also written to create a map of the area with the measurement points, allowing the results obtained to be visualised.

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# The effect of the termination of the hydrodynamic wings of the Celka solar racing boat on its hydrodynamic properties - a study using numerical fluid mechanics, in particular LES methods.

The paper focuses on work related to the effect of the different shape of the end of the hydro wings of a solar racing boat on its hydrodynamic properties, and in particular on the ratio of lift to drag force generated by the hydro wings. In the study, more than a dozen different variants were modeled, and compared using CFD methods with LES-type models - that is, models that very accurately represent the turbulence that occurs. The study used the resources of computing clusters, including Ares.

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# Rescue mission using an unmanned autonomous solar aircraft and a drone

The AGH Solar Plane student association is constantly engaged in the development and construction of unmanned solar aircraft, and thanks to the team's efforts a fully composite structure called Foton has been built. It is a platform well suited for long-duration flights, allowing it to patrol large areas. Wanting to take advantage of this characteristic, the team began working on a search and rescue operation project.

The project uses a solar aircraft to patrol user defined areas and a drone to provide assistance to the found victims. In addition, a charging station was built, allowing the drone to be charged while it waits for information with coordinates from the patrol plane. The detection of the victims was implemented using a machine learning model - YOLOX and optimized with the OpenVINO toolkit. Pixhawk was used as the main control unit with the help of a RaspberryPi 4 companion microcomputer, responsible for calculating the real-world position of the victim. For data transmission between aircrafts radio communication modules operating on the 433 MHz band and using the LoRa system were used.

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**Mechatronics**

# Path planning system in AGH Racing autonomous bolide

Presentation is about autonomous system in AGH Racing autonomous bolide with the emphasis on pathplanning module. We will discusse used algorithms, their implementation and tests results. Our system allows autonomous driving which appears to have a huge potential for future arrangements.

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# Design of software system for a solar-powered car.

The presentation on the design of software system for a solar-powered car will consist of several important elements.

Firstly, the construction of the software system will be discussed, which must take into account the specific requirements for vehicles powered by solar energy. This includes ensuring optimal energy management, so that the car can operate in various weather conditions and on different types of routes.

The next important topic of the presentation will be the choice of programming language and applied technologies.

A critical element of the presentation will also be the discussion of methods for testing and verifying the correct operation of the software system, which is extremely important in the case of a solar-powered car.

Finally, examples of software application in solar-powered cars will be presented to demonstrate the benefits for the environment and users, such as minimizing carbon dioxide emissions and increasing the car's efficiency.

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# Application of machine learning in chemical analytics

The qualitative chemical analysis utilizes chemical reactions that produce insoluble precipitates, colored complexes, and gases for the identification of ions in solution. To improve the efficiency of the analyst in the laboratory, automated recording of the results at each stage of the analysis and the use of Machine Learning for the classification of the changes in the solution during the chemical reaction by image detection are employed. This paper presents a web Single Page Application (SPA) combining these two advantages. A neural network, Single Shot MultiBox Detector (SSD), trained by the TensorFlow library, is used in the application. Furthermore, the tools used during its creation, the architecture scheme, the data relationship scheme, and the implemented functionalities are presented.

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**AGH Drone Engineering**

# Aerial SLAM algorithm with global alignment based on satellite imagery

This work presents a vision based positioning and navigation system for use on drones. It uses a down facing camera mounted on a drone to estimate motion, which lets the drone navigate without a GPS sensor. In addition, the system builds a map of the environment in real time, performs global alignment and loop closing, and uses external satellite imagery to improve long distance navigation. Traditional SLAM algorithms suffer from an incremental mapping error. By using a reference satellite image map, this error can be reduced to a constant factor. The algorithm for satellite image global alignment uses a neural network to compute a grid of map region embeddings, which are a semantic representation of the area. By interpolating the embeddings between grid points, an alignment error function is defined. Global alignment is performed with gradient descent using this error function. The system has been tested in many scenarios, including long distance flights. Thanks to the use of the actor based computational model, the system operates in parallel and in real time.

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**New-Tech**

# Comparing the performance of different neural network architectures and pre-trained neural networks to classify forest flora and fauna

The aim of this project is to compare the effectiveness of different neural network architectures and pre-trained models for the classification of forest flora and fauna. Experiments were conducted on a dataset containing images of selected plants and animals found in the forest. The project covers the basics of convolutional neural networks, and compares the architectures of the networks used in the study. The results of the experiments compare the effectiveness of different neural network architectures and pre-trained models, such as EfficientNet or ResNet50. The study includes the training times of selected neural networks, classification times of individual images, and their effectiveness. Additionally, the impact of pre-training networks on the ImageNet dataset on the quality of neural network classification was compared. The purpose of this project was to determine the neural network with the most optimal parameters for use in our robot, Rumcajs, which is to be used for monitoring and mapping forest flora and fauna.

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# Real-time gesture-based quadcopter control system

Several implementations of a gesture-based drone control system have already been proposed; however, achieving a combination of reliable gesture recognition in different environments and efficient performance of a vehicle with limited hardware capabilities remains a challenging problem. Here we present on implementation of a robust real-time control system that allows a quadcopter to be manually guided and commanded to take action using hand gestures.

A lightweight Pytorch-based AI model was developed and trained on manually collected data to perform palm detection and gesture recognition. Training dataset was chosen so as to allow the detector to perform reliably in difficult visual conditions. In order to minimise flight safety risks, a number of features were implemented in a custom controller, including a gesture buffer and a forced motion cessation following a lack of positively detected gestures.

The solution was successfully tested on a real quadcopter with a camera and in a software-in-the-loop simulation, exhibiting a satisfactory performance. Solutions targeting user-enabled control of vehicles, as opposed to joystick or remote control, provide several benefits including improved accessibility, ease of use and are particularly valuable in situations where the use of traditional control methods is limited.

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# Tree protection system

The lectrure focuses on the latest advancements in drone and robot technology in managing forested areas and responding to tree diseases, with a particular emphasis on the use of drones and bionic dogs. Specifically, the use of drones for accurate terrain mapping and the use of bionic dogs for maneuvering on unstable surfaces were discussed. In such conditions, they can be a more effective and efficient alternative to traditional methods.

One of the main goals of the presentation is to showcase algorithms that allow for efficient path-finding to reach specific trees. Bionic dogs are able to move on diverse surfaces, approach objects, and transmit images for further analysis to confirm tree diseases. The lecture also presents the process of identifying tree diseases and the use of medicines and protective measures.

In summary, the presentation contains an in-depth analysis of the benefits and potential of using bionic dogs for efficient and effective management of forested areas. It aims to provide information on the latest advancements in bionic robot technology and ways to apply it to address some of the most pressing challenges in the plant care industry.

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**Mechabajt**

Koło Naukowe MechaBajt

# Intelligent temperature identification system for moving objects

A vision system is a system of collaborative devices that enables automatic image-based inspection and analysis for applications such as automated testing, process control and robot control, most often for industrial purposes. The vision system can be based on thermal imaging, which consists in obtaining information about the ambient temperature based on IR radiation emitted by objects. Vision temperature identification systems are used as a non-invasive, non-contact and safe way to find faults (e.g. electrical), find places of thermal energy loss (gaps in insulation) and detect the risk of fire. It surpasses classic smoke detectors, the ability to detect fire hazard before emitting smoke, which is necessary to excite it.

The aim of the work is to design, perform and carry out verification tests of an intelligent temperature identification system.

This system consists of a thermal imaging camera and a Raspberry PI 3B+ microcomputer, whose task is to acquire, process and analyze the image and control the system through an object identification algorithm. Image processing includes binarization, morphological transformations, and edge detection through the Laplasian filter. Ultimately, the system will enable the identification of static and moving objects with a specific temperature. After successful tests verifying the operation of the system, the object identification algorithm will be enriched with fuzzy logic.

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**Creative**

# Development of a heating module and a numerical model of dieless drawing process

The purpose of the work was to develop a heating module and to implement a numerical model of the dieless drawing process using ABAQUS software. The main component of the heating module is a resistance furnace, to which voltage is applied using a laboratory power supply. The power supply is controlled using a script, which has been tested with the use of a thermocouple. The numerical model of the process is generated using a Python script. Modification of key process parameters, as well as execution of the process of both wires and pipes is possible. Furthermore, the script allows to specify a temperature distribution in the heating element. The numerical model was validated in two stages. The first stage was comparison of the returned simulation results with literature data, and the second stage involved execution of the dieless drawing process in laboratory conditions and subsequent numerical simulation of the process with the same parameters. Based on the validation, it can be concluded that the developed solution works correctly and may provide an aid in the selection of parameters for the dieless drawing process.

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Koło Naukowe MechaBajt

# Identification of objects using a vision system

In recent years, a very intensive development of vision systems has been noticed due to their practical applications and the growing computing power of personal computers. Due to the interdisciplinary nature of the field, such systems are used in many areas - from industry and security systems to medical imaging.

The aim of the work is to design, physically implement and verify the vision system for identifying, classifying and measuring the speed of vehicles moving on a two-way road. The work consists of four main parts: analytical-critical analysis of literature and current solutions, theoretical, executive and verification.

In the first stage, a detailed review of books and literature items (along with legal acts) was carried out in order to get acquainted with current market trends and the state of knowledge. In the second stage, issues related to the field of image processing and machine learning were discussed.

Subsequently, the environment in which the system will operate was defined – monitoring vehicles on a two-way road. A vision system was also developed to identify, classify and measure the speed of vehicles using low-cost components, i.e. the Raspberry Pi 4 model B microcomputer, camera and other components.

The algorithms were written in the C/C++ and Python programming languages. The purpose of building such a solution was to examine the quality and correctness of identification and speed measurement, bearing in mind the hardware limitations of the platform. In the last stage, verification tests were carried out in the Matlab environment.

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Koło Naukowe MechaBajt

# Non-destructive testing of concrete using air-coupled ultrasound

The construction of any nuclear power plant requires very large amounts of concrete. It is built into various elements whose exposure to radiation is heterogeneous. The absorption of a large dose of radiation by concrete, characteristic of structures after several decades of operation, affects a number of their functional features. Among other things, a deterioration in the strength characteristics of concretes depending on the amount of radiation absorbed was observed. The reduction in compressive strength can reach up to 50%, the decrease in bending strength can be even greater. This can lead to damage, e.g. in the form of scratches. Non-destructive testing methods play an important role in testing the integrity and quality of concrete reactor casing structures. They help to identify possible structural deformations early, so utilities can address them before excessive downtime or loss of generation capacity occurs. Such methods are useful in ensuring the safety of power plants. Guided ultrasound waves are revolutionizing the approach to non-destructive testing (NDT) and structural health monitoring (SHM). Great possibilities result from the many forms of vibration and frequencies that are possible with this technique.

The aim of the work is to design a measuring station and carry out non-destructive tests of the technical condition of concrete using ultrasonic technology in coupling by air. Experimental research is supported by theoretical analyses and computer simulations.

As part of the work, a review of available non-destructive methods of concrete testing was carried out. In addition, the principle of operation of laser measuring devices, such as a scanning laser vibrometer and a laser microphone, was familiarized. They were used to carry out non-destructive laboratory measurements of concrete samples to detect material discontinuities using ultrasonic waves.Piezoelectric transducers were used to generate waves of a specific frequency. Their main structural element is a piezoelectric material, belonging to the group of intelligent materials. Measuring the vibrations of the concrete surface using non-contact laser methods avoided loading the samples with additional mass.

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Koło Naukowe MechaBajt

# Design and construction of a remotely controlled aircraft

Remotely controlled flying, driving and floating vehicles have an extremely wide range of applications, ranging from simple constructions, such as miniature car models, for didactics and fun, to vehicles that save lives or perform missions that do not require direct human presence. Examples of such applications are search and transport drones, rovers exploring distant planets and sapper robots. Most of them are controlled wirelessly by the operator, and some may additionally have an autonomous control variant.

The purpose of the prepared work is to design, perform and conduct tests of a remotely controlled aircraft. Various wing layouts were analyzed. An important issue is the optimization of the wing profile in order to achieve high lift while reducing drag. The available variants of drives, their controllers and power supply systems were checked. An analysis of the possibilities of manufacturing aircraft structures, including 3D printing, was made, taking into account the advantages and disadvantages of individual filaments. The next steps will include the implementation of CFD simulations, the introduction of the resulting optimization and design changes. Preparation of the geometry of key elements requires taking into account the mechanisms controlling the moving elements of the designed vehicle. The next stage will be the creation of individual fragments, and then the construction of an entire aircraft model from them. The finished facility will be tested on the ground under safe conditions to ensure that all components are working within the intended ranges. The final verification of all previous works will be a test flight, during which all solutions used in the vehicle will be checked.

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# Air quality monitoring system

An important step towards solving the problem of air pollution is the monitoring of concentrations of toxic gases and particulates in the air. This will allow the localization of pollution concentrations. Finding the causes of the poor state is crucial in the process of change. Political institutions responsible for climate with a tool in the form of a reliable system for monitoring pollution have an argument in the fight to improve air quality. Pollution monitoring also has educational advantages. Proper communication of measurement results to the public allows to raise public awareness of the problem of air pollution.

The aim of the work is to design, manufacture and carry out verification tests of the air quality monitoring system based on "cheap" technologies. To achieve the above goal, the following steps were carried out: review of selected solutions of air quality monitoring systems, air pollution and air quality parameters, assessment of air quality in selected zones, development of monitoring system algorithms, construction of the monitoring system and verification tests of the designed and implemented system.

In the first step, the available solutions were analyzed and the construction requirements of the "air quality sensor" were formulated. In the next step, air pollutants, their impact on human health and methods of interpreting their concentrations in the air were reviewed. In the next stages, the construction of the system began. As a sensor collecting data, a measuring system consisting of Raspberry Pi 4, NextPM dust sensor, and electrochemical sensors from alphasence was used. The algorithm responsible for the operation of the system has been implemented using Python.The measuring frames are sent via WiFi (MQTT communication protocol) to a server from which data can be loaded using a web application with a convenient GUI. System evaluation based on data from GIOŚ measuring stations.

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# Development, design and implementation of system used to determine the mechanical parameters of materials

The main purpose of the work is to develop, build and implement a system for determining the mechanical parameters of materials.

The introduction describes the research methods used to determine the mechanical parameters. Mechanical parameters obtained by means of a static tensile test are also described.

Existing machines on the market that enable the static tensile test were reviewed and briefly characterized. The most important components needed to build the machine are also described. The parts needed to assemble the machine were developed using CAD software. Parts of the prototype were made in 3D printing technology.

A diagram of the connection system of electronic devices and communication was made, on its basis a prototype was made.

The Raspberry Pi and Arduino programming platform was used to control the device,

allowing communication and control of components.

A desktop application has been developed that allows you to perform a static tensile test, generate a report and save test results.

In addition, possible ways of expansion and development of the prototype will be described in order to explore the possibilities of determining the mechanical parameters.

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Koło Naukowe MechaBajt

# SAR imaging analysis for infrastructure health monitoring

Radar imaging is the process by which an image is created using radar. The radar sends radio waves to objects and analyzes the waves reflected from the objects. Radar imaging objects reflect and scatter radio waves in different ways. SAR (Synthetic-Aperture Radar) is a technology that allows you to create images of the Earth's surface using specialized radars placed on satellites. The location of radars in Earth orbit allows the creation of a "synthetic" high-resolution antenna while maintaining the very small dimensions of the satellite. Synthetic aperture radar imagery is useful in monitoring the condition of infrastructure such as bridges, dams, floodplains, crops, seaports, forests and more.

The aim of the work is to design an algorithm that performs comparative analysis of radar imagery made using SAR technology. The algorithm is designed to detect changes between individual images using the DIC (Digital Image Correlation) method. The DIC method is one of the most modern tools for the analysis of SAR imagery. It consists in comparing two images taken at different times. The aim of the study is to check the effectiveness of this method for the analysis of SAR imagery.

As part of the project, SAR imagery from the ICEYE archive was analyzed using the Python programming language. As part of the work, image processing tools were used, including OpenCV and NumPy. The aim was to detect changes and displacements in the imagery and visualize them. The results of the conducted analyses were presented in the form of conclusions regarding the effectiveness of the DIC method in monitoring the condition of infrastructure on SAR imagery. The impact of factors such as image quality, weather conditions or interference was also assessed.

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# Intelligent document recognition system

By document we can understand a certain medium of information, often in physical form

(sheet of paper) or electronic (scan, computer-generated document). These media are widely used in various processes ranging from data archiving up to various types of business and market processes. That is why it is so important to the issue of recognition and proper processing of documents, especially under with respect to minimizing human participation in these activities.

The aim of the work was to design, test and verify the operation system for recognizing selected types of documents. In addition, as part of the increase possible practical applications of the designed system, this goal has been extended to include extraction specific data from recognized documents. In addition, as part of the increasepossible practical applications of the designed system, this goal has been extended to include extraction specific data from recognized documents. Therefore, the finished system consisted of several partial elements implementing the following stages of the process Document processing: pre-processing, document classification and extraction

Data. The whole solution was implemented using Python. Pre-processing is aimed at the appropriate preparation of input data to next stages. It includes a number of image processing operations for which mainly the OpenCV library was used, and the process of extracting the text layer from document. For this purpose, primarily OCR technology was used, and more specifically the engine Tesseract. The classification of documents is carried out on the basis of their vector representation obtained using natural language processing techniques such as the TFIDF algorithm.

The role of the classifier can be performed by several selected algorithms, including carrier vector algorithm and multilayer perceptron. Data extraction is based on language processing techniques

natural and the use of prepared document templates. In them, in turn, geometric relationships between elements located on the document. The designed system was tested using prepared samples documents in PDF format, both in the scanned version and documents natively generated in a digital environment.

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# Modeling and analysis of a multirotor flying robot

In recent years, one could notice an increase in interest in unmanned aerial vehicles in Poland and in the world. Unmanned aerial vehicles can be used practically everywhere. From autonomous parcel delivery, through visual inspection of places difficult to reach for humans to military applications. This flexibility of the platform is the main reason for its rapid development in recent years.

The work consists of four parts. The first is a brief historical outline, which presents the history of both unmanned aerial vehicle and rotorcraft technology and their general division in terms of various criteria. The second part is an analytical-critical study, which reviews the literature for various drone applications around the world. Subsequently, the dynamics of multirotor flying machines are described.

Another part was the implementation of the derived motion equations into the SIMULINK environment in order to create a dynamic model of the drone. Engine models were also implemented and PID controllers were calibrated so that it was possible to control the drone in the simulation. The purpose of building this model was to be able to study the behavior of drones and calibrate controllers in external weather conditions without the risk of destroying the unit. Finally, verification tests were carried out using a real object.

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## Section VIII Material Engineering

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**Energon**

### Investigating the feasibility of thermoforming foams and composites on 3D printed biomimetic molds.

Molding composites into complex shapes is now becoming a necessity or at least an interesting solution for many industries. Biomimetic inspiration allows the creation of new, rapidly developing technologies and materials with very advanced properties and the possibility of extensive modification. The purpose of this work is to explore the concept of whether it is possible to reproduce a complex biomimetic structure with a 3D FDM printer and then use it as a mold to shape composite materials.

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**AluminaTi**

# The effect of thermo-mechanical treatment on the structure and mechanical properties of rapidly solidified 6082 alloy

The paper presents the results of the influence of thermo-mechanical treatment on both mechanical and structural properties of the rapidly crystallized 6082 aluminum alloy. Experimental work involves uniaxial tensile tests and microstructure observations performed by scanning electron microscopy SEM. In order to identify typical structural features and intermetallic phases of tested alloy SEM/EDS analysis was used. Grain size measurements based on microstructural observations combined with mechanical properties were key elements, which allow us to determine the Hall-Petch relationship for the tested material.

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**AGH Solar Plane**

# Testing the strength of wing connectors used in AGH Solar Plane aircraft

The aircraft during take-off, cornering or landing is subject to overloads that may lead to the violation of its structural integrity. The connectors are responsible for transferring the forces loading the wings. Damage to the wing connector during flight poses a danger and prevents further flight. The strength properties of the wing connectors made of composite materials and the connector made of aluminum were compared. The composite materials used are carbon, glass and aramid-carbon fibers. The composite samples had an extruded polystyrene core cut on a thermal plotter. The metal connector is made of aluminum 6060-T4. The samples were compared for the accuracy of target dimensions and weight. The bending strength of the samples was tested on the HUNG TA HT-2402 testing machine. The results of the maximum bending forces for each of the samples were compared with their characteristic properties, and on this basis the best wing connector for the Foton solar unmanned aircraft was selected.

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# One-step synthesis of Pt-Pd@ACF catalyst

The study focused on the synthesis of a noble metal-based bimetallic catalyst. To produce the catalyst, a chemical reduction method was used, where Pd (II) and Pt (IV) ions were reduced to their metallic form in a controlled manner. The reductant in the process was ascorbic acid, which, in addition to its excellent reducing properties, is also non-toxic and environmentally friendly. The process was carried out in a flow microreactor system, which made it possible to produce metal nanoparticles and deposit the obtained product on activated carbon fibers (as a catalyst carrier) in a single stage of system operation. As a result of the experiments, bimetallic catalysts with different compositions (the proportion of individual metals) were obtained, which was controlled by the rate of flow of reactants in the system. The proposed method of producing bimetallic Pt - Pd catalysts can be a good alternative to the currently used methods of producing such materials.

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**Hydrogenium**

# Synthesis and properties of layered oxides NxMeyMn1-yO2 as cathode material for sodium ion batteries.

In recent years, growing interest on sodium ion batteries (SIBs) can be observed. Main reason for that, is that SIBs can potentially replace the currently used lithium ion batteries (LIBs). The main advantage of SIBs is high sodium availability, which reduces costs of buying substrates for battery production, thus allows to significantly lower the final cost of batteries for consumers. In our studies we synthesised layered oxides NaxMeyMn1-yO2 (Me=Al, Li, Mg), through sol-gel method. In this work, results of crystal structure and morphology studies of synthesised materials were presented. Also, the electrochemical measurements results of batteries assembled, using our cathode materials batteries, were presented.

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**Hydrogenium**

# Impact of synthesis conditions on structure and properties of Prussian blue analogues, for sodium ion batteries.

In recent years, growing interest on sodium ion batteries (SIBs) can be observed. The main reason for that, is that SIBs can potentially replace the currently used lithium ion batteries (LIBs). The main advantages of SIBs are the high sodium availability, which reduces the costs of buying substrates for battery production, thus enables to significantly lower final cost of the batteries for consumers. Prussian blue analogues(PBAs) NaxFeyIIFe1-y[FeII(CN)6] are promising cathode materials for SIBs, due to high availability and low costs of substrates that are used to synthesise the material. Their main disadvantage is that the reaction mechanism is still not fully understood, which results in a complexed synthesis process, that requires taking into consideration many variables during the synthesis process. This paper discusses the synthesis methods used and their effects on material structure and sodium content. Also discusses the initial electrochemical tests that were carried out on batteries assembled using the synthesised cathode material.

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# Virus elimination via adsorption

The COVID-19 pandemic has initiated an intense search for novel methods to inhibit viral transmission through air and water. The primary objective of this research has been the effective removal of pathogens from enclosed spaces such as offices, buildings and other public utilities. Preference is given to techniques that are economically viable, low in production and operational costs and have a minimal ecological impact. Adsorbents, which are already employed in water purification, air purification and medical diagnostics, meet these criteria. This paper will provide an overview of existing research on the use of adsorption as a virus removal technique from water, wastewater, air and soil. Adsorbents will be compared based on their virus removal efficiency, adsorption capacity and process costs, including the cost of their production. Moreover, the processes and factors that influence virus adsorption mechanisms will be discussed.

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**Eko-Energia**

# Comparison of manufacturing methods for lamination molds

The paper will discuss the subject of manufacturing molds for lamination, selected methods of manufacturing molds and composite parts will be briefly discussed. The paper will introduce the topic of designing for the lamination process and then, on the example of one of the molds, the vacuum infusion process will be discussed. In the further part of the presentation, one of the forms will be shown on which attention will be paid to its key features necessary for the lamination process and the mistakes made during its first design. The last stage will be the presentation of selected methods of mold production and discussion of their advantages and disadvantages, then conclusions will be drawn from the implementation of the process, the molds will be evaluated in terms of parameters such as execution time, the maximum number of possible parts made in it and the costs of execution.

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## Section IX Metal Engineering

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# The influence of 3D printing parameters on the quality of tool steels elements.

The subject of this paper is the analysis of 3D printing technology, which involves producing spatial objects layer by layer based on a computer model. This is a breakthrough technology that can allow the efficient production of parts with complex geometries that are difficult to produce using conventional methods, while at the same time producing minimal waste. The dynamic development of incremental technologies, among other things, through the widening availability of input materials and the modernisation of printing machines, means that they are constantly finding application in new industrial sectors, which is supported by extensive investment in research and development activities in this field. The aim of this paper was to investigate the level of available knowledge of incremental technologies and to analyse the influence of the various input parameters of the process on the mechanical properties of the parts produced, as well as their surface quality. For this reason, a comprehensive literature review was carried out.

Despite the wide range of input raw materials, the paper focuses exclusively on technologies based on metallic materials - particularly on the Maraging M300 tool steel.

In the next part of the work, a review of information related to the additive manufacturing process in the Maraging M300 steel was drawn up using a considerable number of scientific publications. The knowledge obtained was divided according to several criteria, including the influence of component direction, heat treatment and the choice of input parameters on the mechanical properties of the finished product.

The final stage of the thesis was to compare and verify the messages obtained from the available sources, by performing tests with the Maraging M300 tool steel sample.

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**Hexagon**

# Analysis of the mechanical and structural effects of plastic deformation of AZ91 magnesium alloy with different grain size.

Nowadays, in many industries, including aviation and automotive, structural materials that have a favorable ratio of strength properties to weight are in demand. For this reason, magnesium alloys are becoming increasingly popular. Among all available Mg-based alloys, magnesium alloys with the addition of aluminum and zinc are very popular, i.e., the AZ series (AZ31, AZ61, AZ91), which are characterized by good mechanical properties and fine corrosion resistance.

This work describes the deformation behavior of AZ91 magnesium alloy with different grain size produced in direct extrusion process by controlling the extrusion temperature. The grain size effect was determined in uniaxial tensile and compression tests at ambient temperature. The characteristic features of the microstructure of the alloys before and after plastic deformation were determined by observations using a light microscope and a scanning electron microscope, as well as diffractometric measurements.

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**Hefajstos**

# Tests of mechanical characteristics of control cables in simulated operating conditions.

The subject of the work was to check the mechanical properties of control cables for robotics applications. During the test, the cables were tested in a static tensile test to see which component is responsible for the tensile strength, then the flexibility properties were determined in a triaxial bend test, and finally the cable was tested for torsional strength. In addition, tests were carried out on the measuring bridge in order to check whether the degradation of the cable affects the electrical conductivity and whether it is possible to diagnose possible damage to the cable during operation. Wires with two types of insulation will be compared and in the case of torsional strength, the electrical properties of the tested wires will be compared to a single conductor of class 5.

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**AluminaTi**

# Influence of graphene oxide on the microstructure and properties of the titanium matrix composite.

A composite based on titanium with the addition of graphene oxide (GO) was produced using the extrusion method. Microstructure studies were carried out using a scanning microscope (SEM). The mechanical properties of the tested materials were assessed.

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**Hexagon**

# Analysis of the mechanical properties anisotropy in WE43 magnesium alloy

The latest trends in the industry aim to reduce weight as much as possible. Magnesium alloys, characterized by low density and relatively high specific strength, are at the forefront in the "race" of construction materials of the future. Magnesium, even though it has been known for many years, has a number of limitations that once prevented it from being used as a construction material. The most serious disadvantages include low resistance to corrosion, low ignition temperature (especially filings, flakes and dust), and limited plastic deformation. Today's development of technology and science allows us to eliminate or minimize the impact of the above factors. Research related to modern magnesium-based alloys with rare earth elements as major alloying elements. Specifically, thesis focuses on the anisotropic aspects of the mechanical properties of Mg-based materials produced by hot extrusion process, including the WE43 alloy and commercially pure magnesium (99.95%). Experimental works included structural and phase characteristics of as extruded materials and uniaxial compression tests carried out parallel or perpendicular to the extrusion direction. Complementary studies of the macrotexture of materials before and after plastic deformation were carried out. Based on obtained results, the degree of anisotropy of the mechanical properties of the tested materials was determined and finally it was concluded that the texture is an important factor determining the mechanisms of plastic deformation of the materials after extrusion.

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# Mechanical properties analysis of EN AW-7075 alloy with various amount of Fe and Si additives

The purpose of the research was to determine and compare the mechanical parameters of the EN AW-7075 aluminum alloy with different iron and silicon content in the composition. The tests included uniaxial tensile tests on a testing machine, hardness measurements on a Vickers hardness tester and microstructure analysis using a scanning electron microscope. Based on the performed activities, summary tables with results and graphs for each of the samples were created. The results will be used in the author's master's thesis.

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**Metalurgii Surówki i Stali**

# Development of lightweight, porous metal structures with a nature-inspired structure characterized by increased compressive strength produced using 3D printing in the LPBF process

The aim of the conducted research is to create compressive-resistant structures inspired by nature. Two variants of structures occurring in the natural environment were studied - honeycomb and the chitinous armor of the Allomyrina dichotoma beetle. Simplified models of the aforementioned structures were prepared using SOLIDWORKS software. Cylindrical samples with different internal wall thicknesses ranging from 40 µm to 120 µm were prepared. Cylindrical samples with a diameter and height of 8 mm x 8mm were produced using laser powder bed fusion (LPBF) process. The morphology of the surface and microstructure of the produced samples were examined. The printed samples were subjected to compression strength tests to identify the structure with the best properties. Additionally, the relationship between the weight of the samples and the compressive strength of the nature-inspired structures was compared. Based on the obtained results, a possible optimization of the LPBF process parameters and the model was proposed to obtain better properties of the produced samples.

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# Corrosion resistance of the coarse and sub-microcrystalline 5xxx aluminium alloys subjected to the sensitisation treatment.

The paper presents research on coarse and ultrafine crystal of three aluminium alloys subjected to the sensitisation process. One comparative and two externals, which were smelted in the laboratory. The phenomenon of sensitivity has a connection to the magnesium content in the aluminium alloys and the heat treatment carried out. The "NAMLT" - "Nitric Acid Mass Loss Test" test was presented, which defines the corrosion resistance of aluminium alloys. In report, two variants of the thermal treatment and one variant of the surface quality was tested. Photographs of the samples were also taken using a scanning optical microscope with a magnification of 50 times, 100 times and 2000 times, respectively.

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# Influence of the type and thickness of Co, CoW, Ni, NiW galvanic coatings on the microstructure and properties of the produced coating systems.

The aim of the work was to increasing knowledge on the use of multilayer protective coatings. The type of NiAl/Co/CMSX4, NiAl/CoW/CMSX4, NiAl/Ni/CMSX4 and NiAl/NiW/CMSX4 coating systems were tested. The tests carried out were to determine the effect of the type and thickness of the galvanic layer deposited on the CMSX4 nickel alloy substrate on the properties of the produced coating systems. The outer NiAl aluminide layer was deposited in the process of low-activity aluminizing using the CVD method at the temperature of 1100°C and time of 12 hours. The analysis of the microstructure and the study of the chemical composition were carried out using Hitachi-SU 70 scanning electron microscopy with the use of energy dispersive spectroscopy (EDS). The coatings were subjected to cyclic isothermal oxidation tests at 1100°C and the Vickers microhardness was measured. Research has shown that the type and thickness of galvanic coatings affect the corrosion resistance of the resulting coating systems. All tested layers significantly increase the resistance to oxidation compared to the substrate alone.

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**Hefajstos**

# Development of technology for manufacturing multilayer composite armor based on high-entropy and ceramic materials

The purpose of this study was to develop and fabricate a sample of composite armor consisting of a ceramic layer and a sheet of high-entropy material, and then test the quality of the armor by performing ballistic tests. The testing procedure included the selection of the chemical composition of the high-entropy material, its fabrication in the form of an ingot, and its plastic processing through forging and hot rolling. The process parameters were chosen to obtain sheets with thicknesses of 2 and 3 mm without violating the consistency of the material. In the second stage of the work, the ceramic part of the ceramic armor was made. In the end, six different variants of armor samples were produced, taking into account: ceramics alone, a combination of ceramics with Hardox steel, and the combination of ceramics with the fabricated high-entropy material. The obtained samples were subject to ballistic tests using small-caliber projectiles. The paper presents both the results of these tests and the procedure for making composite armor taking into account the high-entropy material.

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**AGH Solar Boat**

# Optimization of the infill geometry of the propeller made by the LPBF method for the racing solar boat "Celka"

The main subject of the project is optimization of the infill geometry of the propeller made by the LPBF method for the racing solar boat "Celka". The process is aimed at reducing the cost of material consumption and the print itself by using an appropriately modelled geometry with as little infill as possible while maintaining high strength and non-deformability. The propeller is a component exposed to compressive forces, among other things. In order to determine the optimal infill geometry, a compression test was conducted on a testing machine. A series of cylindrical specimens with different parameters and infill geometries were modeled using CAD software. Models prepared in this way were printed from the target hub material (316L steel) and then subjected to a compression test. By comparing the measurement results of all the specimens, the geometry that will be used to print the target hub was selected.

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**Hexagon**

# Analysis of the heat treatment effect on the microstructure and hardness of BA1032 aluminum bronze

Copper, which is the major alloying component of bronze, is one of the oldest materials used by humans. Initially primitive tools made from copper extracted from contaminated ores have evolved into copper-based parts, tools, components, wires used daily by people around the world. Copper by itself is an attractive material, mainly because of its high conductivity and corrosion resistance, but by mixing it with other elements we can obtain a new material that has properties which can be controlled by, among other things, manipulating the composition of the alloy. One type of alloy in which copper plays a key role is bronze. There are several types of bronzes: phosphor bronzes, silicon bronzes, cupronickel bronzes and aluminum bronzes; each has different applications, properties and a different approach to machining it. One of the aluminum bronze is BA1032 alloy, which contains aluminum, iron and manganese in addition to copper. This bronze is used in many industries, especiallu due to its ability to heat treatment. Considering the phase diagram of bronze, it is easy to locate the β phase which is the most favorable phase in terms of the possibility of changing its hardness after properly selected heat treatment conditions. To obtain the β-phase, the alloy must be heated to a sufficiently high temperature and then rapidly cooled to a relatively low temperature to avoid eutectoid decomposition.

The present work focuses on the effect of heat treatment of commercial aluminum bronze BA1032 alloy on the microstructure and hardness. Specifically, it adresses: (i) the effect of the cooling rate of the BA1032 alloy from the b phase stability range, on the microstructure and hardness of the material, and (ii) the effect of temperature and tempering time on the microstructure and hardness of the martensitic BA1032 alloy. Detailed planned heat treatment operations combined with Vickers hardness tests and microstructural observations at the magnification and resolution level offered by light microscopy and scanning electron microscopy allow to determine the most favorable heat treatment conditions for the BA1032 aluminum bronze.

Research supervisor of the paper:
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## Section X Welding Engineering

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**Promat**

# Analysis of changes in the microstructure and properties of the welded joint made of duplex 2205 steel after high-temperature annealing

The subject covers changes in the microstructure and properties of a welded joint made of duplex stainless steel 2205 after long-term, high-temperature annealing. The main objective is to assess the size and effect of intermetallic phases such as sigma and chi and chromium carbides/nitrides.

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**Metaloznawców**

# How to combine it? Bulk metallic glasses - chapter I

In recent years, popularised bulk metallic glasses have been gaining ground as advanced materials. These amorphous materials are characterised by their special mechanical, physical and chemical properties, which is why they are increasingly being marketed. One problem, which is the clou for their economic application, is their combination. Residual research and a hitherto unexploited field of study prompted efforts in this direction.

This lecture presents the results of tests on welded joints (butt and lap) of Zr50Cu40Al10 alloy. The joints were made using an electric arc furnace at different current intensities for 30/40/50 [A] at a constant time of 2 [s].

Microstructural analysis was carried out using light microscopy (LM) and electron microscopy (SEM, EDS). X-ray diffraction (XRD) was used to identify the phases and structure of the native material. In addition, a hardness map of the tested joints was produced.

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# Space materials – cladding materials

The paper presents the technology of explosive cladding. The focus was on one of its main advantages, i.e. the ability to combine multiple layers of materials in one shot. A ten-layer material consisting of Armco iron, Ti Gr. 1 and Al 1050 was presented. The following tests were discussed: ultrasonic tests, static tensile test, static bending test, static shear test, determination of RGP coefficient. Macro and microscopic studies were also carried out. In addition, the application of this material and further development work with expected results are presented.

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**Metaloznawców**

# Kinetics of σ-phase precipitation in welds of duplex steels

The aim of the study was to investigate the precipitation of intermetallic phases, especially the sigma (σ) phase, formed in welded joints of duplex steels. The weld was made on LDX 2101 plate using the manual metal arc welding method with coated electrodes. The additional material was ELGA DUPLEX LP/E2209-17 which are rutile electrodes. The analysed welded joint samples were annealed at 800°C and the effect of heat treatment time on their microstructure and selected mechanical properties was investigated.

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**Metaloznawców**

# Microstructure and hardness of nickel alloy padding welds for power plant industry applications

The study investigated the microstructure and hardness of a triple-layer Inconel 625 alloy deposition welded on 16Mo3 sheet for power generation applications. The microstructure of the deposition has a cell-dendritic structure, in which no inconsistencies excluding the deposition from use were found. The required chemical composition was achieved in the third layer of the deposition.

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# Characterization of the microstructure of the dissimilar joints using in railway industry

The analyzed joint was a combination of Hadfield steel with non-alloy steel through an austenitic Cr-Ni spacer, which is used in the railroad industry and was made by spark welding. Two samples of Hadfield steel taken from the joint from the crack area and the area next to the crack were also tested. Research presents the results of macroscopic, microscopic (light microscopy and scanning electron microscopy) and hardness measurements performed. The tests made it possible to indicate the welding inconsistencies present, the microstructure of the joints, and the EDS analysis of the chemical compositions of the examined areas of the joints.

Based on the study, it was shown what the microstructures are in heterogeneous joints and what can be observed at the boundaries of the joined materials, among other things, an increase in hardness in the joint made by spark welding. Higher hardness values were obtained for Hadfield steel specimens from the defect area and next to the defect than for measurements taken at the joint.

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# Analysis of the structure and hardness of a welded joint made of L415ME steel

The energy industry is a crucial element of the global economy. Modern industry and high living standards for society have been built on its foundations. One of its strategic components is the transportation and storage of various media, with the gas distribution industry being a crucial part of this supply chain.

This study examined a selected fragment of a high-pressure gas pipeline made of L415ME steel. Visual inspections of the welded joint and surrounding material were performed, also macro- and micro-structure observations were made on the collected samples. The hardness measurements were taken on cross-sections of the tested materials.

The research allowed the determination of the quality of the welded joint used in the gas pipeline, which will improve pipeline production processes in the future and extend their service life.

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**Powierzchnia**

# Experience shapes a person, but what shapes the weld?

Welding technology is a defined course of action to be followed when making welded joints. Welding technology comprises, among other things, the welding process, the type and preparation of base materials to be welded, the type of consumables to be used, any ancillary procedures such as preheating, post-heat treatment and, finally, post-weld inspection. Many of the above-mentioned components of the technology are so-called Essential Variables, i.e. conditions whose change significantly affects the whole technology and its effects. One of the fundamental variables is the welding process parameters.

This study analysed the effect of changing the basic welding process parameters (arc voltage, current, welding speed) on the geometry of the resulting weld. Visual and macroscopic examinations were used to assess the weld geometry. Changes in the width of the heat-affected zone were also made dependent on the amount of heat input to the joint, calculated on the basis of the basic welding process parameters.

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## Section XI Physical Metallurgy and Surface Engineering

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**Energon**

### Experimental methods of optimization of the modern trebuchet "Hurricane" .

The paper will focus on the intricacies of the mechanics of the trebuchet - a mechanical device that converts the potential energy of gravity into kinetic energy, the operation of which is only seemingly trivial. Building a trebuchet is an excellent engineering exercise, as it combines mechanics, mathematics, strength of materials and metrology. The construction, principle of operation, as well as how to test and possible methods to improve the efficiency of conversion of potential energy into kinetic energy will be presented. Two trebuchets of our science team's design will be tested: a modern one and a historical replica.

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**Era Inżyniera**

# Influence of technological parameters on adhesion joint properties in TWIST-OFF caps

The research work presented during the paper was aimed at determining the significance of pasteurization on the adhesive bonding in TWIST-OFF caps and its effect on technological parameters. Caps in which different adhesive varnish and two types of plastic granules,

i.e. PE/ PVC-free and PVC, were used were tested.

The caps before and after the pasteurization process were subjected to observations using a stereoscopic microscope, optical microscope and scanning electron microscope.

In addition, tests of the adhesion of the inner part of the cap were performed using a disc knife, and "cold" and "hot" leakage tests were carried out on both bottles and steel heads. Tests of the moment of opening of bottles and steel heads were also performed.

From the state of the research presented in the paper, it was concluded that significant differences were observed in the properties of adhesive bonds in the tested caps before and after pasteurization, i.e. a decrease in the adhesion of polymer coatings leading ultimately to a deterioration in technological parameters such as tightness and TWIST-OFF cap opening torque.

Part of the research was carried out as part of my professional work at the holding company CANPACK Metal Closures Sp. z o.o., part of the CANPACK Group, a well-known manufacturer of metal packaging. The company's core business is the production of twist-off and pry-off crown closures with a diameter of Ø26 mm. In response to growing market demand, in 2012 the production program was supplemented also with aluminum pull-off closures of the CPX type.

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**Eko-Energia**

# Types of surface connections. Comparison of the virtual design with the physical representation based on a composite part

The paper will discuss the subject of comparing the type of surface continuity, and the mathematical way of describing geometry in 3D programs will be briefly discussed. The paper will introduce the topic of surface design in automotive standards and will indicate the use of such connections of surfaces. After presenting the theoretical scope of work, a comparative model will be presented and attention will be paid to its key features of mold, necessary for the lamination process of comparative panels. The next stage of the presentation will be the presentation of the mold making process and the lamination process itself. The paper will be crowned with an analysis of the obtained effects with the computer equivalent of the target surfaces, conclusions will be drawn from the implementation of the process. The comparison will show the visual compatibility of analytical tool condition testing tools such as "zebra stripes" and "mirror effect".

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**Metaloznawców**

# Water harvesting from the fog with electrospun polymer fibers

Nowadays, millions of people still struggle with the problem of lack of access to drinking water. One of the methods of obtaining water in areas with limited access to conventional sources is harvesting water from fog.

The aim of the study is to produce polymer fibrous membranes using the electrospinning method, which will allow for effective water harvesting from the fog.

The fibers were made of cellulose acetate (CA) and thermoplastic polyurethane (TPU). In addition, core-shell fiber membranes were produced by using a coaxial nozzle. The morphology of the fibers was imaged with a scanning electron microscope (SEM), and then the wetting and mechanical properties of the obtained membranes were determined. Finally, fog water collection tests were conducted in laboratory conditions using an environmental chamber.

SEM imaging made it possible to determine the size of the produced fibers and confirmed obtaining the composite core-shell fibers. Moreover, hydrophobic TPU fibers showed higher mechanical properties than fibers obtained from hydrophilic CA. Fog water harvesting tests confirmed the ability of fiber membranes to collect water from the fog.

ACKNOWLEDGMENTS

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- the BioCom4SavEn project funded by the European Research Council under the European Union's Horizon 2020 Research and Innovation Program (ERC Grant Agreement No 948840).

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**Metaloznawców**

# Effect of strain rate on compressive behavior of Zr-Cu-Ag ternary system metallic glasses

Due to the combination of metallic bonding and an amorphous structure, metallic glasses exhibit extraordinary properties superior to conventional crystalline alloys. While the functional properties and biocompatibility of metallic glasses have been extensively researched and confirmed, a solid understanding of their mechanical properties is still lacking.

Two alloys with nominal composition (at. %) Zr50Cu37Ag13 and Zr42Cu40Ag18 were prepared from high purity elements and suction cast into a copper mould. Mechanical properties were studied via a uniaxial compression test and hardness measurements. Scanning electron microscopy was applied for microstructure characterisation and chemical composition analysis. An amorphous structure was confirmed by means of X-ray diffraction measurements, while glass-forming ability was evaluated using differential thermal analysis.

Compressive test results show that Zr50Cu37Ag13 alloy exhibits ductility while for Zr42Cu40Ag18 alloy this property can be disregarded. This is caused by their inner structure where Zr42Cu40Ag18 alloy has a less disturbed amorphous halo in its diffractogram.

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**Metaloznawców**

# Microstructure and properties of diamond cutting elements for wire saws.

The technology of powder metallurgy is used, among other things, for the production of metal-diamond tools, especially the working elements of tools. The properties of materials produced by powder metallurgy depend on the chemical composition of the mixture, type of powder, and consolidation process parameters. The study investigated the physical and chemical properties of self-lubricating powder, which was used to produce segments. The research section presents the results of studies on the working elements (beads for diamond wire saws) produced by a company specializing in the production of diamond tools. The chemical composition of the matrix material, selected material properties, and microstructure were determined depending on the tape travel speed during sintering in an industrial belt furnace.

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**Metaloznawców**

# Effect of the type of quenching medium on the properties of steels of S235 and 36CrNiMo4 grades

Hardening is one of the heat treatment processes that enable the microstructure of a metallic material to be changed, thus improving its properties. The course of this process is closely dependent on the selection of austenitizing parameters and cooling ('hardening') conditions. The literature states that an appropriately selected cooling medium, and thus an adequate cooling rate for a given steel grade, is possible through the selection of an appropriate hardening medium.

The work contains a planned and executed heat treatment experiment and an analysis of the performed comparative studies of the effect of the cooling medium on the properties and microstructure of steels of S235 and 36CrNiMo4 grades. The selected structural steels were subjected to volumetric hardening using different cooling media, such as air, Hartex 70 type hardening oil, water, 15% aqueous solution of NaCl, as well as 8% aqueous solution of Polyhartneol E8 and 15% aqueous solution of Polyhartneol HO.

After the heat treatment process, the S235 and 36CrNiMo4 steel specimens tested were subjected to Brinell hardness measurements, Charpy hammer impact tests, fractographic observations of the fractures using scanning electron microscopy, and microscopic observations after successive hardening steps in different cooling media.

On the basis of the performed tests, an analysis and evaluation of the effect of a given hardening medium on the obtained properties of S235 and 36CrNiMo4 steels was carried out. The experiment performed, the tests carried out and the analysis of the results obtained made it possible to determine which of the hardening media used is the most adequate for a given grade of industrial steel.

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**Hefajstos**

# Testing the properties and analysis of the manufacturing technology of a blade made from explosively bonded materials

The paper is focused on research of the use of explosively bonded materials in knife making. The study investigates a bimetal produced by bonding copper and steel through explosive energy. The basic applications of explosive welding are being described, as well as the use of steel-copper bimetal in knife making. The presentation analyzes a series of processes and tests, such as examination of the microstructure of the steel-copper bond, carburization, chemical composition analysis of the steel after carburization, changes in the microstructure of steel after carburization, and the selection and implementation of heat treatment processes. The results of the microstructure analysis of the produced blade are being described, and the hardness of the samples after hardening at different austenitizing temperatures is also being examined. In the final part of the presentation, conclusions are drawn from the conducted research.

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# Effect of cooling rate on mechanical properties 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 industries. The purpose of this study was to compare the mechanical properties of Zr52.5Cu17.9Ni14.6Al10Ti5 alloy cast under different cooling rate conditions controlled by the temperature of the cooling system.

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

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*Wydział Inżynierii Metali*
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**Metalurgii Surówki i Stali**

# Preliminary research of the possibility of 3D printing using laser powder bed fusion for powder obtained by ultrasonic atomization from Hardox 450 steel

Preliminary research on possible use of additive manufacturing using laser sintering layers of metallic powder bed for material obtained in process of ultrasound atomization on Hardox 450 steel.

Abrasive wear is major problem which generates costs in transport just like in industry of: metalurgic, mining, glass, building materials etc. Commonly used materials with high abrasion resistance and in the same time with acceptable costs are low-alloyed steels with increased abrasion resistance, such as Hardox 450. On other hand additive manufactuing allows use to manufacturate with high speed and low-volume productions of small metal elements, which allows for quick replacement of worn metal elements.

The paper analyzes the possibilities of additive manufacturing by laser selective bonding of the powder bed layer (LPBF). For this purpose, a spherical powder was produced using ultrasonic atomization of Hardox 450 steel, which was used for 3D printing in the LPBF. The influence of the LPBF process parameters on the porosity, microstructure, chemical composition and hardness of the low-alloy steel samples was analysed.

The study examined the possibility of using Hardox 450 steel in additive manufacturing, and the preliminary results show the possibility of using this material in LPBF.

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**Metaloznawców**

# Can fencing stress the smallsword?

This paper describes the evaluation of stress states of smallsword fencing blades used during classical fencing training regimes after three different stages of use.

The chemical composition and the microstructure of the material were also analyzed in the areas of most interest in regards to stress distribution of the tested fencing blades.

Based on the research, the processes of microstructure degradation and changes in the stress states leading to the failure of the product during fencing bouts conducted with the use of the blades has been analyzed.

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**Powierzchnia**

# 3D printing, yes it is possible...

This paper presents the results of tests on metallic alloy 15-5 PH obtained by the additive method. Static tensile test, impact measurements at +20 and -20°C, as well as macro and microscopic tests were performed on the printed samples. The specimens were produced using different 3D printing parameters and with different infill structures.

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**Metaloznawców**

# 28 years and still working

The paper presents the material used in the construction of conventional power plants, which is steel P265GH. The characteristics and requirements of such materials are described. Macro and metallurgical microscopy were carried out on samples taken from a working CHP plant, which allowed to show the effect on the material of 28 years of working at elevated temperature. Degradation processes arising during long-term operation are discussed. Attention was drawn to the resulting cracks from the inside and outside of the tested tubes. Microscopic examinations were also carried out on a long-service pipe which had undergone repair welding after perforation had occurred.

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**Metaloznawców**

# Where steel meets coffee - or what grinds our beans.

In the project, the analysis of steel grains used in professional catering coffee grinders was carried out. The study looked at chemical composition, phase composition, hardness and microstructure.

Using scanning electron microscopy, a detailed visual analysis of the cutting edges was also carried out, both of the worn-out and new burrs.

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## Section XII Metallurgy, Casting and Recycling

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**Promat**

### Atomization of AlSi7Mg alloy chips and analysis of the obtained powder for use in 3D printing process

The main objective of the thesis was to produce a powder for the process of selective laser melting in the process of atomization of a compact obtained from chips of AlSi7Mg alloy, followed by qualitative analysis of the obtained powder. AlSi7Mg alloy was selected for the diploma project. In order to obtain powder from aluminum chips, the feedstock was subjected to cleaning before the compaction process. The chips were then subjected to SEM-EDS analysis. Pressing of the chips was carried out on a hydraulic press, in closed dies, and at room temperature. The resulting compacts were 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.

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**Zgarek**

# Analysis of the selected factors on the 3-D printed models made of PLA material quality

The purpose of my work titled Analysis of the selected factors on the 3-D printed models made of PLA material quality was to examine chosen factors that impact quality of the surface of the 3D models made with PLA in 3D print.

Theoretical part of work contains knowledge about 3D print technology it beginnings and different technologies used today. Additionally few of the most popular and most used materials in 3D printing were described. Also CAD software, STL format and G-code were mentioned as they're important element in function of 3D printer. In later parts factors that impact quality of 3D printing were described and how carry quality check of them.

In research part model used in research was shown. Test were conducted on 3D printer in FDM technology. In first step carried on 3D print of the model in standard setting slowly raising temperature to maximum limits in next step cooling of the models was reduced to partial and in final step it was fully reduced. In the next part model was prepared in 3 different software used to prepare models for 3D print using the same parameters and observed how it impacted the final model. In the last part of the research the top of the 3D printer was covered with prepared chamber and models were printed with same parameters like in the first part and it was compared how closed environment impacted quality of the models. At the end all of data was collected and after analysis best parameters for printing on this material were chosen.

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**Zgarek**

# The use of CAD systems and 3D printing to make a model and prototype of an object known from literature

The aim of the thesis named The use of CAD systems and 3D printing to make a model and prototype of an object known from literature was to design and print a prototype of an object known from the literature. Excalibur, King Arthur's legendary sword, was chosen as the model for this thesis.

The first part of the thesis is devoted to the introduction of theoretical issues related to CAD systems and additive technologies. Several of the most popular programs for computer design of 3D objects are described and the principles of operation of various 3D printing methods are presented.

The practical part of the work discusses the model design process in the SolidWorks program as well as the model preparation process and its printing on a 3D printer. It also describes the modification of the model and reprinting to eliminate the defects obtained at the first attempt.

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# Development of climbing holds production technology

Climbing has been gaining popularity in recent years. Lots of people who wants to try it begins on climbing wall. We are AGH students and climbers at once. That is why we would like to connect and improve that two things. Climbing grips mostly are made by resin founding and then screw to the wall. Manufacturer attempts to make their products lighter ( it makes easier to anchor grip to the wall), moreover they try to reach unwanted shape to keep eyes on it. Purpose of our project is devise new manufacturing technique which include polyurethane resin founding with special 3D printed framework in FDM technology. Deployment the framework will let us to curb usage of resin and production costs.

During The accomplishment we reached:

Devise manufacturing technique of making climbing grips by resin founding, creating workframe and die plate and connect into composite.

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**Promat**

# Recycling metal chips - from industrial waste to multifunctional composite decking.

In recent times, there has been a great emphasis on ecology, which is why it is so important to give a second life to industrial waste such as metal shavings by putting them into circulation in another form. The research presented here shows an analysis of mechanical properties such as tensile strength, for example, and the possibility of using metal shavings that are the waste material of cavity machining in a functional way. The specimens created are a polymer matrix composite, which were reinforced using metal shavings obtained in the recycling process.

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KOŁO NAUKOWE STUDENTÓW
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# Sway bar link - constructional and technologic solutions and their alternatives

The paper presents a short outline of the development of vehicle suspension and a discussion of the currently used constructional design and technological solutions used in the production of sway bar links. Afterwards, alternative solutions are proposed involving the use of aluminum alloys that have never been and still are not used on such a large scale as the competition. Their design assumptions, the process of creating three-dimensional models, simulations of mold filling and solidification processes are presented. The process of producing casting models using 3D printing is also described, as well as the results of strength tests performed in the laboratories of the Faculty of Foundry Engineering of elements.

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# Stages and process of making statuette casting of bronze BK331

Making a statuette of multi-component silicon-zinc-manganese bronze (BK331) using the FDM (Fused Deposition Modeling) incremental method. The report covers topics related to the implementation of the concept from the idea through the preparation of the project in the SolidWorks program and its printing with the selected incremental method to obtaining the casting and its finishing, aimed at achieving the assumed aesthetic effects.

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# Numerical simulation and experimental validation of the heat treatment of a steel casting

The purpose of this thesis was experimental verification of the L500-II carbon cast steel heat treatment numerical simulation results.

In accordance to the assumption, a computational simulation of the heat treatment process was carried out using the SysWeld software. Experimental tests, during which the cooling curves were recorded, were carried out simultaneously. After conducted quenching in the water, the hardness distribution on the cross-section of the sample was examinated, as well as the microstructure in selected areas, using a light microscope and ImageJ software.

The results of the computational simulation were verified by comparing data such as the temperature distribution in the sample during cooling, the hardness distribution and the volume fraction of phase components. It was shown, that the numerical simulation results differ from those obtained in the experiment.

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# Design of the cylinder of the S-38 engine and development of the technology of its production.

The paper aims to present the process of designing a new cylinder for the S-38 engine, and then to develop the technology of making this cylinder in investment casting technology. In the theoretical part of the work, the functions and requirements of the cylinders of two-stroke engines are presented at the introduction. The properties of aluminium alloys were then discussed. The cylinder will be made of aluminum alloy with copper and magnesium with the designation 390. 0. For the production of the cylinder, investment casting technology was chosen. The paper presents in detail the process of mold manufacturing, materials used for models and molds, as well as disadvantages, advantages and application of technology. The course of the technology design process was also analyzed, i. e. how to select processing allowances, compensate for shrinkage and shape errors, design and calculate the filling and feeding system. The work also discusses the programs, their most important features, which will be used to design a new cylinder, as well as to develop the technology of its construction. In the practical part, the 3D cylinder design was developed as a fusion of solutions from the D50B0 engine and the S-38 engine. The engine equipped with this cylinder was then simulated. Subsequently, studies were carried out on the integrity of materials used in 3D printing with binders used in investment casting technology and an illustrative model of the designed cylinder in 3D printing technology was made. Having developed the cylinder body, we proceeded to the design process of the filling and feeding system starting from the required calculations. On the basis of the calculations, three variants were designed, taking into account the different orientation of the cylinder and the different places of supply of the liquid alloy. In the final stage, a simulation of pouring and solidification was performed for all prepared variants. Based on the results of the simulation, the casting system was selected to ensure the highest quality of the casting.

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# Analysis of the influence of selected alloy additions in aluminium alloys

The diploma thesis is divided into two main parts. The first part is a theoretical part containing basic information on aluminium, its most used alloys and alloy preparation and casting technology. It also includes a description of the effect of different alloy additives on several aluminium-based alloys in order to show the effect and potential of alloy additives.

The second part to the practical part, which describes the tests carried out. They concern the effect of the addition of iron and manganese of different weight contents on AlSi11 – a para-eutectic alloy from the group of aluminium-silicon alloys. Tests of basic mechanical properties were carried out: tensile strength Rm, relative elongation A5 and hardness by Brinell method. Thermal analysis of the casting process and observations of microstructures of all alloys were carried out.

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# Research on the refining process of aluminum alloys

The topic of this work is " Research on the refining process of aluminum alloys." The work attempts to study the effects of strontium and sodium as refining elements on the A383 alloy, which is a typical peri-eutectic aluminum alloy. Tests have been carried out to verify the correctness of the modification process and its effect on the mechanical properties of the aforementioned alloy depending on the modifier used and the time it was held in the furnace from the moment it was introduced into the liquid metal.

The first part of the paper introduces the subject of aluminum. It shows, among other things, the history of aluminum from the beginning of our era when it was only called "alum" until 1855 when an ingot of the metal was presented for the first time at a trade fair in Paris, which contributed to a surge of interest in the subject.

The first part also collects information on the characteristics of pure aluminum and its alloys as well as their thermal treatment and the influence of individual elements on the mechanical properties of the alloy. The subject of two examples of refining aluminum alloys - refining and modification - was mentioned and introduced.

In the second part of the work, research was undertaken to evaluate the real effects of strontium and metallic sodium with different holding times in the furnace on mechanical properties. The test methods used in performing the tests were characterized. Rm tensile test, A5 elongation test, HB hardness test and microstructure analysis of A383 alloy were carried out. Both the results and analysis of the aforementioned tests are presented.

The present work is a collection of information on aluminum and its alloys. The work was carried out on the example of A383 alloy as a representative of the most popular group of aluminum alloys - the periautectic siluminides.

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# Technology of smelting and casting aluminium alloys used in artistic casting

The topic of the work is technology of smelting and casting of aluminum alloys applied in artistic casting. The realization included the design and execution of a spatial sculpture in the form of a bust of a woman. The model was made of quick-drying clay. Due to the complicated shape of the original model, the technology of molten models was used by using Ruby Red wax and CerrCast 2000 gypsum. The work included the preparation of the matrix and the production of wax models, the production of a model set with the main filler and feed filler. Based on the models made of ceramic mass were prepared, which were then subjected to heating to melt the wax and anneal. In the first stage, castings were made based on an aluminium alloy. For this purpose, AlSi7Mg alloy was selected. For comparison purposes, a casting of commonly used alloy was additionally made for this type of artistic castings, silicon bronze CuSi3Zn3FeMn. The resulting castings based on aluminium alloys require precision at every stage of the work. The applied technology of molten models with the use of Ruby Red wax and CerrCast2000 gypsum allows to make a mold and obtain castings from both aluminum alloys and copper alloys. The difference in the properties of the used alloys, like AlSi7Mg and CuSi3Zn3FeMn, requires the use of slightly different temperature parameters of ceramic molds at the time of pouring, especially when making thin-walled castings with complex shapes.

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# Making a cast from a model manufactured in 3D printing technology

In this thesis, a thin-walled (3mm wall thickness) casting of the pliers, which operate on the principle of a prone mechanism, was made from aluminum alloy with composition close to 201.0 . To make the casting, an approach combining the investment casting with additive manufacturing was used, referred to as the Rapid Investment Casting (RIC). Using FDM printing, a prototype and 3 samples of different thicknesses were manufactured from polylactide (burn-in evaluation of the prints). Taking into account the obtained data, a mould technology was designed for gravity casting in plaster mould, in which the mould cavity is mapped using a PLA pattern. The design of mould was intended to make 3 castings. 3d prints of the gating system and patterns were printed on a 3Novatica Gate FDM printer. A cubic pattern with a 20% density of was used as the infill. A plaster mould made was heated at 700°C for 6 hours, allowing the pattern to gasify. Of the 3 casts in the mould, only the cast with the greatest inclination (in the mould) did not show underfills. The sound casting and a sample taken from the main casting were subjected to the T6 heat treatment necessary for the 201.0 alloy to reach full strength. At the stage of solution heat treatment and quenching the casting was damaged at places of smallest cross section.

Research supervisor of the paper:
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# A comparative study on the core curing pattern using Multi-tool Numerical Simulation approach for PUCB system

The presented research has illustrated the relevance of using multi-tool numerical simulations over standard numerical simulations. Simplified models such as those capable of simulating only shooting or curing process are helpful for fast evaluation. However, to fully understand the relationships and differences between process parameters and various simulation tools, and get closer to real-world conditions, the use of multi-tool simulations, such as the combined shooting and curing process, is necessary. The proposed simulation approach can be used for further research and development of the PU Cold Box process. Especially in areas of redesigning the gassing system (supply pipe, gassing head, and nozzle system) and selection of optimal curing parameters for complex core geometries, to name a few.

Research supervisor of the paper:
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## Section XIII Metal Forming

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### Design and manufacture of laboratory tools based on resin for sheets metal forming

Present thesis shows the result of research on the process of design and manufacture of laboratory tools based on resin with metallic powders and non-metallic fibres for sheets metal forming. The proposed dimensions of the stamps and models were presented using computer aided design software Solidworks 2021. Based on the created model, the prints were made on a 3D printer, which were used to create silicone molds. Fourteen compositions of resin components for stamps were determined and then castings were prepared.

Conducted tests are based on composite tools made. The castings were analyzed for internal structures without interfering with their physical structure. Topography and tools roughness have been verified. The occurrence of internal defects such as vacancies, material continuity violations, cracks and laminar defects were assessed. The hardness of the samples was also measured. The conclusions drawn from conducted analysis constitute the basis for further research and development work on increase the operating characteristics of the composite tools used for the sheet metal forming.

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# Wear analysis of counterweight forging dies

The purpose of this study was to analyze the wear of counterweights forging tools. In this work, research was conducted to eliminate cracking in the lower forging die. Using 3D scanning technology, a model was created and then compared with a CAD model of the tool. The obtained results were analyzed to select areas of intensive die wear. The next step was to analyze the results of numerical simulation in the QForm program of the technological process used in the forge. Various variants of the forging process were analyzed in order to obtain more satisfactory results. Both technological and geometrical factors were varied. After simulation, the obtained results were compared with each other and the most optimal variant for forging the counterweight was selected. The final step was to verify the mechanical properties of the tool. In order to do this, dies were cut into pieces, from which specimens were created for hardness, impact strength and microstructural testing. In addition, the chemical composition of the tool steel was examined.

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# Design and analysis of dies for extrusion of thin-walled profiles with fabrication of prototype tools using 3D printing technology

The subject of the thesis is the design and analysis of die construction for the extrusion of a thin-walled profile. The analysed profile, made of aluminium alloy EN AW-6060 is a connecting element for polycarbonate sheets used in roof construction.

Based on a drawing of the finished profile, a flat extrusion die was designed using SolidWorks software. Using FEA computer analysis in QForm software, a simulation of the forming process was performed. The main focus was on the analysis of the extrusion speed and the bending of the profile. Based on the analysis, modifications were made to the geometry of the die calibration part in order to correct material flow. The modifications were made based on the tool editor in the QShape software. A full analysis of the tools and the extrusion process was then carried out after the simulation was run again. The mean stress values, temperature distribution, pressures to which the tool is exposed, the stress intensity and strain intensity were analysed to check the tool's susceptibility to damage. In addition, a profile and die failure risk analysis was performed using fracture models based on Cockroft and Latham and Freudenthal models.

Once the dies were designed correctly, they were made using 3D printing technology. The plastic tools will be used to carry out the actual extrusion process, where the raw material will be modelling clay. For this purpose, an extrusion device was designed and manufactured. The equipment was made using machining technology with lathes and milling machines.

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**Promat**

# Production of sintered materials and their hot rolling - research on the efficiency of processing 40H steel chips

The paper presents the results of research addressing the issue of hot rolling of materials obtained as a result of processing steel chips. The tested material used in the work was 40H steel chips resulting from the processing of the chips. The chips were cleaned from the coolant in an ultrasonic cleaner using an isopropyl alcohol solution. The material was then cold compacted using a hydraulic press. Pressing was carried out with variable pressure, which made it possible to develop a pressing curve. The produced compacts were sintered at temperatures of 900°C, 1000°C and 1100°C. The obtained sinters were deformed on a quarto type rolling mill in two passes. Longitudinal rolling was carried out at a speed of 267 mm/s and at 900°C. The influence of the densification process parameters was determined by analyzing the microstructure of the produced material, as well as by performing hardness measurements and static tensile test results. The use of several variants of process parameters made it possible to determine the most effective variant for processing chips from 40H steel.

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**Promat**

# Physical modeling of the deformation process of Ti-6Al-4V compacts using the MaxStrain module

The aim of this research was to determine the impact of different types of initial heat treatment with Severe Plastic Deformation using the MaxStrain module after heat treatment is finished, have on Ti6Al4V alloy's microstructure and mechanical properties which was manufactured with prealloyed powder. This study also presents a sample which was deformed using SPD with MaxStrain module but without the initial heat treatment, for comparison. The heat treatments processes used, were especially designed to gain a certain type of bimodal and lamellar microstructure. Observation on samples' microstructures were carried out in: baseline stage, after two versions of heating treatments, after SPD with MaxStrain modulus and also after combining the heating treatments with SPD and MaxStrain module in two versions. Additionally, the study includes the mean values of microstructures' hardness measured, in each sample variation. In conclusion, heat treatment which lead to achieving a lamellar microstructure was the most efficient in gaining the highest grinding of material and resulted in significantly increasing its hardness after the deformation. The lack of initial heat treatment of this material leads to high heterogeneity in the microstructure after Severe Plastic Deformation using the MaxStrain module, which results in large spread of hardness distribution along the whole microstructure. The results of the experiment also proved that using multi-axial forging with MaxStrain modulus and with initial heat treatment aimed to achieve lamellar microstructure in the end lead to much higher hardness value than in baseline sample. The analysis of all results obtained in the study also allowed to conclude that application of pre-heat treatment of Ti-6Al-4V alloy moldings and a specific way it is carried out, have significant effect on the microstructural state and hardness of samples which were Severely Plasticly Deformed in MaxStrain module.

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**Promat**

# Developing an Effective Technological Pathway for Hot Processing of AlSi7Mg Chips to Obtain Material with High Density and Mechanical Properties

This paper presents the results of a study on the processing of AlSi7Mg alloy chips by hot plastic processing. The process path used in the work included chip cleaning, hot compaction, hot direct extrusion and heat treatment of the material. Chip compaction was carried out in closed dies using a hydraulic press. The process was carried out at 450°C with a pressure of 150 MPa applied for 5 minutes. The relative density of the resulting compacts was 99.7%. The material was then heated to 450°C and deformed by direct extrusion, inflicting a speed of 0.15 mm/s. The sample after extrusion was subjected to heat treatment consisting of solution treatment and aging. As part of the study, metallographic samples were prepared and microstructure observations were made using light microscopy. The mechanical properties of the produced material were determined based on the results of compression testing and hardness measurements. The obtained results allowed to conclude that the proposed process path makes it possible to produce a competitive material for AlSi7Mg alloy obtained by the casting method.

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**Doskonalenie jakości**

# Design and manufacture of laboratory tools based on resin for sheets metal forming

Present thesis shows the result of research on the process of design and manufacture of laboratory tools based on resin with metallic powders and non-metallic fibres for sheets metal forming. The proposed dimensions of the stamps and models were presented using computer aided design software Solidworks 2021. Based on the created model, the prints were made on a 3D printer, which were used to create silicone molds. Fourteen compositions of resin components for stamps were determined and then castings were prepared.

Conducted tests are based on composite tools made. The castings were analyzed for internal structures without interfering with their physical structure. Topography and tools roughness have been verified. The occurrence of internal defects such as vacancies, material continuity violations, cracks and laminar defects were assessed. The hardness of the samples was also measured. The conclusions drawn from conducted analysis constitute the basis for further research and development work on increase the operating characteristics of the composite tools used for the sheet metal forming.

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# Development of a manufacturing process and FEM analysis of mechanical properties for selected implants for small bone anastomoses in human orthopaedics and veterinary medicine under the conditions of BHH Mikromed

The aim of this paper was to analyze the process of manufacturing implants for hand bone fusion and veterinary applications, as well as to investigate simulated deformations and stresses that occur in the assembly of implant models using the finite element method. For many years, BHH Mikromed has been producing implants that supply markets on different continents. The creation of an osteosynthesis implant system called System 2.0 1.5 introduced another set of blocking plates and screws to the manufacturer's range. The analysis of the implant models included in System 2.0 1.5 was conducted in Autodesk Inventor by applying specific properties of materials used in production, and then applying loads that may occur during their usage. The obtained results reflect the real behaviour of implants in the patient's body and all types of implants studied fulfilled the expectations. Differences in the results show which implant characteristics are most important in this specific scenario.

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# Analysis of the influence of microstructural elements of multiphase steels on the hardening behaviour with the determination of the yield surface

Today's industry needs to use more and more new materials due to very strict environmental and economic standards. The need to reduce the carbon footprint of end products makes it necessary to constantly seek the possibility of using materials with a pre-engineered composition so as to obtain a high-strength, low-weight product at the production stage. Depending on the volume fraction of the individual material phase, the strength characteristics can change dramatically. Thus, designing a material to meet specific requirements can be quite a challenge. Dedicated solutions based on numerical analyses can help to speed up the process and automate it.

The aim of this work was to develop an automated tool for selecting the volume fraction of individual phases in multiphase steels using digital material representations. The project implemented an application that allows the preparation of numerical simulations and micro-scale analysis. This makes it possible to analyse multiple microstructures with different volumes of the individual phases together with automatic plotting of the yield surface of the designed system, which will allow the volume fractions of the individual phases to be determined in such a way that the final product meets the expected properties.

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# Effect of rolling direction change on mechanical properties of material.

The presented work was focus on the analysis of the revers rolling process. The main aim of the work was determination of the correlation between applied strain path change and final properties after deformation process. For this purpose, the single - direction and reversing rolling process was carried out and compared. The samples after both deformation processes were subjected to mechanical properties tests and microstructural analysis. Based on the obtained results the value of the Bauschinger coefficient characterizing the strain path change was determined.

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# Evaluation of the drawability of multilayer systems produced by explosive welding

In the thesis formability of the explosive welded materials was analyzed. Special attention was focused on the contemporary and future materials for drawing and their technological requirements. The study also describes various methods of producing multi-layer components, especially explosive welding.

The aim of the research was evaluation of the three-layer material to drawing which was produced by explosive welding and consisted of 316L steel, copper and 410S steel. Analysis techniques used in the experiment included macro- and micro examinations, bending tests, heat treatment, hardness tests, tensile tests and drawability tests with the use of Erichsen method.

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# A device for the execution of dieless drawing process

The main purpose of the work was to develop and construct a dieless drawing device. The developed machine consists of two main modules: a system for stretching the drawn sample and a heating system based either on a laser or on a resistance furnace. The laser-based heating module variant required the addition of a stepper motor-driven mechanism for sample rotation. The resistance furnace-based heating module variant requires the use of a laboratory power supply controlled by the RPi computer. In addition, the machine was equipped with a sample strength analyzing system, allowing for stress-strain curve determination. This system operates using a strain gauge and the ORB algorithm. To ease the interaction with the system of the machine, a window application has been implemented. Moreover, an ABAQUS software script was implemented, to allow the generation of a numerical FEM model of the dieless drawing process. Execution of numerical simulation for both pipes and wires is possible. The correct operation of the machine and the numerical model was verified by performing a multi-stage experimental validation. The correct operation of the numerical model was additionally verified by comparing the simulation results with literature data. On the basis of the validation, it can be stated that both the device and the numerical model work correctly.

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# Development, construction and implementation of a uniaxial tensile test machine.

The main purpose of the work is to develop, build and implement a device for uniaxial tensile testing. The introduction describes the research methods used to determine the mechanical parameters. Mechanical parameters obtained by means of a static tensile test are also described. Existing machines on the market that enable the static tensile test were reviewed and briefly characterized. The most important components needed to build the machine are also described.

The parts needed to assemble the machine were developed using CAD software. Parts of the prototype were made in 3D printing technology.Using a Raspberry Pi and a force sensor, the device measures the tension force in real time. The video extensometer measures the strain of the sample. The desktop application controlling the device allows you to control the speed of deformation.

The measurement data was used to generate a stress-strain diagram and to calculate e.g. Young's modulus, tensile strength, yield strength, maximum strain and Poisson's number.

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### Mobile application using machine learning to warn drivers of children at pedestrian crossings

Mobile application using machine learning to warn drivers of children at pedestrian crossings

The aim of the project is to create a mobile application for the Android operating system, which, thanks to the machine learning model, will be able to recognize children standing at pedestrian crossings using a camera directed at the road, to display a warning for the driver and suggest extreme caution. The topic is related to the desire to explore the various aspects of artificial intelligence, which is increasingly present in everyday life (personalized display of ads so that the display of products is targeted to a specific person, sorting and classifying emails in the inbox, voice assistants, autonomous vehicles).

The application was developed in the Android Studio environment in Java programming language, while the machine learning model that classifies children in the zebra crossings was built and trained in Python programming language. Integration of the model with the application is provided by the TensorFlow Lite library, which allows the finished model to be converted into a suitable format for deployment in the mobile application.

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# AIn Eingarp

The goal of the project is to create an AIn Eingarp motivational frame. The frame will be designed to generate and display images representing the frame owner. These images will mobilize the user to do a specific action, helping him or her to achieve the desired goal. For example, a person preparing for a marathon will see himself as a winner on the podium. Visualizing success will mobilize the user to train.

The project will use off-the-shelf, available deep learning models that transform text into images. A combination of several models is planned, due to the limited number of queries available for one user. The program, upon receiving the user's text and image as input, will send the query to a model. The model will generate a "motivational" image, which will then be displayed. The project will be based on the Raspberry Pi platform and a color display.

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# MeetMe Web Application

The aim of the project is to create an application that enables the optimization of event search in a given area. Events will be sorted according to various criteria, including type, location, date, and ticket availability, allowing for quick and convenient searching. Available events will be presented both in the form of a list and a map showing the exact location. The application user will be able to create an account and log in to the platform, gaining access to additional functionalities such as creating their own events.

The Spring framework will be used in conjunction with additional libraries to create the application. Event data will be obtained using SerpApi, which utilizes the Google platform. To reduce the number of generated queries to the external API, an SQL database will be used in the project.

The motivation for developing the application is the lack of similar solutions in the Polish market and the desire to offer users innovative functionalities.

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# Classification of emails using various machine learning algorithms.

The project aims to measure the effectiveness of different machine learning algorithms in the classification of emails based on the Enron Corpus database. It contains around six hundred thousand labeled e-mail messages created by employees of the Enron Corporation. The models will be trained using algorithms such as: Naive Bayes, Random Forest, and neural network, and their effectiveness in recognizing unwanted messages will be evaluated using metrics such as accuracy, precision, and F-score. The newly developed models will be compared with other email message classifiers. The differences in the architectures of the tested algorithms affecting their effectiveness will be evaluated.

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# Seating Planner

The aim of the project is to develop an application that allows automatic placement of guests in an optimal way, based on preferences towards potential neighbors. The solutions currently available on the market are devoid of such logic, the user has to assign the seats himself, which, as the number of guests increases, can be a monotonous and time-consuming process. As part of our project, we will reduce this issue to an NP-hard problem of combinatorial optimization. Due to the characteristics of this class of problems, several heuristics will be used to determine the solution.

The tool will be in the form of a web application allowing the user to upload an xlsx file containing a list of guests along with their preferences and room layout. In response, a detailed spreadsheet will be prepared (also in xlsx format) containing the calculated solution for the given input data.

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# „Meal Assistant" – meal planning app

The aim of the project is to create a mobile application for the Android operating system in Java. The main purpose of the application will be to help planning meals and managing the time needed to prepare them. Using the application it will be possible to:

- search for recipes suggestions based on time defined by user
- filter out recipes for which we do not have all necessary ingredients
- search recipes on the basis of a specific ingredient that we want to be included in the meal
- enter the name of the recipe and use it to search for a list of products needed to prepare it, highlighting unavailable ingredients
- sort the list of dish suggestions based on the time of their preparation or the best-before date of the products needed to prepare it

The application will be using a barcode reader in order to scan food codes and then enter them into the pool of food products available to the application user. The application will also allow to enter products manually with all necessary informations.

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# FloraMate - Your personal plant caretaker

The goal of the project is to create an intelligent system which is designed to decide when and how to water the plant (and start the watering procedure itself).

The system will consist of a WiFi ESP module, a moisture sensor, a relay that controls the pump, a power supply, a water supply pipe, and a water tank. Using the WiFi module, a web server will be connected to a MySQL database that stores information about the owned plants and their requirements.

Through the Website, the user can monitor current plant parameters and modify the required soil moisture level. In the form of a short condition evaluation form, the user can provide their comments on the plant (leaf condition, blooming), as a result of which the application, using the web scraping technique, can advise a change in soil watering parameters or recommend a different method of care. Additionally, the system will notify when the water in the tank needs to be refilled.

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# Intelligent system for monitoring safe child's sleep

The aim of the project is to develop a system to control the state of the infant during sleep. The main elements of the platform will include a sound level sensor to alert the caregiver to the baby's crying after waking up. In addition, a mechanism will be prepared to monitor the infant's vital functions in order to prevent cot death.

The system will be distinguished by its operation as a standalone product. To use it, there is no need to install any applications or have additional devices. All that is needed is a phone with access to the mobile network. The system will use a highly reliable cellular network to transmit alarms by making phone calls to the supervisor's number. Thanks to this, the failure of the Wi-Fi network will not prevent the correct delivery of alarms.

Appropriate sensors, a microcontroller, a GSM module, etc. will be used to implement the project. In addition, electronic components will be packed in a housing constructed thanks to 3D printing.

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# Location estimation using the accelerometer and the magnetometer

In today's world it is hard to imagine a life without a smartphone. Access to the Internet, numerous applications that help us in everyday life or direct and immediate communication with others is a comfort that is difficult for many people to give up. However, there are situations in which even such an advanced device is not able to function properly. One of the core functionalities – localization, relies on the GPS and other satellite navigation systems and is unable to function without them. However, there are situations where knowing the location would be helpful and satellite signals are not available.Navigation in caves has previously required the guide to pinpoint his location using analog methods such as maps or good knowledge of the paths, but if he gets lost, it may be impossible to pinpoint where he is and find a way out. During an armed conflict, signal jamming by military systems is another obstacle that may render GPS-based systems useless. Military vehicles themselves are often equipped with inertial navigation systems, but civilians only have a map and compass at their disposal in such situations.

The goal of the project is to create a mobile application that, after being calibrated using the GPS system, will be able to determine the approximate location of the user in the field. In order to make this system less reliant on satellite navigation, it will be necessary to determine the distance traveled and the direction in which this distance was traveled. After the initial calibration, the system will determine the average distance per step and then use the number of steps to measure the distance. At the same time, the measurement from the magnetmeter (compass) will provide a reading of the direction in which the steps were taken. Thanks to these two elements, the device will be able to determine its position in the field.

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# Smart pet feeder

The aim of the project is to develop and create a model of an intelligent bowl with a dry food dispenser for domestic animals such as cats and dogs. The NodeMCU board with the ESP8266 module, a stepper motor, an optical motion sensor and custom-designed components will be used for construction. The Python language with the MicroPython interpreter and WiFi communication will be used to access a mobile application for monitoring statistics and managing feeding.

The bowl will be distinguished by:

- an automatic and personalized food distribution system for the animal, allowing for on-demand feeding while maintaining appropriate intervals between meals and the total daily food portion

- monitoring and prediction of the animal's feeding habits, facilitating control of the pet's health status and helping to assess the overall level of activity.

This project is a response to the existing gap in the market for automatic feeders for pets, which, in addition to the basic function of providing food at scheduled times, would allow for individual and intelligent personalization to correspond to the habits of both the owners and their pets.

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# DVB-S2 Receiver

DVB-S2 Receiver

The project objective is to design and implement a DVB-S2 receiver, which allows the reception of images and other multimedia data captured by Low Earth Orbit (LEO) satellites. The receiver will be implemented to work on a Software Defined Radio (SDR) HackRF and Ettus Research USRP. The software of the receiver will be written in C++ programming language with the use of GNURadio framework. The programming interface enabling SDR to PC communication will be SoapySDR. The final software will be designed to run on personal computers equipped with processors having SIMD instructions available (SSE in the case of x86).

Ultimately the receiver will be aimed to work with a parabolic antenna designed to work in S-band.

The receiver is part of a bigger project SatLabAGH.

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# Video game console gameKITten

The goal of the project is to create a video game console with the remote controller. The computing unit of the console will be a Raspberry PI platform computer, which will run simple retro-style games. An Android phone will serve as the controller, which will be turned into a HID (Human Interface Device) class device through an application.

The video game console will consist of:

- a computing unit,

- a wireless controller.

The ability to run games will be provided by a graphical user interface (GUI) application that will display games stored in read-only memory (ROM). The ROMs used will be products made available by the community under an open software license.

The controller enabling interaction with the console will be a cell phone. The application running on the phone will simulate a game pad. The connection between the controller and the console will be done remotely, using the Bluetooth communication standard.

It is planned to prepare the components of the console, integrate them with each other and test the functionality of the finished product. The tests will be conducted on a sample game, and during them the responsiveness of the wireless controller will be checked.

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# Interactive digital signage application

The aim of the project is to prepare an interactive digital signage solution (software and hardware implementation examples). Ready-made open source components will be used, for which a web application will be developed to allow integration with existing systems and retrieval of data directly from the user to create interactive content. Techniques will be developed for retrieving and processing data from external sources, taking into account solving the problem of data inconsistency. On the hardware side, a prototype screen will be prepared as a customer proposal, consisting of:

- a computer monitor or TV,
- a minicomputer of SBC type (e.g. Raspberry Pi).

The IEEE 802.11 standard will be used for connectivity to the server to enable easy implementation of the system without the need to create new infrastructure in the building. This technique will provide parameters and connection quality sufficient for the application to work properly. The use of the Angular framework will allow the development of a clear and transparent user interface. The server application will be prepared using the Docker technique, so it will be possible to run it on almost any existing server infrastructure, and in the absence of such infrastructure, an SBC (single board computer), a desktop computer or in the cloud (e.g. Amazon).

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# Autonomous robot using wireless localization system

The aim of the project is to develop and build an autonomous robot which, using an active wireless localization system, will move in a designated space, optimally combining precision with speed. The Raspberry Pi computer will be used to build the project. It will be responsible for operating the algorithms and controlling the robot itself. The driving base of the robot will be iRobot Create 2. The choice of the base was dictated by the simplicity of the device's operation and performance in terms of both precision and speed of movement. The wireless localization system will be based on five DWM1001-DEV boards.

The user will be able to connect to the robot via SSH protocol and enter the coordinates in the room where the robot should go, and an algorithm will determine the shortest route the robot should take.

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# Location Estimation using Photos

The goal of the project is to create a program that can locate a place based on a photo using machine learning. A network trained for image recognition will be utilized for the project and then transfer learning will be used to customize it to the project's needs.

There are many potential applications for such software. For example, imagine a situation where our child is lost in an unfamiliar place. At such a moment, they are likely to be under significant stress and may not know how to check their location. Using our application, they will be able to send us a photo, which will be processed and show us an approximate location, making it easier for us to find them.

A publicly available dataset will be used for the project, or depending on its complexity, it will be created using a script that takes photos available on Google Street View, allowing them to be easily labeled. 75% of the collected data will be used for training, and the remaining 25% will be used for testing.

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# Monitoring application for online marketplaces

The goal of the project is to create an application for monitoring new offers on selected online marketplaces and allowing users to receive notifications about products or services that interest them. The application will help find opportunities or desired offers while minimizing the time required for manually checking websites. The solution will consist of two components:

• The server part of the application, which will be the interface to the database

• Microservices that will retrieve data from marketplaces and send it to the application server.

Both components will be written in Python. The application server will be used for configuration, storing information about offers, users, as well as user search settings.

For each supported portal, a microservice will be created. Each microservice will periodically retrieve a list of searches to be checked from the server and then send the results back. The server will compare the received offers with those stored in the database and notify the interested user of each newly created advertisement.

Notifications will be sent to users through selected, publicly available messengers. For this purpose, there will be the possibility of configuring the notification channel by the user themselves.

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**Telephoners**

# Real-time saxophone note recognition tool

The purpose of my project will be to design a tool for recognizing musical symbols, more precisely - notes, created by playing the saxophone. This tool will have the function of recognizing, displaying the note read by the frequency on the screen and, if possible, recognizing by the notes read and using a previously created base, what song is currently being played.

The greatest attention will be focused on the correct implementation of the entire code, taking into account all the necessary mathematical aspects (possibly Fourier Tranformats, signal processing). The main tool will be the Python language, with its built-in libraries, the Visual Studio Code source code editor, the microphone built into the computer (it may be necessary to possibly purchase a better quality microphone) and, of course, the saxophone (or other instrument) itself. The main goal of the project is a working tool, and the appearance of the application itself (GUI) will be left for possible further stages of application development.

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# Algorithm enabling the prediction of the market price of cryptocurrencies.

The goal of the project is to implement an algorithm that allows for forecasting the market price of cryptocurrencies. The proposed algorithm will be based on price identifiers, which are indicators used for the unambiguous identification of cryptocurrency prices. They enable tracking changes in prices as well as trading.

The price identifiers used will include:

- RSI (Relative Strength Index),
- MA (Moving Average),
- MACD (Moving Average Convergence Divergence).

The project assumes testing different types of machine learning, which will allow determining which one provides the best results. Machine learning enables recognizing patterns and making decisions based on the provided data. The algorithms also enable processing a large amount of data and remembering conclusions from it. The project results can find applications in areas such as investment or cryptocurrency trading, allowing for better decision-making based on cryptocurrency price forecasts.

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# Email classification using different machine learning algorithms

The project aims to investigate the effectiveness of various machine learning algorithms in email classification using the Enron Corpus database. The database contains approximately six hundred thousand labeled email messages created by Enron Corporation employees. Naive Bayes, Random Forest, and neural network algorithms will be used to train the models, and their effectiveness in recognizing unwanted messages will be evaluated using metrics such as accuracy, precision, and F-score. The models will be compared with other email classifiers, and differences in the architectures of the algorithms affecting their effectiveness will be evaluated.

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**Zarządzanie**

Studenckie Koło Naukowe
ZARZĄDZANIE

# The potential of social media platforms as a communication tool

Social media is becoming increasingly important in social and economic life. Social media are an important element of today's information culture and are one of the most important channels of information flow. We can safely say that it is an integral part of our lives today.

The author will analyze the popularity of individual social media platforms and compare their capabilities as communication tools. Discussing the features offered by individual platforms, she will note their effectiveness depending on the communication objectives for which they will be used. In the presented examples, she will show how to build and maintain relationships with recipients on selected platforms such as Facebook, Instagram, LinkedIn and TikTok.

These platforms not only allow people from all over the world to integrate easily, but have also become one of the most important communication tools. The impact of social media on communication is particularly important in the context of marketing and advertising, where it is an increasingly important tool to reach customers and build brand loyalty.

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# Numerical methods for solving higher-degree polynomials

The project focuses on solving higher-degree polynomials using various numerical methods, which is a problem that has many applications in fields such as natural sciences, engineering, physics, as well as in various simulations and mathematical modeling.

An important goal of the project is to accurately compare the effectiveness of the applied numerical methods and to analyze their implementation using different mathematical libraries.

Python, which offers many modules and libraries for numerical calculations, will be used to implement the methods, as well as another chosen programming language, which will be suitable for a given numerical method.

In addition to the implementation of the numerical methods, the project also includes creating unit tests to ensure that the implemented methods give accurate results.

The results of the project have potential applications in various fields of science and industry, where solving higher-degree polynomials is essential for conducting accurate numerical analyses.

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