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EDITORS
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BOOK OF ABSTRACTS

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Preface

The book of abstracts contains a collection of selected papers from 14th International Conference BIOMDLORE2023, which was organized by the Institute of Biomedical Engineering at Bialystok University of Technology, the Medical University of Bialystok, Vilnius Gediminas Technical University and Kaunas University of Technology. The event was held on 22–24 October 2023 in Bialystok, Poland.

The main topic and focus of the conference is already reflected in its name – BIOMDLORE stands for BIOmechanics, Medical Diagnostics, LOcomotion and REhabilitation; The broader scope of the conference focuses on various biomedical engineering problems: biomechanics of the human body, orthopedics and traumatology, assistive technologies, rehabilitation engineering, medical diagnostics, biosignal recording and processing, mathematical modeling, sports biomechanics, robotics, e–health challenges and AI solutions in healthcare and in the areas of a person's subjective well–being.

1. Physicochemical and mechanical properties of flexible magnetic materials modified with biofunctional coatings

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BACKGROUND: Silicone–based materials reinforced with magnetic particles are a developing group of composites. There is a growing interest in the use of these materials in biomedical engineering. This requires the biofunctionalization of these materials in order to protect them against corrosion and the release of powder particles into the environment.

OBJECTIVE: The aim of the work was to examine the influence of the coating type on selected material properties.

METHODS: The coatings' thickness and the coating surface's contact angle were tested. CLSM and SEM microscopic analyzes were performed. Analysis of the movement of materials in a magnetic field was carried out to assess the ability to move in different environments.

RESULTS: The thickness of the coatings deposited on the surface was approx. 103±15 μm. The contact angle of the biofunctional surface was lower (θc=71.1±3.8°) compared to the silicone – NdFeB powder composite surface (θc=92.8±1.2°). CLSM analyses showed a reduction of materials roughness from Ra= 0.253±0.017 μm to Ra 0.171±0.054 μm after surface modification. The results of the SEM–EDS tests showed an even distribution of the active substance in the sample. The presence of the coatings affected the movement of the composite. The thicker the surface layer, the higher value of the magnetic field required to bend the sample to 90°.

CONCLUSIONS: The obtained studies indicate that the surface–modified composite material retains its elastic properties after applying biofunctional layers. However, advanced rheological testing of materials in a controlled magnetic field is needed.

2. Design and implementation of intelligent monitoring of loneliness in the elderly using a serverless architecture with real–time communication API

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BACKGROUND: Loneliness and social isolation are recognized as critical public health issues. Older people are at greater risk of loneliness and social isolation as they deal with things like living alone, loss of family or friends, chronic illness, and hearing loss. Loneliness increases a person's risk of premature death from all causes, including dementia, heart disease, and stroke. To address these issues, the inclusion of technological platforms and the use of commercial monitoring devices are vastly increasing in healthcare and elderly care. In this research, serverless architectures are employed because of their benefits, including deploying applications in a simple way without the necessity of using a dedicated server, the combination of security with performance, reducing operating costs and development times, having no scaling restrictions, and streamlines internal processes and facilitates continuous improvement.

OBJECTIVE: The objective of this study is to design and develop a loneliness monitor serverless architecture to obtain real–time data from commercial activity wristbands through an API.

METHODS: For the design and development of the architecture, the Amazon Web Services platform has been used. To monitor loneliness, the Fitbit Charge 5 bracelet was selected, through the web API offered by the AWS Lambda service, the data is obtained and stored in AWS services with an automated frequency thanks to the event bridge.

RESULTS: In the pilot stage in which the system is, it is showing great results in the ease of collecting data and programming the sampling frequency. Once the request is made, the data is automatically analyzed to monitor loneliness.

CONCLUSIONS: The proposed architecture shows great potential for easy data collection, analysis, security, personalization, real–time inference, and scalability of sensors and actuators in the future. It has powerful benefits to apply in the health sector and reduces cases of depression and loneliness.

3. Methods for reducing ring artifacts in tomographic images using wavelet decomposition and averaging techniques

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BACKGROUND: Computed tomography (CT) is one of the fundamental imaging modalities used in medicine, allowing for the acquisition of accurate cross–sectional images of internal body tissues. However, during the acquisition and reconstruction process, various artifacts can arise, and one of them is ring artifacts. These artifacts result from the inherent limitations of CT scanner components and the properties of the scanned material, such as detector defects, non–uniform distribution of radiation from the source, or the presence of metallic elements within the scanning region.

OBJECTIVE: The purpose of this study was to perform identification and reduction of ring artifacts in tomographic images using image decomposition and average filtering methods.

METHODS: In this study, tests were conducted on the effectiveness of identifying ring artifacts using wavelet decomposition methods for images. The test was performed on a Sheep–Logan phantom with implemented artifacts of different intensity levels. The analysis was realized using different wavelet families, and linear approximation methods were used to filter the image in the identified areas. Additional filtering was performed using moving average methods and empirical mode decomposition (EMD) techniques. Image comparison methods, i.e. RMSE, SSiM, MS–SSIM, were used to evaluate performance.

RESULTS: The results of the study showed a significant improvement in the quality of tomographic Phantom images. The different wavelet families have different efficiencies with relation to the identification of induction regions of ring artifacts. The applied additional moving average filtering and EMD permitted to improve image quality, which is confirmed by the results of image comparison.

CONCLUSIONS: The obtained results allow to assess how the used methods affect the reduction of ring artifacts in phantom images with induced artifacts.

4. Experimental and theoretical investigation of aortic wall tissue in tensile tests

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BACKGROUND: The mechanical properties of aortic tissue are essential to develop numerical computation tools and assess the risk of fracture of the aortic aneurysm. Tensile tests using aortic wall specimens allow for the determination of stress and strain depending on the location and direction of the sample.

OBJECTIVE: The aim of this study was to perform a mechanical tensile test using animal aorta samples, process the experimental data, and perform a numerical simulation of aortic tissue tension.

METHODS: Dogbone–shaped samples were dissected from animal aortic segments. The initial measurements were made at zero tension and then the tensile tests were carried out with a speed of 10 mm/min until rupture. Force and stretch data were used to obtain engineering and true stress–strain curves. True stress–strain curves until ultimate strength were taken, smoothed, and fitting was performed using a logistic function with three coefficients. A smoothed and fitted stress–strain curve was used as a material mechanical property for the numerical model of the aortic tissue tension. A simplified rectangle form was used to mimic the middle of the dogbone–shaped part of the tissue specimen. The experimental displacement data were taken for the boundary condition of finite element 3D model.

RESULTS: In experimental data processing we found that the logistic function describes the nonlinear behaviour of the soft tissue of the aorta with an accuracy of 95% from tension beginning to first–layer rupture. By applying numerical simulations, we obtained a correspondence of the load curve with RMSE = 0.069 in theoretical and experimental external tension data.

CONCLUSIONS: During the numerical investigation the validation of non–linear soft tissue was achieved by applying a logistic function approach to the mechanical properties of the aortic wall.

5. **Mechanical properties of 3D printed PLA scaffolds for bone regeneration**

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BACKGROUND: The growing interest in biodegradable scaffolds for bone regeneration created a need to investigate new materials suitable for scaffold formation. Poly (lactic acid) (PLA) is a polymer commonly used in biomedical engineering, e.g. in tissue engineering as a biodegradable mate–rial. However, the mechanical behavior of PLA along its degradation time is still not explored well. For this reason, the mechanical properties of PLA scaffolds affected by incubation in physiological medium needs to be investigated to show the potential of PLA to be used as a material for biodegradable scaffold formation.

OBJECTIVE: The purpose of this research is to determine the mechanical properties of PLA scaffolds before and after incubation, and to apply constitutive material models for further behavior prediction.

METHODS: Two sets of PLA scaffolds were printed by the 3D printer "Prusa i3 MK3S" and sterilized by ultraviolet light and ethanol solution. The first set of specimens was incubated in DMEM (Dulbecco's Modified Eagle Medium) for 60, 120, and 180 days maintaining 36.5 °C temperature. The mechanical properties of the scaffolds were determined after performing the compression test in the "Mecmesin MultiTest 2.5–i" testing stand with a force applied at two different speed modes. The obtained data was curve fitted with the hyperelastic material models for a model suitability study. The second set of specimens was incubated in PBS (Phosphate Buffered Saline) for 20 weeks and used in a polymer degradation study.

RESULTS: The obtained results show that the mechanical properties of PLA scaffolds do not decrease during incubation in physiological medium for a predicted new bone tissue formation period, though hydrolysis starts at the very beginning and increases with time.

CONCLUSIONS: The mechanical properties of 3D printed PLA scaffolds do not change during incubation, therefore the scaffolds support the formation of bone tissue, which lasts about 6 months. The degradation process of PLA would be longer than the time required for bone formation and would not negatively impact bone development because it does not create toxic compounds.

6. **Monitoring vital signs using multiple pulse radars**

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BACKGROUND: Contactless vital measurements using electromagnetic (EM) radar technology are gaining popularity due to unobtrusiness and decreasing costs of the technology. In this research, monitoring of breathing and heart rate using multiple pulsed radars was evaluated by measuring movements of chest during respiration for breathing rate measurement and pericardial pulsations for heart rate measurement.

OBJECTIVE: Evaluation of the feasibility of multiply pulsed radar setup for vital signs monitoring.

METHODS: Five A121 pulsed coherent radar sensors (Acconeer AB, Malmö, Sweden) were used for radar array setup. Radar signal phase change was extracted from each radar and signal was processed with signal processing algorithms and compared to reference measurement. Signals were acquired from 15 volunteers sitting on the chair at a distance of 1.5 m, resulting of 30 signals of 60 seconds duration, before and after physical exercise.

RESULTS: The respiratory rhythm study show a value of Pearson's correlation coefficient equal to 1; mean square error equal to 0.24 breaths/min; standard deviation 0.24 breaths/min; repeatability (1.96 SD) of 0.46 breaths/min or 3.1%; coefficient of variability 1.6%. Heart rate measurement results show a Pearson correlation coefficient value equal to 1; mean square error equal to 0.91 bpm; standard deviation 0.88 bpm; repeatability (1.96 SD) of 1.7 bpm or 2.5%; coefficient of variability 1.3%.

CONCLUSIONS: With test subject at rest and using multiple radar setup there is possibility to choose the best quality signal for vital signals detection. Radar signals that do not represent satisfactory vital signs results contain information about human movements and can be included as a noise source for adaptive signal processing to improve the signal–to–noise ratio of vital signs signatures in radar signals.

7. Improvement of the rheological properties of mucin–based gels by the addition of polysaccharides

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BACKGROUND: Among prosthesis users and immunocompromised patients, the oral cavity, especially the mucosa, is prone to mechanical injuries and biofilm–related infections. The primary treatment strategy for these problems is the oral application of antimicrobial lubricating gels with special rheological properties. New–generation gels made from natural mucins have demonstrated outstanding potential for these applications. However, their viscoelastic properties characterized by the storage modulus G' and the loss modulus G" are insufficient. As a result, we investigated the potential of modifying these gels with various types of polysaccharides.

OBJECTIVE: This paper presented studies on the rheological properties of a new generation of mucin–based oral gels. We determined the effect of various rheological modifiers on viscoelastic properties using shear rheometry methods over a wide range of shear amplitude, frequency, and temperature. We used for the prepared gels xylitol, guar gum, xanthan gum, and additives with different percentages of gum arabic, carob gum, and k–carrageenan. We also tested the rheological properties' stability over a week.

METHODS: We conducted a series of rheological tests on a HAAKE Rheostress 6000 rheometer, with a Peltier temperature control system, in a plate–plate arrangement. These tests included dynamic viscosity assessments in the 0.1–200 1/s shear strain rate and amplitude sweep and frequency oscillation tests (at shear strain ranges of 0.001–10 and frequencies of 0.01–10 Hz). We also tested the influence of temperature in the range of 25–55°C. Additionally, we evaluated the contact angle of the surface of polydimethylsiloxane and acrylic prostheses. All these tests were carried out on gels incubated at 4°C for 1, 3, and 7 days.

RESULTS: By incorporating polysaccharides into mucin–based gels, the rheological properties, such as dynamic viscosity, storage modulus, and loss modulus, were significantly improved. The most favorable and synergistic outcomes were observed when combining k–carrageenan and gums, particularly locust bean gum. In addition, the gels demonstrated rheological stability for seven days. The tested gels show reversible changes in temperature changes (from 25°C to 50°C), which is crucial in the context of palliation and real conditions of use in the oral cavity. In addition, the gels demonstrated rheological stability for seven days.

CONCLUSIONS: The rheological properties of mucin–based gels can be modified by adding suitable polysaccharides. This serves as a foundation for advancing these materials' development and suitability for use in the oral cavity.

8. Investigation into physicochemical properties of oxide layers formed on Ti6Al7Nb titanium alloy

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BACKGROUND: Anodizing titanium and its alloys is a commonly used procedure that improves the functionality and durability of prosthetic and orthopedic systems. Appropriate selection of anodizing parameters allows for obtaining nanostructures that significantly affect the surface properties, e.g., increasing the implant's adhesion to the bone.

OBJECTIVE: This work is aimed at the electrochemical oxidation of Ti6Al7Nb titanium alloy and the evaluation of the obtained coatings.

METHODS: Anodizing was performed in 2M H3PO4 with and without adding 0.4% HF. Microhardness, wear, wettability, and corrosion tests were carried out. The *scanning electron microscope was* used to *observe* the microstructure of the samples.

RESULTS: Obtained results show that nanotube structures are rougher and more wettable, which may improve osseointegration and drug delivery capabilities. However, homogeneous anodic coatings offer better corrosion and wear resistance.

CONCLUSIONS: The size of obtained nanotubes depends on the voltage of anodizing process and the phase of the alloy on which they are formed. The α phase is a better substrate for nanostructure growth. As a result, the nanotubes cover entire areas and show a much more regular structure. In the case of the β phase, only grain fragments are occupied, and their arrangement is much more random.

9. Dry EEG and fNIRS Signal Analysis in the Frequency Domain: Case of Study of pain detection during exercises with wearables devices

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BACKGROUND: Pain is an aversive sensory and emotional experience typically caused by actual or potential tissue damage. It is an experience that feels different depending on the person because pain is always a subjective experience influenced by biological, psychological and social factors. Throughout life, people learn the concept of pain. Regarding the expression of pain, there is not only a verbal description, since the inability to communicate does not deny the possibility that a human or non–human animal experiences pain. Previous studies proposed the study of EEG and fNIRS signals for pain detection with pain stimulus.

OBJECTIVE: The objective of this study is to analyze EEG and fNIRS signals in the frequency domain to detect pain moments during exercises.

METHODS: The measurements of the signals are carried out during the performance of different exercises at the same time that painful stimuli are received. To perform the measurements, a portable EEG helmet with dry electrodes (CGX Quick–32r) and a Bluetooth fNIRS device (NIRSport2) are used. Then, signal processing techniques are applied and a a data set has been created in order to apply in the near future machine learning models in order to be able to predict the behavior.

RESULTS: The first results have shown great potential in the ease and precision of recording the signals. Pain has been detected in alpha, beta and theta waves at frequencies between 8 and 70 Hz. The signals of the accelerometer incorporated in the EEG device are used as reference signals to apply filters to possible noises with the movement, being able to clean the signals and subsequently filter the selected waves.

CONCLUSIONS: The proposed analysis together with the devices used to take measurements have great potential for the following stages of the investigation to perform the analysis in real time. Also, there is potential to be able to apply different models of artificial intelligence during the different exercises.

10. The use of international masterclasses as a teaching–learning strategy: educational impact measurement

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BACKGROUND: This paper presents a real experience carried out in the first year of the Biomedical Engineering Degree.

OBJECTIVE: One of the objectives of this degree is to promote internationalization (at the level of communicative and intercultural competence) through different activities that include 2–hour hybrid master classes with international experts, both from research and business.

METHODS: The experiment was carried out with a group of 44 students, 68,2% women and 31,8% men. The methodology followed was: phase 1, 30 minutes of contextualization where the students were guided through a series of internet searches to learn about the speaker's biography, the activity of the company/university/research team where he/she works, and the latest products or publications to be highlighted. In a second phase, students attended a 45–minute talk that included interactive activities through video viewing or online searches. Phase 3 was a questions and answers session followed by phase 4, where they completed a survey of 7 likert–type questions plus an open–ended field for general comments. The questions approached different aspects of the learning design such as content, clarity of instructions, lecturer's expertise, technology used, perception of learning and overall satisfaction.

RESULTS: The results obtained after the evaluation of the first semester show an average of 89 % level of satisfaction through 5 questions and highlights the suggestion of to include more talks by companies in the sector stands out.

CONCLUSIONS: As a conclusion, the level of motivation of the students increases with this type of activities, as well as their interest in carrying out activities in the near future with other foreign centers. This would allow to have promotions of biomedical engineers trained not only at the level of technical competences but also at the level of transversal competence of internationalization that supposes a quick adaptation to business or research environments at international level, as well as to multidisciplinary teams.

11. The effect of the molecular weight of hyaluronic acid on the rheological and tribological properties of artificial synovial fluid

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BACKGROUND: The synovial fluid is responsible for adequately lubricating, moisturizing, and nutritional human joints. This liquid should have appropriate viscoelastic properties and ensure a low coefficient of friction in biotribological systems. Many artificial synovial fluid preparations used in viscosupplementation treatments are based on hyaluronic acid.

OBJECTIVE: This work aimed to evaluate the influence of molecular weight on the functional properties of solutions based on hyaluronic acid.

METHODS: 1% solutions based on hyaluronic acid with five different molecular weights from 50,000 Da to 2 MDa were made. Rheological (viscosity, viscoelasticity), tribological (coefficient of friction, wear assessment), and wettability tests were carried out.

RESULTS: Significant differences were observed in the rheological tests, where the viscosity strictly depends on the molecular weight of the hyaluronic acid. Changing the molecular weight does not affect the coefficient of friction in tribological studies. On the other hand, differences in tribological wear can be noticed.

CONCLUSIONS: The molecular weight of biopolymers is one of the essential parameters in developing new artificial synovial fluids. Using a higher molecular weight of hyaluronic acid increases viscosity and wettability, resulting in less tribological wear.

12. Estimation of the knee joint load using plantar pressure data, measured by smart socks: a feasibility study

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BACKGROUND: Unsupervised sports activities could cause traumas, about 70% of them are those of the low extremities. To avoid traumas, the athlete should be aware of dangerous forces acting within low extremity joints. Research in gait analysis indicated, that plantar pressure alteration rate correlates with the gate pace. Thus, the changes in plantar pressure should correlate with the accelerations of extremities, and with the forces, acting in the joints. Smart socks provide a budget solution for the measurement of plantar pressure. The present paper hypothesizes that this measurement could be used to estimate the load within joints during physical activities.

OBJECTIVE: To estimate the correlation between the plantar pressure, measured using smart socks, and forces, acting in the joints of the lower extremities.

METHODS: The research is case study based. The volunteer performed a set of squats. The arbitrary plantar pressure–related data were obtained using originally developed smart socks with embedded knitted pressure sensors. Simultaneously, the lower extremity motion data were recorded using two IMU, attached to the tight and the ankle, from which the forces acted in the knee joint were estimated. The simplest possible model of knee joint mechanics was used to estimate force.

RESULTS: The estimates of the plantar pressure and knee joint forces demonstrate a strong correlation ($r = 0.75$, $P<0.01$). The established linear regression equation allowed the calculation of the knee joint force using the plantar pressure estimate with an uncertainty of 22%. The accuracy of the classification of the joint force as excessive, i.e., being more than 90% of the maximal force, was 82%.

CONCLUSIONS: The results demonstrate the feasibility of the smart socks for the estimation of the forces in the knee joints. Smart socks therefore could be used to develop excessive joint force alert devices, that could replace less convenient inertial sensors.

13. Testing and evaluation of a prototype of a mobility trainer – verticalizer for children (2 to 7 years) weighing up to 20 kg

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BACKGROUND: The Prototype of mobility trainer – verticalizer is designed to develop existing movements caused by individual physical conditions and disease damage, as close as possible to the natural biomechanics of a healthy person. The aim is to make the equipment comfortable, simple, suitable for everyday use in a variety of environments, from medical institutions to the patient's home, and customizable according to the anthropometric data of the growing child.

OBJECTIVE: To investigate and evaluate the technical characteristics and feasibility of a prototype of a mobility trainer – verticalizer for children (2 to 7 years) weighing up to 20 kg.

METHODS: Empirical research method (anthropometric measurements); quantitative research method (survey); qualitative research method (interviews).

RESULTS: The Prototype of the mobility trainer – verticalizer is suitable for use with children aged 2 to 7 years, although children with various disabilities may have heights, weights and other anthropometric data that fall far below or exceed the healthy standard. The exercise with the use of a Prototype had a positive effect on muscle tone, with a decrease in muscle tone in both the upper and lower limbs. An increased range of motion of shoulder flexion and abduction was observed. In the lower limb, there was an improvement in the range of motion of hip internal and external rotation and the flexion and extension of knee.

CONCLUSIONS: Physiotherapy using mobility trainer – verticalizer had a positive effect on the subject's limb volume and muscle tone, a positive effect on the subject's passive range of motion, and a positive effect on the subject's gross motor function.

14. An application of the scaled–pixel–counting protocol to quantify the radiological features of anatomical structures of the normal tarsal joint in horses

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BACKGROUND: As the high–performance human and equine athletes train and compete at the highest level of effort, the prevention of high–performance–cased disease, such as osteoarthritis (OA), requires knowledge of the anatomy and physiology of subjected bones.

OBJECTIVE: Implementation of the scaled–pixel–counting protocol to quantify the radiological features of anatomical structures of the normal equine tarsal joint as the first step in the prevention of the tarsal joints OA in the high–performance sport horses.

METHODS: A radiographic examination was performed in six cadaverous equine pelvic limbs. The dorso–plantar projection of the tarsal joint was performed using density standard (DS) attached to the radiographic cassette, standard x–ray equipment, and standard diagnostic imaging protocol. On each of the radiographs, pixel brightness (PB) was extracted for each of the ten steps (S1–S10) of DS. On each of the radiographs, seven regions of interest (ROIs) were annotated representing four bones (II TB, II tarsal bone; III TB, III tarsal bone; IV TB, IV tarsal bone; CTB, central tarsal bone) and three joints (PIJ, proximal intertarsal joint; DIJ, distal intertalsal joint; TMJ, tarsometatarsal joint), respectively. For each ROI, the percentage of number of pixels (NP) from each range was calculated.

RESULTS: The % of NP was lower in bones than in joint spaces for S1–S6. The % of NP was also higher in bones than in joint spaces for S8–S10. The % of NP was higher in PIJ than TMJ for S1 and higher in PIJ than DIJ for S4. No differences were found between consecutive bones for all examined steps of DS.

CONCLUSIONS: An application of the scaled–pixel–counting protocol provides the quantitative radiological features of normal bone and joint structures of the tarsal joint in horses making possible differentiation of the lucency of joint space and opacity of bone structure.

15. Design and validation of an optimal mechanical enclosure for low–cost real–time gluten detection using NIR sensor in a portable device

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BACKGROUND: Food allergy, specifically gluten intolerance, is a significant global health issue affecting approximately 7% of the population. Currently, the only effective treatment is a lifelong adherence to a gluten–free diet. Unfortunately, there is no rapid, low–cost, non–invasive testing device available to patients suffering from this disease. The research is carried out in the framework of a research project called TECAM funded by the Basque Government and in collaboration with the leading Leartiker and CEIT.

OBJECTIVE: The overall objective of this research project is to design and implement a technological solution for a widespread use of celiac people, which can query the gluten contamination of a food sample in real time and with a low cost device based on a near infrared (NIR) sensor (DLP NIRscan Nano). This paper focuses on the mechanical design and validation of the sensor's integration into a device that meets the necessary physico–mechanical requirements for optimal NIR spectroscopy.

METHODS: To evaluate the impact of environmental factors on sample acquisition, experiments were conducted to analyze the influence of various disturbances. These disturbances included sensor height, light exposure, device temperature, and sample preparation. The tests utilized the SparkFun AS7263 sensor. The results indicated the importance of minimizing sensor height and external turbulence, necessitating the use of a closed, opaque enclosure that allows the sensor to be as close to the sample as possible. Once the operating conditions for the NIR sensors were discovered, an enclosure was designed using CAD tools. The design was printed using 3D printing technology. Two assessments were used to validate the design: „Software Usability Scale" (SUS) and „USE Questionnaire: Usefulness, Satisfaction, and Ease of Use".

RESULTS: Twenty prototypes were printed during the iterative design process. The final design successfully accommodates the DLP NIRscan Nano in a sleeve attached to a joint, enabling easy sample extraction with a single movement. The device aligns with the design 4 all philosophy while ensuring optimal sensor operation.

CONCLUSIONS: This study developed a low–cost, portable mechanical design for integrating a NIR sensor to detect gluten in food samples. The experiments emphasized the need to minimize environmental disturbances to obtain accurate measurements,

leading to the validated final design. User feedback was utilized to enhance the device's usability, resulting in an accessible and practical tool for celiac sufferers to quickly and non–invasively assess gluten contamination in their food.

16. Parkinson's disease classification with CWNN: using wavelet transformations and IMU data fusion for improved accuracy

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BACKGROUND: Parkinson's Disease (PD) is a chronic neurodegenerative disorder characterized by motor impairments and other symptoms. Early and accurate classification of PD patients is crucial for timely intervention and personalized treatment. Inertial measurement units (IMUs) have emerged as a promising tool for gathering movement data and aiding in PD classification.

OBJECTIVE: This paper proposes a Convolutional Wavelet Neural Network (CWNN) approach for PD classification using IMU data. CWNNs have emerged as effective models for sensor data classification. The objective is to determine the optimal combination of wavelet transformation and IMU data type that yields the highest classification accuracy for PD.

METHODS: The proposed CWNN architecture integrates convolutional neural networks and wavelet neural networks to capture spatial and temporal dependencies in IMU data. Different wavelet functions, such as Morlet, Haar, Mexican Hat and Daubechies, are employed in the continuous wavelet transformation (CWT) step. The CWNN is trained and evaluated using various combinations of accelerometer data, gyroscope data, and fusion data.

RESULTS: Extensive experiments are conducted using a comprehensive dataset of IMU data collected from individuals with and without PD. The performance of the proposed CWNN is evaluated in terms of classification accuracy, precision, recall, and F1–score. The results demonstrate the impact of different wavelet functions and IMU data types on PD classification performance, revealing that the combination of Morlet wavelet function and IMU data fusion achieves the highest accuracy.

CONCLUSIONS: The findings highlight the significance of combining Continuous Wavelet Transformation (CWT) with IMU data fusion for PD classification using CWNNs. The integration of CWT–based feature extraction and the fusion of IMU data from multiple sensors enhance the representation of PD–related patterns, leading to improved classification accuracy. This research provides valuable insights into the potential of CWT and IMU data fusion for advancing PD classification models, enabling more accurate and reliable diagnosis.

17. Instability level and sensory information interactions for human postural control adaptation

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BACKGROUND: Human postural control (PC) is crucial for maintaining balance and depends on the central nervous system (CNS) integrating sensory inputs. Understanding CNS adaptability to varying instability levels (IL) under changing sensory conditions is vital for human balance assessment and rehabilitation.

OBJECTIVE: This study aimed to examine the effect of sensory information quantity on postural control maintenance across different instability levels.

METHODS: Twenty–five voluntary healthy participants (12 men, 13 women, 24.5 ± 6.1 years) performed balance tasks on Abili® platforms with adjustable ILs (1, 2, 3) and stable background (0IL). Participants stood with eyes open (EO) and closed (EC) to alter sensory information. PC efficiency was assessed by measuring chest movement›s 95‘th CI ellipsoid volume and average velocity. Statistical comparisons were made using Wilcoxon signed–rank tests and Cliff›s delta effect size.

RESULTS: The influence of instability levels on chest volume and average velocity was notably amplified in the EC, especially at higher IL. However, in the low instability range (0IL to 1IL), the differences were not as pronounced even EC. For instance, when comparing 0IL to 2IL, chest volume increased from 179.46 cm^3 to **771.59** cm^3 (EO) and 186.05 cm^3 to **3213.84** cm^3 (EC). Similarly, average velocity increased from 0.78 cm/s to 1.07 cm/s (EO) and 0.86 cm/s to 2.20 cm/s (EC). Statistically significant differences were observed between 0IL–1IL and 1IL–2IL in both groups. The Cliff›s effect size was larger in the EC group across all IL. However, no difference was found between 2IL–3IL in both groups.

CONCLUSIONS: Sensory information significantly influences the effects of ILs on PC maintenance. These findings have practical implications for balance training and rehabilitation, optimizing CNS adaptability and improving balance maintenance with varying ILs and sensory input conditions.

18. Functional analysis of the new design of the temporomandibular joint implant

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BACKGROUND: The temporomandibular joint (TMJ) is made up of two bony elements, the mandibular fossa (acetabulum) and the head of the mandible. Pathogenic factors, and precisely their effect on the temporomandibular joint, can cause inflammatory processes not only in adulthood, but also during the development of the child. Inflammation can affect individual elements of the joint, the entire joint or the joint together with the muscular apparatus. The harmful effects of pathogenic factors can disrupt the proper development of the temporomandibular joints.

OBJECTIVE: In order to restore the proper functioning of the temporomandibular joint, implants are used. The paper presents a proposal for a new design of the temporomandibular joint implant.

METHODS: In order to verify the correctness of the designed structures, tests using computer methods were used. For this purpose, 3D models of the endoprosthesis structure and bone tissues (skull and mandible) were designed. Which were then subjected to numerical analysis using the FEM method.

RESULTS: As a result of FEM analyses, reduced stress distributions according to the Huber–Mises hypothesis were obtained. The distribution of the safety factor was determined and a modification of the plate fixing the implant to the bone was proposed.

CONCLUSIONS: The designed structure is a new alternative to the implants present on themarket. The conducted analyzes allow to predict its greater functionality and durability.

19. The NVIDIA Xavier AGX based biomechanical feedback assessment system using neural networks

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BACKGROUND: Biomechanical feedback assessment systems are used more widely in different areas such as medicine, physiotherapy, and sports training. However, they are mostly stationary and quite expensive. Using many synchronised camera systems or sensors attached to the human body in certain places, it is possible to transform the human body pose scanned data into human movements described by biomechanical equations, which can further be evaluated by doctors, physiotherapists, or sports trainers.

OBJECTIVE: The aim of this work was the creation of a compact, easily transportable, and adjustable biomechanical feedback assessment system with functionality like that of a stationary system, which would then be accessible to a wider list of target users.

METHODS: To date, a prototype of such a device has already been created using the Intel Realsense D435 spatial 3D video camera, NVIDIA Xavier AGX artificial intelligence accelerating computing module, human body 2D segmentation software, and the unique Python 3 App we have created that combines visual sensor, computational module, and neural network software.

RESULTS: The developed prototype gives a numeric output of 18 main points characterising the human pose in C3D format, which allows the obtained observation results to be analysed using Mokka software or self–developed software for joint angles calculation.

CONCLUSIONS: The algorithmically obtained human upper limb angles calculated from human body pose joints coordinates were compared and validated with the corresponding angles obtained by the BTS Engineering motion measurement system.

20. Comparison of heating rates at the proximal phalanx of fingers and palm in rheumatoid arthritis and healthy subjects

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BACKGROUND: Thermography is a non–invasive imaging technique that has been used for the assessment of rheumatoid arthritis (RA).

OBJECTIVE: The purpose of this research was to compare the heating rate phalanx proximal of the fingers and the whole palms in RA and healthy subjects.

METHODS: The study was conducted on 50 patients with high disease activity hospitalized for RA and 45 healthy subjects. The thermograms were taken with the FLIR camera E60bx. Subjects were instructed to immerse both hands up to the wrist in water thermostatically controlled at 0°C for 30 s Then the hands were pulled out of the water; the warm–up period was 180 sec. Thermograms were used to study the affected joints, which are typically the hands in RA patients. Image pre–processing included: segmentation, extraction, and anatomy identification.

RESULTS: The mean value of the heating rate for whole palms and the phalanx proximal in the RA group was lower than in the control group ($p<0.05$). This coincides with the uneven flow of the heat–transfer blood caused by the disease. The difference in heating rate of the phalanx proximal was greater than that of the entire hand. In addition, the phalanx heating rates of the 2nd, 3rd, and 4th fingers were higher than those of the outermost two fingers, as expected based on the anatomical images.

CONCLUSIONS: The study may lead to a better understanding of the inflammatory process in RA patients.

21. **DNA–based rheological model of microbial biofilm**

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BACKGROUND: DNA has evolved to carry genetic information and serve as a structural biopolymer in various extracellular substances, including microbial biofilms that form in some body fluids such as pus and cystic fibrosis sputum. The DNA concentration in these structures can range from 0.2 to 20 mg/mL, which is thought to contribute significantly to biofilm remodeling and drug resistance. In terms of mechanobiology, it is intriguing to consider how the composite structure of biofilms, including cells and DNA, influences their mechanical properties.

OBJECTIVE: The research aimed to determine how the structural features of DNA–cell composites, such as the state of DNA cross–linking or the total volume of cellular components, affect the rheological properties.

METHODS: To analyze the connection between biofilms' structure and mechanical behavior, a model involved in integrating microbial cells and cell–mimicking dextran beads into DNA hydrogels was developed. The viscoelastic properties of DNA–cell composites were then examined using shear rheometry, specifically the storage modulus G' and the loss modulus G", at varying levels of normal pre–stress.

RESULTS: It has been shown that the rheological properties of DNA–cell composites depend both on the DNA structure and the volume and type of cellular components. Cross–linked DNA is characterized by higher values of G' and G" modules than non–cross–linked DNA, which translates into higher mechanical properties of the tested composites. The higher the volume concentration of cellular components (up to 50%), the higher the mechanical properties of the composites. Moreover, higher viscoelastic modulus values were observed with dextran beads incorporated than with *C. albicans* cells. For composites containing nothing or a small amount (up to 10%), we did not observe the compression–stiffening effect characteristic of biofilms. In comparison, this effect was visible for composites with a higher content of cellular components (30–50%) – both with non–crosslinked and crosslinked DNA.

CONCLUSIONS: DNA–based models confirmed that DNA has a significant influence on the rheological properties of biofilms. This finding provides insight into potential therapeutic strategies to combat biofilms by targeting DNA to disrupt its structural integrity. In addition, these models can be used to study other mechanical and structural aspects of biofilms.

22. Real–time Evaluation of Dynamic Parameters in Physical Exercise Using Biomechanical Model–Based System

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BACKGROUND: Real–time motion analysis is crusial in managing neurological and orthopedic disorders. It offers immediate feedback to therapists and patients, creating opportunities for real–time interaction with biomechanical data during examination and treatment. Real–time assessment of dynamic movement parameters like muscle force or joint torque in rehabilitation can provide useful information to rehabilitation staff without using excessive amounts of devices, as well as ensuring a quick and clear response from doctors, without the need to perform an assessment with preliminary data.

OBJECTIVE: The objective of this article is to explore the development and implementation of a biomechanical model–based system that enables real–time evaluation of dynamic parameters during physical exercise.

METHODS: Biomechanical data was collected in real–time using inertial sensors during standartized exercise protocols. A simplified upper extremity biomechanical model was developed and validated for the exercise movements, considering joint angles, segment lengths, and anthropometric measurments. A real–time evaluation system was implemented in MATLAB to process and analyze the collected data. The system computed dynamic parameters such as joint forces during the exercise, while the input to the model was kinematic data collected from inertial sensors. The collected data were analyzed using statistical tests to evaluate the system's performance and the relationships between dynamic parameters and exercise performance.

RESULTS: The findings of the study, including the performance of the real–time evaluation system and its implications for clinical practice, rehabilitation, and future research, were presented. Limitations were addressed, and recommendations for further improvement and investigation were provided. Such system creation and evaluation allow to evaluate the system in real time by creating 2000 frames per seconds with less than 4 ms of delay. The purpose of this report is to present the system and its development steps, which make the system as detailed as possible and reduce the delay time compared to the systems already analyzed in the literature. This system has strong potential in modern rehabilitation practice using personalized musculoskeletal models.

CONCLUSIONS: Systems of this type allow evaluation and measurement to obtain kinematic and dynamic measurements of muscles and joints. By improving such systems, reducing the delay, and increasing the number of measurements, an increasingly accurate system is obtained.

23. Properties of implants for the treatment of chest deformities made of 316 LVM steel with a nitrocarburized layer

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BACKGROUND: Implants made of 316 LVM steel when adjusted to the anatomical curvatures of bone fractures may be exposed to mechanical damage of the surface what can lead to reduction of corrosion resistance. This leads to the release of ions of steel elements, leading to allergies or inflammation. Increasing the barrier properties of the surface can be achieved by using a technology combines the process of low–temperature nitriding and carburization in a low–temperature plasma.

OBJECTIVE: The main aim of the study was to investigate the influence of the nitrocarburizing process carried out in the low temperature plasma using the active screen at 420°C on the physicochemical properties of the 316LVM steel used for anterior chest wall deformities treatment. The samples were tested after sterilization, and exposure to Ringer's solution, respectively.

METHODS: In order to the evaluation of the layer produced, the following tests were carried out: potentiodynamic test for pitting corrosion, the potentiostatic test for crevice corrosion, surface wettability and electrochemical impedance spectroscopy was conducted.

RESULTS: More favorable electrochemical properties were obtained for the surface with a layer after sterilization. Exposure to Ringer's solution reduced the resistance to pitting and crevice corrosion. Based on the EIS results, it was found that the sterilization process resulted in the formation of two sublayers – compact inner and porous outer one with greater porosity and tightness. Obtaining a hydrophilic character of the surface with low wettability is a favorable phenomenon for short–term implants.

CONCLUSIONS: The formation of a diffusion layer has a beneficial effect on the physicochemical properties of the implant surface. In the next stages, fatigue tests of the layer should be carried out to determine the possible decohesion process during cyclic loading, biological tests, and tests in clinical conditions.

24. **The use of 3D printing to develop a silicone orthopedic insole**

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BACKGROUND: Nowadays, many people lead an active lifestyle, which is the reason why foot protection is becoming a key element of healthcare and comfort. Silicone orthopedic insoles are becoming a popular solution that can effectively reduce cushioning and relieve pain caused by disc herniation. The use of 3D printing will make it possible to precisely adjust the insoles to the anatomical features of the patient's foot. Flexible and shock–absorbing insoles have the ability to reduce the load on the feet, minimizing the risk of injury and bringing relief when walking or running for a long time.

OBJECTIVE: The aim of the work is to present the possibility of using 3D printing technology to obtain a silicone orthopedic insole. Silicone insoles made by 3D printing can be designed taking into account different areas of support, correction of posture defects and reduction of pressure on problem areas of the foot.

METHODS: The shape and structure of the silicone insole was developed in the SolidWorks software. The prototypes of the inserts were printed on the F–NIS printer (Sygnis). The insole prototype was made of two types of silicone with different rheological properties.

RESULTS: Microscopic observation of 3D printed insole prototypes showed that the structure is homogeneous and there are no gaps between the printing paths. It was noticed that the print paths were not of the same width, which may be due to the change in printing pressure during the process. Uneven paths were visible in places where the relief structure was designed.

CONCLUSIONS: An orthopedic insole with a variety of structures in the relief parts was developed. A prototype of a relieving orthopedic insole was made using 3D printing. The use of 3D printing enables the creation of an individual orthopedic insole with a variety of structures.

25. **Prevention of stomatitis in relation to modern prosthodontics**

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BACKGROUND: Removable partial dentures (RPDs) are a group of prosthetic restorations that supplement missing teeth and damaged tissues of the prosthetic base in the maxilla and mandible supported by periodontium and mucosa, where the advantage of one or the other component depends on the quality, distribution and quality of the pillars. The transmission of chewing forces through the periodontium is considered the most physiological of due to the propri–receptive nature of neuromuscular control and the reduction of the component burdening the toothless alveolar processes. The aim of that kind of reconstruction is not only to restore the proper functionality of the stomatognathic system and aesthetics, but also to have a preventive effect aimed at maintaining the natural biological conditions and biomechanical balance for as long as possible. Initially, RPDs were produced from and cast metal alloys using the lost–wax technique. Digital production, computer–aided design and digital milling and printing manufacturing techniques have become prevalent and is gaining popularity due to its various advantages such as improved quality and faster manufacturing. The specificity of the oral cavity environment determines the requirements to be met by prosthetic restorations – including high corrosion resistance and good mechanical properties. One of the basic materials used for the production of prosthetic restorations, with many advantages, are cobalt–chrome alloys.

OBJECTIVE: Assessment of the impact of manufacturing conditions using the low–temperature atomic deposition process of the ZrO2 coating on the surfaces of cobalt–chrome alloys on the safety of use in the oral environment. The formation of a zirconium dioxide coating on the substrates of cobalt alloys for contact with the oral cavity environment has not been reported in the literature yet.

METHODS: A properly selected research program that allowed for a full characterization of the biomaterials of the substrate, the coating produced and the processes occurring on the surface of prosthetic products after their introduction into the oral cavity, e.g. microstructure of the substrate and the surface layer (phase composition of the surface layer), electrochemical and physical properties, evaluation of the tolerance of the set and real geometry as well as microbiological testing.

RESULTS: The obtained results were the basis for recognizing the use of zirconium oxide on the surfaces of cobalt prosthetic devices as a promising strategy reducing the accumulation of bacterial biofilm to the surface, and at the same time safe for the human body.

CONCLUSIONS: The creation of an adhesive surface layer with favorable electrochemical and physical properties, in the light of the new Regulation MDR 2017/745 of the European Union, may affect the justification for the use of cobalt alloys in the environment of the stomatognathic system.

26. **Feasibility study of non–invasive analysis of the bioelectrical impedance**

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BACKGROUND: This study explores the practical application and impact of bioimpedance analysis in mobile devices for monitoring human health.

OBJECTIVE: The objective of the study is to propose a feasible application of noninvasive bioimpedance analysis by using the tetrapolar electrode connection method and the Cole–Cole model.

METHODS: Bioimpedance measurements and calculation of electrical parameters are performed using ANSYS HFSS software for theoretical calculations and digital signal processing technology for real–time measurements using hardware devices. The study focuses on a model of the front arms, including tissues such as bone, fat, muscles, arteries and skin, with glucose concentrations as test cases.

RESULTS: The simulated characteristic impedance with the ANSYS HFSS software package at 125 kHz varied from 315.8 Ω to 312.6 Ω, and the measured forearm characteristic impedance with hardware varied from 150.1 Ω to 151.3 Ω. The measured characteristic impedance when the heart is in systole and diastole also differed, with a difference of about 0.85% of the maximum impedance measured.

CONCLUSIONS: The study demonstrates the potential of noninvasive bioimpedance analysis to address health issues such as obesity and heart disease. It also highlights its usefulness as a non–invasive alternative for measuring glucose concentration in diabetic patients, reducing the risk of infection. The findings indicate the feasibility of using bioimpedance analysis in mobile devices for health monitoring purposes.

27. **Rheology measurements as a tool for biomimetic materials design**

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BACKGROUND: Over the last years, many efforts have been oriented toward the development of suitable biomaterials for biomedical engineering applications. A multidisciplinary testing approach includes mechanical, physicochemical, tribological, biological, and microscopy research of functional biomaterials, drug delivery systems, nanomaterials and biomimetic materials. Health engineering encompasses the study of those materials called soft matter, where rheological tests are of great interest, especially both elastic and viscous behaviours exhibited by the materials for tissue engineering, regenerative medicine, cell therapy, synthetic fluids and modified gels. A significant factor in the designing of such materials is the appropriate selection of the components, i.e. the matrix and filler that will modify the rheological properties of the material in order to obtain the most biofunctional properties. An important role in obtaining the appropriate properties is played by the type, concentration and shape of both of the above components.

OBJECTIVE: The aim of the work is the assessment of rheological properties of hydrogels and elastomers materials with/without magnetic field, taking into account the complex magnetorheological properties of modified elastomers.

METHODS: Polysaccharide–based naturally derived polymers, magnetorheological gels as well as silicone–based composites were tested in this study. The HAAKE Rheostress 6000 rheometer (Thermo Scientific, USA), with a Peltier temperature control system, and reometer with magnetic cell (Anton Paar, Austria) in a plate–plate arrangement, were used. For hydrogels, tests included dynamic viscosity assessments in the 0.1–200 1/s shear strain rate, amplitudę sweep and frequency oscillation tests. For elastic composites, the tests include a quantitative analysis of the frequency dependence of magnetically induced dynamic shear modules.

RESULTS: Mucin–based gels, modified by different polysaccharides enhanced their viscoelastic properties, which is of high significance when consider lubrication between mucosa and prosthesis during their oral applications. The major challenges in the field of oral gels are to mimic structures existing in natural saliva with different components and their concentration. Especially, it allows reproducing the functions of the biological system and obtaining appropriate biofunctional properties by rheologically controlled process of components selection. Some synergistic effect between different ingredients were also observed, which is important from both biologic and economic

point of view. In the case of magnetically–contolled composites, it was observed that the magnetic flux density influence on G' and G" modules. What more, some differences between non–modifeied and Surface modified composites were stated.

CONCLUSIONS: The rheological tests play a decisive role in testing materials and might be a good tool for designing new biomaterials with controlled morphology and shear–thinning behavior in well–defined conditions.

28. Study of foot support during gait in healthy children from neighbouring countries

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BACKGROUND: Healthy children's gait support patterns play a critical role in their development and overall well–being. Therefore, in order to develop a correct gait, it is necessary to constantly update knowledge.

OBJECTIVE: To identify differences in gait support among children in neighbouring countries.

METHODS: 44 healthy children from Poland and Lithuania (4–11 years old) participated in the study. The spatiotemporal and plantar pressure parameters of 88 neutrally aligned feet were analysed and compared.

RESULTS: Statistically significant differences between stance, single–limb support, double support, swing duration, cadence, and velocity, max. force and pressure in the forefoot, as well as in the times of occurrence of max. forces in all three zones. Defined that age is related ($p<0.05$) to cadence ($R=0.32$), swing phase ($R=0.53$), max. force under the midfoot ($R=0.35$) and the heel ($R=0.47$), max. pressure under the forefoot ($R=-0.52$), midfoot ($R=-0.63$) and heel ($R=-0.47$).

CONCLUSIONS: The results can help caregivers, as well as clinicians and researchers, understand how gait mechanics change with development and the growth course of the children of that country. Also, the results are important for the analysis and comparison of children's gait, as control reference data from the same country.

29. Application of convolutional gaited recurrent units u–net for classification of retinitis pigmentosa

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BACKGROUND: Retinitis Pigmentosa (RP) is a group of inherited retinal diseases characterized by the progressive dysfunction of rod and cone photoreceptors in the retina. The majority of cases are inherited in Mendelian patterns, namely as autosomal dominant (30–40% of cases), autosomal recessive (50–60%), or X–linked (5–15%) inheritance. Artificial Intelligence has gained a prominent role for medical purposes. The rapid development of computer science fields has caused that it has become a meaningful part of modern healthcare. Image–based analysis involving neural networks is a very important part of eye diagnoses.

OBJECTIVE: The main contribution of this study is to classify the Retinitis Pigmentosa. Three classes were defined: healthy cases, cases with cone–rod dystrophy (CORD) and cases with RP on the periphery of an eye.

METHODS: The Convolutional Gaited Recurrent Units (GRU) U–Net was created for RP classification. The dataset, gathered in the Chair and Department of General and Pediatric Ophthalmology of Medical University in Lublin, consisted of 230 ultra–widefield images. For the purpose of applying deep learning classification, the dataset was artificially enlarged using augmentation involving image manipulations. The final dataset contained images: 264 for healthy persons, 240 for patients with RP and 240 for patients with CORD.

RESULTS: A series of experiments were performed considering a random split of the data into training and testing sets: 80% and 20%, respectively. To reduce the randomness of the results, 10 iterations were performed independently. The mean accuracy exceeds 94%, the mean precision 95%, the mean sensitivity 93%, the mean specificity 92%, and the mean F1 score 94%.

CONCLUSIONS: The developed Convolutional GRU U–Net has a great potential in practical software implementation to diagnose RP diseases as a supporting tool. It may help to decrease time of diagnoses. It also may give the recommendations for further treatment.

30. Quantitative assessment of the effect of instability levels on reactive human postural control using different sensory organization strategies

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BACKGROUND: Reactive postural control (RPC) is crucial for maintaining human balance and utilizes visual, vestibular, and proprioceptive sensory inputs. Traditional rehabilitation methods often inadequately address balance challenges in real–world scenarios. This research evaluates the combined effects of instability levels (ILs) and sensory integration strategies (SIS) on RPC without external force application.

OBJECTIVE: To understand the influence of varied ILs and SIS on RPC.

METHODS: 25 participants (mean age 24.5, SD=6.1) executed balance tasks on Abili® platforms with ILs ranging from 0 (stable) to 3. Sensory integration was modified using the mCTSIB, encompassing Basic, Visual, Proprioception, and Vestibular strategies. RPC efficiency was gauged via chest movement's ellipsoid volume and velocity, with statistical analysis via Wilcoxon signed–rank tests and Cliff's delta.

RESULTS: Chest movement velocity increased 256% transitioning from Basic to Vestibular strategy at 0IL, and 462% at 3IL. The largest increase, approximately 580%, was seen from Basic at 0IL to Vestibular at 3IL. Chest movement volume rose by 386% moving from Basic at 0IL to 3IL, with an exponential 7176% increase from Basic at 0IL to Vestibular at 3IL.

CONCLUSIONS: RPC is profoundly impacted by platform instability and reduced sensory input, notably under the Vestibular strategy and heightened instability. Different IL and SIS combinations can intentionally destabilize postural control, presenting a wide adjustment range for instability sensation. Even young healthy subjects can find it challenging to maintain balance under certain conditions.

31. **Automatic method of macular diseases detection using deep CNN–GRU network in OCT images**

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BACKGROUND: The increasing development of Deep Learning mechanism allowed ones to create semi–fully or fully automated diagnosis software solutions for medical imaging diagnosis. The convolutional neural networks are widely applied for central retinal diseases classification based on OCT images.

OBJECTIVE: The main aim of this study is to propose a new network, Deep CNN–GRU for classification of early–stage and end–stages macular diseases as age–related macular degeneration and diabetic macular edema (DME).

METHODS: Three types of disorders have been taken into consideration: drusen, choroidal neovascularization (CNV), DME, alongside with normal cases. The created automatic tool was verified on the well–known Labeled Optical Coherence Tomography (OCT) dataset. For the classifier evaluation the following measures were calculated: accuracy, precision, recall, and F1 score. Based on these values, it can be stated that the use of a GRU layer directly connected to a convolutional network plays a pivotal role in improving previously achieved results. Additionally, the proposed tool was compared with the state–of–the–art of deep learning studies performed on the Labeled OCT dataset.

RESULTS: The Deep CNN–GRU network achieved high performance, reaching up to 98.90% accuracy. The average precision for each class surpasses 96%, ranging between 92% and 98%. The average recall surpassed 97%, with individual values falling within the range of 92.06% to 99.82%. The F1 score, calculated based on precision and recall, yielded high results with a mean value exceeding 94%. The proposed tool demonstrated its highest accuracy in recognizing NORMAL cases. It performed slightly worse for cases with DRUSEN, CNV and DME.

CONCLUSIONS: Proposed Deep CNN–GRU has a great potential in practical software implementation to diagnose macular diseases as a supporting tool. The obtained results of classification performance place the tool as one of the top solutions for diagnosing retinal diseases, both early and late stage.

32. **Automatic gender and unilateral load state recognition for biometric purposes**

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BACKGROUND: Automatic recognition of a person's gender as well as his or her unilateral load state are issues that are often analyzed and utilized by a wide range of applications. For years scientists have recognized human gait patterns for purposes connected to medical diagnoses, rehabilitation, sport, or biometrics.

OBJECTIVE: The present paper makes use of ground reaction forces (GRF) generated during human gait to recognize gender or the unilateral load state of a walking person as well as the combination of both of those characteristics.

METHODS: To solve the above–stated problem parameters calculated on the basis of all GRF components such as mean, variance, standard deviation of data, peak–to–peak amplitude, skewness, kurtosis, and Hurst exponent as well as leading classification algorithms including kNN, artificial neural networks, decision trees, and random forests, were utilized. Data were collected by means of Kistler's force plates during a study carried out at the Bialystok University of Technology on a sample of 214 people with a total of 7,316 recorded gait cycles.

RESULTS: The best results were obtained with the use of the kNN classifier which recognized the gender of the participant with an accuracy of 99.37%, the unilateral load state with an accuracy reaching 95.74%, and the combination of those two states with an accuracy of 95.31% which, when compared to results achieved by other authors are some of the most accurate.

CONCLUSIONS: The study has shown that the given set of parameters in combination with the kNN classifying algorithm allows for an effective automatic recognition of a person's gender as well as the presence of an asymmetrical load in the form of a hand–carried briefcase. The presented method can be used as a first stage in biometrics systems.

33. Numerical modelling of an orthopedic brace with increased functional characteristics for the treatment of idiopathic scoliosis

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BACKGROUND: Orthotic braces play a key role in medical biomechanics, particularly in the correction of spinal deformities. The effectiveness of these devices largely depends on the choice of material, design and distribution of corrective forces transmitted through the corset shell.

OBJECTIVE: The present study aimed to improve the functional characteristics of the brace while maintaining its corrective function.

METHODS: A model of a brace shell was used for the study. The distribution of corrective forces transmitted by the orthosis was evaluated using the finite element method (FEM). The distribution of force flow lines in the corset shell was determined using the plotted trajectories of maximum principal stresses. Areas of the orthosis, which had minimal impact on the overall stiffness, were identified and material from these areas was removed. The modified orthosis shell was subjected to minor adjustments to maintain its corrective stiffness.

RESULTS: With the modifications made, a 39% reduction in the weight of the orthosis was achieved, while maintaining its corrective stiffness. The distribution of shell displacements under corrective loads in the transverse plane showed only very slight changes compared to the original design, indicating that the corrective function was largely preserved.

CONCLUSIONS: The study provides a novel approach to orthosis design demonstrating that optimizing the structure using the distribution of maximum principal stress trajectories can significantly improve the functionality of the brace. The proposed method offers potential advances in the design of various types of orthoses, contributing to developments in the field.

34. Exploring the impact of body mass change on the functioning of the muscular system during daily activities

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BACKGROUND: Correct body weight is one of the factors that allows you to maintain a properly functioning body for years. Underweight, overweight or obesity can cause various diseases, i.e., diabetes, hypertension or arthritis. Abnormal body weight can also cause disorders in the functioning of the human musculoskeletal system, as well as the cause of the appearance of functional limitations.

OBJECTIVE: The aim of the present study was to determine the effect of mass change on the functioning of the muscular system during daily activities.

METHODS: The evaluation of musculoskeletal functioning was based on the results of computer simulations conducted in the AnyBody Modeling System. The following activities were analysed: standing, sitting down and getting up from a chair, holding and lifting an object, and walking. The simulations of the analysed activities were carried out by changing body mass in the range of 50kg to 100kg with a step of 2kg, making it possible to map different nutritional status from excessive thinness to extreme obesity. The simulations made it possible to determine the value of muscle fatigue and the level of muscle activity.

RESULTS: For activities, i.e., standing, sitting down and getting up from a chair, and walking, it was observed that the value of muscle fatigue increases with increasing body mass. However, for activities that are more loaded on the musculoskeletal system, i.e. lifting and holding an object, the highest value of muscle fatigue was observed in underweight individuals.

CONCLUSIONS: The change in body mass alters the functioning of the muscular system and thus the ability to perform activities. In the present study, it was shown that in underweight, overweight or obese people, abnormal body mass can be the reason for the appearance of difficulties in performing the activities of lifting and holding a 20 kg object, as well as walking

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35. Prediction of exam scores using multi–sensor approach for wearable exam stress dataset with uniform preprocessing

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BACKGROUND: This paper investigates the prediction of grades using physiological signals, employing various models and feature selection techniques. The study involves a feature vector comprising 301 distinct features extracted from seven signals, laying the groundwork for the investigation.

OBJECTIVE: The primary objective of this research is to explore the effectiveness of physiological signals in predicting grades and to assess the impact of different models and feature selection techniques on predictive performance.

METHODS: To achieve our objective, we extract a comprehensive feature vector from seven signals and implement a uniform preprocessing technique for all signals. In addition, we analyze different algorithmic selection features to design relevant features for robust and accurate predictions.

RESULTS: The study reveals promising results, with the highest scores achieved using 100 and 150 features. The corresponding values for accuracy, AUROC, and F1–Score are 0.9, 0.89, and 0.87, respectively, indicating the potential of physiological signals for accurate grade prediction.

CONCLUSIONS: The findings of this study suggest practical applications in the field of education, where the use of physiological signals can help students cope with exam stress and improve their academic performance. The importance of feature selection and the use of appropriate models highlight the importance of engineering relevant features for precise and reliable predictions.

36. Assessment of the disease severity in patients hospitalized for COVID–19 based on the National Early Warning Score (NEWS) using statistical and machine learning methods: an electronic health records database analysis

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BACKGROUND: The coronavirus disease (COVID–19) was a cause of concern in healthcare system and increased the need for disease severity indicators. However, they still vary in use to evaluate in–hospital outcomes and severity. National Early Warning Score (NEWS) is routinely used to evaluate patient health status at the hospital. Further research is needed to ensure if NEWS can be a good instrument for an overall health status assessment with or without additional information like laboratory tests, intensive care needs, the history of chronic diseases.

OBJECTIVE: To evaluate if NEWS can be an indicator to measure COVID–19 patient status in–hospital.

METHODS: We used fully anonymized Electronic Health Records (EHR) characterizing patients admitted to the hospital with COVID–19 disease. Data was obtained from Vilnius University Hospital Santaros Klinikos EHR system (SANTA–HIS) from 01–03–2020 to 31–12– 2022. The study sample included 3875 patients. We created several statistical and machine learning models for discrimination between inhospital death/discharge for evaluation NEWS as a disease severity measure for COVID–19 patients. In these models, two variable sets were considered: median

NEWS and its combination with clinical parameters and medians of laboratory test results. Assessment of models' performance was based on the scoring metrics: accuracy, sensitivity, specificity, area under the ROC curve (AUC), and F1–score.

RESULTS: Our analysis has revealed that NEWS predictive ability for describing patient health status during the stay in the hospital can be increased by adding the patient's age at hospitalization, gender, clinical and laboratory variables (0.853 sensitivity, 0.992 specificity and F1–score – 0.859) in comparison with single NEWS (0.603, 0.995, 0.719, respectively). A comparison of different models showed that stepwise logistic regression was the best method for in–hospital mortality classification. Our findings suggest employing models like ours for advisory routine usage.

CONCLUSIONS: Our model demonstrated incremental value for COVID–19 patient's status evaluation.

37. **Automatic diagnostics using deep learning methods**

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BACKGROUND: The application of rapid diagnostics to accelerate patient treatment remains a challenge of modern medicine. The use of deep learning methods for feature extraction and patient classification provides the opportunity to conduct rapid diagnosis of diseases that affect the entire population.

OBJECTIVE: The goal of the work was to create a system that would recognize widely occurring infectious diseases with similar syptoms with high accuracy.

METHODS: The study created classification models using deep learning methods to classify healthy, COVID–19 and viral influenza patients based on chest X–rays. In this study, two classification models were created, differing in the method of feature extraction obtained during X–ray examinations. Applied manual and automatic feature extraction methods to build the most efficient classifier.

RESULTS: Finally, the values of quality coefficients for the model with automatic feature extraction were more optimal than those obtained for the model with manual extraction. The classifier created within the framework of the present study achieved high values of fit measures. The model based on automatic feature extraction achieved 83% accuracy for the test set and 97% for validation.

CONCLUSIONS: The results indicate that deep learning methods offer the possibility of automatic diagnosis of common widespread infectious diseases, using test results that can be performed routinely on patients.

38. Diagnostics of functional mobility of patients with multiple sclerosis with the use of biomechanical tools

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BACKGROUND: Multiple sclerosis (MS) is one of the most common neurological diseases in young adults. The beginning of symptoms can be seen between the ages of 20 and 40. It is estimated that a total of 2.8 million people live with MS worldwide, or 35.9 people per 100,000 population. The condition affects balance and motor coordination. To check these parameters, the Up and Go test can be used. It is a simple and quick test to assess movement, mobility and dynamic and static balance.

OBJECTIVE: The purpose of this study was to determine the impact of multiple sclerosis disease on functional mobility using the Up&Go test.

METHODS: The study involved 35 people with stage II and III multiple sclerosis. The participants were tasked with performing the Up and Go test, which consists of the following steps: getting up from a chair, walking 3m, turning and returning to the starting point, turning number 2 and returning to a sitting position. During the Up and Go test, each subject wore Noraxon IMU sensors.

RESULTS: Analysing the durations of the various phases of the Up&Go test, it can be seen that the longest time each time is achieved by men, which also makes the total time of the test in men longer compared to women. In men, there is also an increase in the values of temporal–spatial parameters such as walk cadence, walk strike time.

CONCLUSIONS: On the basis of the results, it can be seen that men achieve worse time values of the Up–and–Go test, which may mean that there is a greater deterioration of locomotor function and motor coordination in them.

39. **Artificial intelligence in biomedical imaging**

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BACKGROUND: Biomedical imaging is a multidisciplinary branch of medical science that consists of many scientific disciplines, e.g., medicine, biology, bioinformatics, and image analysis. Moreover, it covers various medical specialties. In recent years, a huge development of this field of science has been observed. The consequence of this is a large amount of data generated (e.g. based on radiomics), among others as a result of the processing, analysis, and recognition of a wide class of biomedical images obtained through increasingly advanced medical imaging devices. The analysis of these data requires the use of advanced IT methods, which include those related to the use of artificial intelligence, and in particular machine learning.

OBJECTIVE: This presentation summarizes the selected applications of artificial intelligence, including machine learning in the processing, analysis, and recognition of biomedical images.

METHODS: Fundamentals of various AI techniques with application to analysis of medical image data will be briefly discussed along with the basics of texture analysis approach.

RESULTS: Sample results regarding biomedical image segmentation, organ recognition, disease detection classification, etc., will be demonstrated and discussed.

CONCLUSIONS: The growing role of medical imaging requires the development of dedicated algorithms that will reveal some useful diagnostic information, often unavailable by means of simple visual assessment. It is therefore necessary to encourage doctors to use various quantitative methods of image processing and analysis and expand cooperation in this area with computer scientists and biomedical engineers. New information obtained thanks to such analyzes will enable better efficiency and repeatability of the diagnostic process.

40. **Stroke severity prediction using data mining techniques**

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BACKGROUND: Stroke is the third most common cause of mortality and claims the top spot for causing long–lasting disabilities among adults worldwide. An important tool in the diagnosis and management of stroke patients is NIHSS (National Institutes of Health Stroke Scale). It helps doctors determine the degree of neurological deficit and plan appropriate treatment. The NIHSS scale assesses various neurological functions, such as speech, vision, limb movements, balance and more. The highest possible score on the NIHSS is 42, which indicates the most severe neurological condition. A lower score indicates a lesser degree of deficit. Evaluation of a patient using the NIHSS scale is done both on entry and on leaving the patient.

OBJECTIVE: The aim of this paper is to extract classification rules and action rules that can be useful to doctors. The purpose of this article is to distinguish classification rules and action rules. It can be useful for doctors in diagnosing patients and indicate those features that allow to reduce neurological deficits (reduce scores on the NIHSS scale).

METHODS: The initial phase of the study focused on selecting attributes and examining their impact on the accuracy of categorizing patients into different neurological deficit groups. The next stage was to construct models that included all attributes, as well as attributes extracted through feature selection. The final stages of the research included the formulation of classification rules and the extraction of action rules.

RESULTS: It was identified those factors that have the greatest impact on neurological deficits. Two models were then built and evaluated. Based on the implemented algorithms, decision rules and action rules were obtained.

CONCLUSIONS: The obtained model, the selected attributes and the extracted classification and action rules can support the work of neurologists and identify those factors that have the greatest impact on the reduction of scores on the NIHSS , i.e. on the reduction of neurological deficits in post–stroke patients.

41. **Extreme biomimetic approach: steel melting on carbonized 3D spongin scaffolds**

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BACKGROUND: Spongin is a natural and renewable biopolymer with complex chemical structure. Spongin – based 3D constructs have been characterised by elasticity, toughness, durability, softness, absorptiveness, porosity, flexibility and compressibility. Extreme biomimetics is a discipline initiated in 2010 by Prof. dr hab. Hermann Ehrlich. It consists in searching for natural inspirations leading to new solutions that are far beyond human comfort zone, e.g. temperature, pH, pressure.

OBJECTIVE: The transformation of spongin into new composite materials with a wide spectrum of possible applications in medicine, biotechnology, nanotechnology, tissue engineering and industry were investigated.

METHODS: Different types of steel in the form of shavings or powder were melted on carbonized spongin templates in the furnace in the temperature 1450°C in argon atmosphere for 90 min. To confirm obtaining novel materials digital microscope analysis, SEM and EDS analysis were performed.

RESULTS: Due to the reaction of the carbonized sponge skeleton with steel during melting, it was obtained novel composite materials containing iron which was proved by digital microscope, SEM and EDS analysis.

CONCLUSIONS: Using the extreme biomimetics approach it was obtained composite materials with previously unknown properties which may substitute harmful artificial polymers.

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42. Influence of different finishing and polishing methods on surface roughness and microhardness of dental composites

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BACKGROUND: Composite materials in dentistry are mixtures of polymers and fine–grained fillers. Choosing the right polishing methods is critical to achieving the best quality and durability of your restorations while maintaining the tooth's geometry and durability.

OBJECTIVE: The purpose of this in vitro study was to evaluate the effect of three different polishing systems on the surface roughness and microhardness of resin composites used for dental fillings.

METHODS: Six different composites were used in the study. From each material, 40 cylinder–shaped samples were made. All samples were polymerized and polished using three different methods. To determine surface roughness a confocal laser microscope was used, and microhardness was determined using a universal Vickers hardness tester.The data were analysed using the one–way ANOVA test at a significance level of 0.05 for both tests.

RESULTS: The smoothest surfaces in all groups of composites were obtained for control samples. Also in all groups of composite samples no statistically significant differences were found between the Sof–Lex and Enhance+PoGo. The measurement of surface roughness obtained for the Kenda system showed significantly lower values than for the other two methods. The surfaces of the control samples showed statistically significantly lower microhardness values compared to all polishing systems for all six tested resin composites, additionally no statistically significant differences were found between all finishing and polishing methods.Regardless of the finishing and polishing method used, the lowest microhardness values among microhybrid materials were found for Charisma Flow, while among nanohybrid materials the lowest values were obtained for Herculite HRV Ultra.

CONCLUSIONS: Finishing and polishing increases the microhardness of microhybrid and nanohybrid composite resin. The use of Kenda® three step polishing system resulted in smoother surface for all tested composite materials compared to the Sof–Lex and Enhance+PoGo systems, while the finishing and polishing method had little effect on the microhardness of the surface.

43. Numerical analysis of oxygen distribution in biological tissue exposed to external heat impulse regarding the influence of oxyhemoglobin dissociation curve parameters

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BACKGROUND: Oxygen insufficiency in the body, known as hypoxia, can arise due to changes in temperature caused by factors such as exercise, illness, or external heat. Elevated temperature can modify the properties of tissue, potentially causing thermal damage and thus disrupting the vasculature and oxygen delivery. Furthermore, the temperature is one of the parameters (beside pH, CO2, and 2,3–DPG) that can alter the shape of the oxygen dissociation curve (ODC).

OBJECTIVE: The purpose of this study was the numerical analysis of the phenomena associated with changes in oxygen distribution in biological tissue under the influence of an external heat impulse. In particular, the effect of ODC parameters on tissue oxygen levels was studied.

METHODS: Thermal analysis is based on the Pennes bioheat transport equation with the tissue parameters treated as temperature– or thermal–damage dependent. The thermal model is supplemented with an additional model based on the Krogh cylinder concept, which is used to analyze changes in the partial pressure of oxygen in the capillary vessel and surrounding tissue. The oxygen distribution model is linked to the thermal model by using a relationship between blood velocity in the capillary and the perfusion coefficient.

RESULTS: Changes in the level of oxygen partial pressure in the tissue resulting from the effects of elevated temperature that affect tissue perfusion and blood velocity in the capillaries are easily detected. Furthermore, the values of the hemoglobin dissociation curve parameters affected the oxygen distribution. As the temperature increased, the ODC shifted to the right, while a decrease in blood velocity resulted in hypoxia.

CONCLUSIONS: An external heat impulse affects biological tissue at various levels. Changes are evident for the thermophysical parameters of the tissue, particularly the perfusion coefficient, as well as for the capillaries responsible for oxygen delivery to the tissue.

44. **Novel polylactide composites modified with steel fibres and octa(3–thiopropyl) silsesquioxane derivatives**

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BACKGROUND: Polylactide (PLA) is a commonly used polymer in medicine because of its favourable processing properties and high transparency. However, it also has disadvantages, including high brittleness, low flexibility, and a lack of reactive groups in the chain that can make surface modifications difficult. To address these issues, researchers are exploring new modifiers in the form of natural or chemical fillers to improve selected properties of PLA.

OBJECTIVE: The aim of the work is to analyze the impact of adding steel fibres and modified fibers with organosilicon compounds on selected mechanical and surface properties as well as thermal stability.

METHODS: In this work polylactide (PLA) type Ingeo 2003D, low–alloy steel fibres, octa(3–thiopropyl)silsesquioxane and its derivatives were used. The first stage covered the modification of steel fibres with organosilicon compounds and obtaining a concentrate. The prepared masterbatches were diluted with PLA directly in the Engel e–victory 170/80 injection molding machine. Final system concentrations were 0.5% w/w, 1% w/w, 1.5% w/w, 2.5% w/w, 5% w/w. Tensile tests of the obtained specimens were performed on a universal testing machine INSTRON 5969. The Charpy impact strength test was performed according to ISO 179–1. Water contact angle measurements were performed using the sessile drop technique. Thermogravimetry (TG) was performed using a NETZSCH 209 F1 Libra gravimetric analyzer (Selb, Germany).

RESULTS: The mechanical properties of the PLA–based composite were affected by the use of organosilicon compounds as steel fibres modifiers. The modified composites showed an increase in impact strength and elongation at break. Moreover, the organosilicon compound had a significant impact on the change in the contact angle value.

CONCLUSIONS: The use of organosilicon compounds as plasticizers in the polymer matrix increased the flexibility of the material. Additionally, the hydrophobic groups in these compounds affected the composite's surface properties.

45. **Novel polymer blends for applications in FDM 3D printing**

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BACKGROUND: There is a growing selection of FDM–dedicated materials available on the market today, considering the polymer matrix – PLA is the most common, but PET, PET–G, ABS, PC, PEEK, TPU, HIPS, PA12 and other options are available. Still, many of the mentioned materials are difficult to print, especially on simple printer machines, or the models produced with their use do not meet the user requirements in terms of elasticity or ultimate elongation. There are also materials very interesting for printing, yet problematic in this matter. Blending the polymers of choice together may produce materials of superior printability and final properties of the objects produced.

OBJECTIVE: The aim of the work was to produce polymer blends novel in terms of FDM 3D printing and assess their utility for producing objects of improved mechanical characteristics in comparison to common filament–dedicated polymers. Additionally, verification of applicability of organosilicon additives as compatibilizers and processing aids was verified.

METHODS: A series of polymers, in particular PMMA, POM, EVA, iPP, IIR and ABC copolymer were applied for the study and blended in appropriate combination and at a variety of proportions. The blends were both injection molded and extruded into filaments for FDM 3D printing. The filaments were tested in 3D printers and the so obtained printed samples compared in terms of their mechanical properties with their injection molded counterparts. For some blends, organosilicon additives were used as well to test if polymer blending can be increased or the blends' performance further improved.

RESULTS: The mechanical properties of the base polymers were strongly affected by blending, in most cases undesirably, as significant reduction of mechanical strength was observed. However, plasticization of POM and PMMA was observed.

Due to differences in flow properties, 3D printing process required further tuning for the obtained blend filaments. Blending allowed for producing POM and PMMA filaments of acceptable printability and attractive mechanical parameters, especially controllable stiffness.

CONCLUSIONS: The results show that blending of polymers, printing of which being problematic or the material itself being of limited utility in FDM, allows for both acceptable printability and for obtaining material of more attractive mechanical properties. Also, the method produces tunable materials, strongly dependent on the blending ratio.

46. Searching for people in floods using human position recognition techniques and 3D joint coordinates using unmanned aerial vehicles

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BACKGROUND: Drones are proposed to be used to search for people in floods as they are highly mobile and help to collect large amounts of video data.

OBJECTIVE: The objective of this work is to develop a hybrid method using You Only Look Once (YOLO) algorithms to automatically and accurately recognize a person's position and its 3D joint coordinates based on markerless methods in flooding conditions.

METHODS: Initially, reference frames from the video stream are selected to reduce the amount of visual information that will be processed. A motion analysis method, such as the optical flow algorithm, is used to sift out static frames. A neural network method based on the YOLO architecture is used to detect a person or human body parts in the reference frames. Since the human position recognition is done in flood conditions it is necessary to determine whether the person is alive or not. In order to understand that the person is alive and his body parts are moving, joint coordinate recognition, called human position analysis, is performed. This is based on the data obtained from the processed video frames. By analyzing successive frames, it is determined how the coordinates of the joints change over time. This allows to reveal the movement and dynamics of each body part. To solve the problem of real–time human position recognition using drones, we propose the use of a small RaspberryPi single–board computer on board the drone.

RESULTS: Based on the experimental results, it can be stated that the proposed method significantly improves the detection efficiency of survivors in the flood zone. Specifically, the results confirm that the method has an average detection accuracy of 97%.

CONCLUSIONS: The proposed method has the potential to improve human detection operations in flood conditions.

47. The impact of multifunctional polysiloxanes on enhancing the properties of polyethylene terephthalate glycol (PET–G) for FDM 3D–printing

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BACKGROUND: PETG (Polyethylene Terephthalate Glycol–Modified) is a popular 3D printing filament material that stands out for its good mechanical properties, chemical stability, excellent aesthetic properties, and biocompatibility. In addition, PET has high resistance to radiation and degradation in the presence of body fluids, which is why it is the most commonly used biomaterial. However, like any material, it does have some weaknesses that users should be aware of: warping, stringing (tendency to produce thin strands or strings of filament between non–contiguous parts of the print), and hygroscopic.

OBJECTIVE: This study aimed to investigate how multifunctional polysiloxanes affect the properties of PETG for its suitability in FDM 3D printing technology. New polymer systems have been developed to address the limitations of 3D printing technology using PETG material.The materials were modified with a series of polysiloxane–based derivates obtained by a hydrosilylation reaction.

METHODS: In this work,Polyethylene Terephthalate Glycol–Modified(PET–G) tSELENIS SELEKT™BD 110 (SELENIC NORTH AMERICA, LLC), polymethylhydrosiloxanesand its derivatives were used. The first stage covered the synthesis of modifiers via hydrosilylation reaction. The next step was the modification of PET–Gwith organosilicon compoundsandobtaining a concentrate. After that, all of the prepared masterbatches were extruded using a twin–screw extruder machine to obtain final granulates. The granulates were diluted with neat PLA up to the final additive loading of 0.10, 0.25, 0.50, 1.0, 1.5, and 2.5 wt%.Tensile tests of the obtained specimens were performed on a universal testing machine INSTRON 5969. The effect of the modifier addition on the mass flow rate (MFR) was determined using an Instron plastometer, model Ceast MF20. Water contact angle measurements were performed using the sessile drop technique.Differential scanning calorimetry(DSC) was performed using a NETZSCH 204 F1 Phoenix (NETZSCH, Selb, Germany).

RESULTS: The mechanical properties of the PET–G–basedcomposite were affected by the use of organosilicon compounds. The modified composites showed an increase in tensile flexibility,bending strength, and improved rheological properties. Moreover, the modifier usedhad a significant impact on the change in the contact angle value- and melt.

CONCLUSIONS: The modifiers, which are used, can be usedas PET–G plasticizers. Furthermore, theycan improve some mechanical properties and increase the contact angle.

48. **Biomechanical assessment of critical factors during patient lifting: shoulder gridle and cumulative moment ergonomic evaluation**

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BACKGROUND: Manual weight handling remains a crucial aspect of daily tasks in the healthcare sector. Healthcare professionals face significant physical demands during patient lifting and transferring, which, while vital, can pose musculoskeletal risks. Research has shown that ergonomic interventions can alleviate these physical demands in manual labor tasks. Shoulder gridle are one of the risky segments for chronic muscle skeletal disorders.

OBJECTIVE: This study aims to assess the risk of shoulder gridle injuries in medical staff during patient transfers. We sought to develop accurate assessment methods by measuring and evaluating motions involved in patient lifting, particularly focusing on shoulder moments with accumulated load.

METHODS: Five participants with different body types were selected for this study, each performing five repetitions. 25 measurements were recorded in total. The test environment consisted of two chairs, 0.5 meters apart, with a 5 kg weight simulating a patient. Participants followed ergonomic lift techniques. Data were recorded using Movella–Xsens 60 Hz inertia measurement units, capturing full body motion. Shoulder moments were calculated as static loads, with the load size set at 36 kg (60% of the patient's body weight).

RESULTS: Shoulder moment were calculated, with an average contribution from body weight at 10.70% ± 2.67%. Extrapolating cumulative shoulder moments and extrapolating to over a 5–year work span revealed that the best techniques would induce 1.86 times less strain on the shoulders compared to the worst techniques.

CONCLUSIONS: Our study introduced a methodology for evaluating shoulder ergonomics during patient lift motion. Evaluation is based on shoulder moment and cumulative load calculations. We conclude that implementing ergonomic lift techniques can significantly reduce the risk of shoulder gridle injuries among healthcare staff during patient transfers. However, we acknowledge limitations in our research, such as population size and uncertainties in calculations. Future research should address these limitations and provide a more comprehensive understanding of ergonomic factors in healthcare.

49. **Computer–aided diagnosis of colorectal polyps**

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BACKGROUND: Colorectal cancer (CRC) was the third most common malignancy in the world in 2020, with the total number of cases exceeding 1.9 million. By 2030, this number will have increased to approximately 2.2 million. A classification model is needed to assist physicians performing colonoscopies to detect adenomatous polyps – precursors to CRC. A reliable classifier can only be constructed using a large, multi–center dataset.

OBJECTIVE: To create a telemedical system that allows acquisition and storage during colonoscopy of narrow–band images (NBI) of polyps. The system can perform a real–time binary classification (hyperplastic vs. adenomatous) of selected colorectal regions. The users can classify the images from the database as training.

METHODS: Apart from NBI images, the cloud database stores patients' age, gender, physicians' classification of polyps according to the NICE scale, polyps' location, and histopathology results (the gold standard for the classification of polyps). We created a deep–learning classification model based on ResNet152V2 to differentiate precancerous/cancerous polyps from hyperplastic. In the initial research stage, we trained the model using NBI images of 428 unique polyps (45% were hyperplastic).

RESULTS: The model achieved an accuracy of 97.3±2.4%, sensitivity of 97.3±2.5%, and specificity of 97.3±2.5%. The AUROC, Matthews correlation coefficient and F1 score were equal to 98.7±1.2%, 94.3±5.1%, 97.4±2.3%, respectively.

CONCLUSIONS: We will deploy the system in several hospitals for further testing and validation.

50. Assessment of the impact of perfluorodecalin content on the properties of artificial blood

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BACKGROUND: Blood as liquid tissue performs extremely important functions in the circulatory system. Its main tasks are to transport oxygen and nutrients, regulate body temperature and fight infections. However, various deviations from the proper composition of blood and disruptions to the blood production process may affect the functioning of the entire body. Despite the progressing knowledge about the development of blood diseases and the introduction of new drugs, the treatment of hematological diseases is a huge challenge for doctors. Additionally, due to the aging population and other aspects, there is a growing problem of lack of blood donors. For this reason, numerous works are taken to develop a blood substitute. Currently, preparations based on human/animal hemoglobin or based on perfluorocarbons are being developed.

OBJECTIVE: The aim of the research carried out in this study was to assess the effect of perfluorodecalin (PFD) on the physicochemical and rheological properties of artificial plasma preparation and to compare these values with the properties of natural blood.

METHODS: An artificial blood containing various concentrations of perfluorodecalin was tested in this study. In the work, the physicochemical and rheological properties of the preparations were tested at different times after their preparation. The multifunctional ionoconductometr with dedicated electrodes was used for measuring pH, conductivity and redox potential. The oxygen concentration was tested using oxygen electrode. The surface tension tests were performed using a balance with a platinum ring and the STA1 tensiometer. The wettability of the materials surface was determined using gniometer. The Haake Rheostress 6000 rheometer was used for viscosity tests.

RESULTS: Analysis of test results indicates that an increase of PFD content in artificial blood preparations does not affect the pH value. The electrolytic conductivity value was between 11.7 and 12.7 mS/cm, which is within the physiological range. In the case of the redox potential, its increase was observed until the 7^{th} day. This is related to the oxidation and reduction reactions taking place in the tested solutions, resulting from their chemical composition and pH value. The increasing PFD content and time of storage correlated with the increase in oxygen concentration in the developed blood substitutes. The surface tension of the tested solutions increased with time.

Contact angle tests showed values lower than 90°, which means that the tested solutions are characterized by good wettability. Rheological tests showed that the tested preparations are non–Newtonian, pseudoplastic fluids, just like natural blood.

CONCLUSIONS: The physicochemical and rheological properties of the tested preparations are similar to those of natural blood. Perfluorodecalin is a neutral compound that does not significantly affect the tested properties of prepared blood substitutes.

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