Advances in Biomedical Sciences, Engineering and Technology (ABSET) Conference, 2023

Book of Abstracts

June 10-11, 2023 | Egaleo Park Campus Conference Center | University of West Attica | Egaleo | Athens | GR

Organized by the MSc Program "Biomedical Engineering and Technology" of the Department of Biomedical Engineering of the University of West Attica

ABSET 2023 – Advances in Biomedical Sciences, Engineering and Technology Conference

Organized by the

MSc Program "Biomedical Engineering and Technology"
Department of Biomedical Engineering
University of West Attica, Greece

ABSET 2023 - BOOK OF ABSTRACTS

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Foreword

It is our great pleasure to extend a warm welcome to each and every one of you to the Advances in Biomedical Sciences, Engineering and Technology (ABSET) 2023 international conference. Participants from different corners of the globe gathered in Athens 10-11 June 2023 at the University of West Attica, Greece, to engage in a fruitful exchange of knowledge, ideas, and experiences in the scientific fields of biomedical engineering and sciences. This conference served as a platform for intellectual growth, collaboration, and innovation, fostering new connections and strengthening existing ones.

Organizer

The ABSET conference was organized by the MSc Program "Biomedical Engineering and Technology" of the Department of Biomedical Engineering of the University of West Attica, Greece. Key features of the MSc Program are the following:

Target group*:* Those who wish for a career change in Biomedical Engineering, having already a background in Engineering, Life and Health Sciences, or other relevant to biomedical engineering Sciences.
Duration: 1.5 years (3 academic semesters)
Studies start: October
Course attendance: Full-time, compulsory
ECTS: 90
Teaching Language: English
Tuition fees: 1200 €

The MSc program's goals are:

a) intensive introduction to biomedical engineering
b) problem-solving skills development
c) active interaction with the biomedical engineering industry
d) prepare students for PhD studies

The MSc program's topics include in vitro and in vivo diagnostic technologies, medical imaging, biomedical instrumentation, rehabilitation and biomaterials, biomedical informatics, artificial intelligence, deep learning, emergency medicine, science, technology, ethics, marketing, management and sales, research methodology and active interaction with the labor market to understand the real-world conditions and the career prospects in the biomedical engineering domain.

The MSc program's teaching staff comprises:

i) Invited professors from **8 Universities**:
- *University of West Attica*, ***Greece*** *(host institution)*
- *National Kapodistrian University of Athens*, ***Greece***
- *Instituto Politécnico do Porto*, ***Portugal***

- *Universidad Rey Juan Carlos,* ***Spain***
- *Georgia Institute of Technology,* ***USA***
- *University of Plymouth,* ***UK***
- *Universitatea Politehnica din Bucureşti,* ***Romania***
- *Trier University of Applied Sciences,* ***Germany***

ii) Invited Researchers from biomedical engineering research facilities

iii) Invited biomedical engineers from the labor market

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Organizing and Technical Committee

The ABSET 2023 Organizing and Technical Committee was responsible for coordinating the conference organization, including the technical programme for the structure, content and format of the ABSET 2023 sessions, as well as the day-to-day planning of the on-site conference. Members of the ABSET 2023 Organizing and Technical Committee were:

- Glotsos Dimitris[†]
- Kostopoulos Spiros[†]
- Athanasiadis Emmanouil[†]
- David Efstratios[†]
- Liaparinos Panagiotis[†]
- Kakkos Ioannis[†]

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Scientific Committee

The ABSET 2023 Scientific Committee consisted of prominent members of academia. These are accomplished researchers and scientists affiliated with premier educational institutions around the world. The committee was responsible for overseeing the peer-review process for the annual conference to ensure consistency in the scientific quality of the presentations.

Members of the ABSET 2023 Scientific Committee were:

- Rinaldi Daniele
  ICRYS Centro di Ricerca e Servizi di Analisi Globale dei Cristalli, Università Politecnica delle Marche, Ancona, IT
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  Department of Biomedical Engineering, University of West Attica, Athens, GR
- Pantatosaki Evangelia
  Department of Biomedical Engineering, University of West Attica, Athens, GR
- Skotadis Evangelos
  Post-doctoral researcher · National Technical University of Athens, Athens, GR
- Loukos Ioannis
  Deputy Technical Director at EKAB (National Centre of Emergency Care), Athens, GR

Editorial

Dear Colleagues,

We are delighted to welcome you to the Book of Abstracts of the Advances in Biomedical Sciences, Engineering and Technology Conference (ABSET 2023), held in Egaleo Park Campus Conference Center, University of West Attica, Athens, Greece, from 10 to 11 of June 2023.

Biomedical Sciences serve as the foundation for understanding human biology, diseases, and their mechanisms. Biomedical Sciences, Engineering, and Technology have revolutionized the healthcare industry by merging scientific knowledge with technological advancements to improve diagnostics, therapies, and patient outcomes. This multidisciplinary field encompasses a wide range of disciplines, including biology, chemistry, physics, engineering, and computer science, to address complex biomedical challenges. Collaboration between scientists, engineers, and healthcare professionals is crucial for translating scientific discoveries into practical applications.

The ABSET 2023 Conference sought to provide answers and explore new ideas, actions, challenges, and outcomes of the Biomedical Sciences, Engineering, and Technology offering a worldwide connection between scholars and enterprises who share a common interest in the field. Our event has attracted a diverse range of contributors and presenters, including 15 countries from 3 continents. This diversity is a testament to the international reach of our conference, fostering multi-disciplinary collaborations and fostering intellectual growth and exchange.

This volume comprises the abstracts of the research works presented at the ABSET 2023 conference.

We would like to express our gratitude to all authors and participants, the members of the academic scientific committee, and especially to the organizing and administration team for making and putting this conference together.

Hoping to continue our collaboration in the future.

Respectfully,

The ABSET 2023 organization committee

Country codes

Bulgaria: BG

Canada: CA

Chine: CN

Cyprus: CY

Egypt: EG

India: IN

Italy: IT

Greece: GR

Germany: DE

Luxembourg: LU

Portugal: PT

Romania: RO

Spain: ES

United States of America: USA

United Kingdom: UK

Abstracts

Keynote: In-Vivo Interface for Neural Signals

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The development of interfaces between the human nervous system and technical systems involves a variety of challenges. Besides biocompatibility and biostability, these include selectivity and signal-to-noise ratio. The speech presents different electrode systems and their advantages and disadvantages for different applications. The application areas here range from brain interfaces for controlling prostheses to stimulation applications in neurodegenerative diseases and retinal implants. But also applications in the peripheral nervous system for stimulation of skeletal muscles or for stimulation of the autonomic nervous system are described. A special focus is on the construction of the electrodes. Classical methods of precision engineering but also microsystems technology are used. The difficulty with ever smaller electrode structures lies in particular in the robustness of the electrodes over a long application time in the body. The large number of electrodes required for visionary applications is also a major challenge. Computer-brain interfaces in particular, but also retinal implants, should be mentioned here. Here, both the electrodes themselves and their contacting to active implants up to their implementation in housings are technical challenges that entail high demands both in terms of production yield and long-term stability in the body. Despite these challenges, the medical application fields are constantly growing and lead to innovative approaches in all areas where an interface between technology and the nervous system is possible.

Keynote: Designing a Massively Scalable, Cloud-Based, Medical Image Ingestion Pipeline for Supporting Research

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The industry-wide paradigm shift towards machine learning (ML) applications and especially deep learning models is mainly fueled by the availability of massive amounts of training data. It has been estimated that AstraZeneca is sitting on top of approximately 6 petabytes (PB) of medical and digital pathology images produced both by clinical and pre-clinical studies. Thus, the data ingestion requirements to support internal research groups are substantial. Here we discuss the motivation behind creating a scalable, serverless, low-cost ingestion pipeline as part of the Imaging Platform, and we outline all the lessons learned in the process, as well as the important technical challenges yet to be addressed.

Keynote: Ultrasound-enhanced Cancer Immunotherapy

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Conventional therapies for brain tumors (chemoradiation and tumor resection) are either ineffective or have significant toxicity and complications. As a result, cancer immunotherapy is increasingly tested for treating primary brain tumors. While early investigations are providing encouraging findings, they also highlight important challenges. These include i) limited therapeutic trafficking across physical barriers (blood brain barrier); ii) antigen loss or heterogeneity (limit chimeric antigen receptor T cell therapy); and iii) on- and off- target toxicity. This presentation will discuss how physical therapies such as ultrasound can overcome some of these challenges to enable safer and more effective brain cancer immunotherapy. Emphasis will be placed on the potential of ultrasound to i) improve the delivery and cytotoxic activity of immune checkpoint inhibitors in Glioblastomas; ii) control the cytotoxic activity of chimeric antigen receptor T cells in the brain tumor microenvironment in breast cancer brain metastasis and iii) guide cell-based therapy.

Acknowledgments: *The work presented is supported by the following grants: NIH-NIBIB R00EB016971, NIH-NCI R37CA239039, and FUS Foundation*

Keynote: A Decade of Motion Management Developments in NM Imaging

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Management of subject motion in nuclear medicine imaging has been garnering sustained research and clinical effort for several decades now. Many methodologies have been developed for both single photon emission computed tomography (SPECT) and positron emission tomography (PET). Motion correction methodologies consist of three steps; motion tracking, motion estimation and motion correction. During the last decade considerable progress has been accomplished in motion tracking (stereoscopic or time-of-flight cameras, laser scanners, centroid of distribution algorithms, etc) and motion estimation (patient specific motion model, joint PET-MR image registration, population-based motion model, etc.). In regards to the step of correction, it has been proven that a highly accurate motion estimation does not guarantee the best possible imaging result because the way motion information used for generating the motion-corrected images (i.e. pre-, during or post-reconstruction) affects the overall performance of the correction. What makes motion management a challenging, ongoing investigation lies in the complexity of dynamic human anatomy, linked with the objective to improve the trade-off between image quality, patient dose and acquisition duration. The complexity of the implementation and the associated computational burden has so far limited the widespread acceptance of these methodologies in clinical practice. Due to these ongoing challenges, ongoing research is also considering how to improve existing methodologies in order to facilitate their adoption in clinical environments. In this talk we will discuss the advances and refinements on motion management in the field of nuclear medicine imaging over the last decade. Recent developments in artificial intelligence offers hope that it will find applicability also in the field of motion management, offering solutions to where current methods, so far, have failed.

Invited: Contrast Enhanced Spectral Mammography - an alternative breast imaging technique to MRI Mammography

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In this presentation we will describe the basic technical characteristics of the Contrast Enhanced Spectral Mammography (CESM) which is an advanced new imaging technique for Breast imaging and is considered as alternative breast imaging technique to MRI Mammography. Mammography is the most common imaging exam during the last 30 years for screening and diagnosis of breast cancer (which is the No1 cancer type among women population). Typically, during a 2D Mammography exam, each breast is twice positioned and briefly compressed for a few seconds to acquire four X-ray images. Contrast-enhanced spectral mammography is the combination of X-ray mammography with intravenous administration of iodinated contrast agent (ICA). The use of Dual Energy breast exposures (about 26–33 kVp and 44–50 kVp) after contrast administration, is allowing the visualization of enhanced findings over the normal unenhanced breast tissue, exploiting the increased contrast uptake of malignancies. CESM is easy to perform in everyday clinical practice and is useful in indications including abnormal screenings, symptomatic patients, preoperative staging of breast cancer, evaluation of response to neoadjuvant chemotherapy, screening women with dense breasts, and screening women at an increased risk of developing breast cancer. It is expected that the use of CESM will further expand, especially where breast MRI availability is limited.

Keywords: *Mammography; Contrast Enhanced Spectral Mammography (CESM); Dual Energy.*

A Theoretical Study of $LaBr_3$:Ce Crystalline Scintillator Thickness Effect In Absolute Efficiency for Radiographic X-Ray Tube Voltage of 50 Kvp

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$LaBr_3$:Ce crystalline scintillator is a material that has been considered for radioisotope imaging. In addition, published experimental efficiency results of $LaBr_3$:Ce, have shown that an encapsulated crystal of 1 cm thickness, excited by X-ray tube voltages above 120 kVp, may be used as part of the detector of a hybrid (SPECT/CT or PET/CT) imaging system. In this study, we theoretically examine the effect of $LaBr_3$:Ce thickness on Absolute Efficiency (AE), i.e. the ratio of the emitted optical light flux over the incident exposure rate, under X-ray exposure of a 20 mm Al filtered 50 kVp spectrum. A published theoretical model was applied to the experimental AE data of 1 cm $LaBr_3$:Ce crystal irradiated with a 50 kVp X-rays. The model assumes that the crystal can be divided into N elementary layers and that the optical photon propagation probability is constant for each layer. The model considers the X-ray attenuation, the optical photon production in the scintillator, as well as the optical photon transmission properties in the crystal. The optical photon propagation probability per elementary thickness was determined by fitting the theoretical model to the experimental AE data. The emitted wavelength peak at 380 nm corresponds to an intrinsic conversion efficiency, i.e. optical photon power created within scintillator mass over radiation power absorbed in the scintillator, of 0.1958. The AE at a 50 kVp spectrum at 72.5 cm distance was 23.576 μWs/mRm^2. The probability of optical photon propagation per elementary layer of 5 μm thickness was found equal to 0.99875. The AE was examined for thicknesses ranging from 0.002 cm to 1.2 cm. The highest AE value was calculated equal to 239.4 μWs/mRm^2 at 0.05 cm thickness. A 0.05 cm thick $LaBr_3$:Ce crystalline scintillator can provide optimum efficiency under excitation of 50 kVp X-rays. This result may be useful for manufacturing specialized detectors for low energy non-medical radiography applications.

Keywords: *Crystals; Detectors; Imaging; Modeling; Radiation.*

pyloadnano: APython Module for Processing Single-Cell RNA Sequencing Spatial Transcriptomics Data from the NanoString CosMx Platform

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As spatially resolved single-cell transcriptomic data analysis technologies continue to advance, the demand for more sophisticated computational tools to process and analyze this type of data is essential. To address this, we have developed the Python module pyloadnano for processing spatial transcriptomic data generated by the NanoString CosMx platform. While processing this data was previously mainly done through the R programming language or the platform's provided software, the use of Python's expanding possibilities for single-cell RNA Sequencing (scRNAseq) analysis necessitated the development of a tool that would allow integration of NanoString's datasets with the Python tool ecosystem. Spatially resolved transcriptomic data consist of transcriptomic data for each cell at a certain time while preserving spatial information, i.e., spatial coordinates of each cell. The CosMx platform generates data on gene expression, spatial coordinates, and histological images of each cell, providing users with information on gene expression in the context of tissue. The pyloadnano package integrates all this data into one Python object, AnnData, which provides a predictable data architecture for efficient and easy management of the large amount of data provided by transcriptomic analyses. This structure includes a gene expression table, cell information, histological images, and more, and is widely used in Python's computational scRNAseq and spatially resolved transcriptomic data analysis packages. The loadnanostring command in the pyloadnano package offers additional features to researchers for efficient and specialized data use, such as saving and loading AnnData objects, selecting specific analysis fields of view, and compressing histological images.

Keywords: *Nanostring; Python Module; scRNAseq; Spatial Molecular Imager; Spatial Transcriptomics.*

Rehabotics: A Comprehensive Rehabilitation Platform for Post-Stroke Spasticity, Incorporating Autoregressive Models and Augmented Reality Serious Games

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Spasticity following a stroke often leads to severe motor impairments, necessitating comprehensive and personalized rehabilitation protocols. This paper presents Rehabotics, an innovative rehabilitation platform incorporating a decision support system (DSS) designed for the rehabilitation of patients with post-stroke spasticity in the upper limbs. The system incorporates a sensor-equipped soft glove, a robotic exoskeleton hand, an augmented reality (AR) platform with serious games of varying difficulties, and an autoregressive model for adaptive therapy personalization. The soft glove collects valuable data regarding hand movements and force exertion levels when the patient touches an object, enabling real-time adaptation of therapy using multiple types of serious game, each of them with variable difficulty. The exoskeleton hand, facilitated by servomotors, assists patients in hand movements, specifically aiding in overcoming the challenge of hand opening. The autoregressive model utilizes all the data collected and in combination with the clinical measurements provides personalized and refined rehabilitation plans and targeted therapy for the affected hand. A pilot study of Rehabotics was conducted with a sample of seven stroke patients. The first step involved a clinician performing an initial assessment, following which data was collected using the soft glove's sensors. This novel system promises to enhance patient engagement and outcomes in post-stroke spasticity rehabilitation, by providing a personalized, adaptive, and engaging therapy experience.

Keywords: *Clinical Decision Support System; Robotic Exoskeleton Hand; Sensors; Soft Glove; Upper Limb.*

Driving a De-Novo Protein Design Using Efficient Classification Based on K-Mers

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De novo protein design using machine learning holds great promise for discovering novel protein folds and structures. A recent study by Gupta and Zou has demonstrated the successful de novo design of new antimicrobial peptides (AMPs). In particular, AMPs are small proteins that are naturally produced by many organisms, including humans, as part of their innate immune response to infections. AMPs are promising candidates for new antibiotics, as they have broad-spectrum activity against a wide range of pathogens and are less prone to resistance development. Gupta and Zou designed new AMPs using a Generative Adversarial Network (GAN) that is guided by a classifier. The classifier plays a critical role in selecting high-quality sequences with antimicrobial properties, enhancing the success rate in the de novo design of new AMPs. Along these lines, this work proposes a new approach for classifying AMPs using the k-mers technique, which captures the local structural and functional properties of biological sequences. This highlights its potential to enhance the efficiency of the GAN architecture for de novo design of AMPs. Experimental evaluation on real data indicates that an optimal k value is either 3 or 4, as smaller values do not capture relevant patterns, while larger values may lead to overfitting and poor generalization performance. The proposed algorithm introduces a computationally efficient classifier that can potentially reduce the time and resources required for designing and testing new AMPs. Last but not least, this work also offers a valuable tool for computational protein design beyond the identification of AMPs, as the proposed approach can be applied to a broad range of protein sequences.

Keywords: *Antimicrobial peptides; DNA classification; Guided De novo Protein Design; Recurrent Neural Networks; k-mers.*

Acknowledgements: *This work was funded by the TITAN ERA Chair project (contract no. 101086741) within the Horizon Europe Framework Program of the European Commission and the Hellenic Foundation for Research and Innovation (HFRI) Ph.D. Fellowship grant no. 5647*.

Unraveling Imaginary and Real Motion: A Correlation Indices Study in BCI Data

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This research investigates the applicability of diverse correlation indices for the differentiation of specific movements (left, right, both, none) and states (real or imaginary) in a private Brain-Computer Interface (BCI) dataset, including EEG recordings of 32 participants. As such, the recorded brain activation data were employed to illustrate the differences between visual and auditory evoked responses during task performance. Our methodology involved a two-pronged approach. Firstly, EEG data were collected capturing both the visual and auditory evoked signals that corresponded to each of the four movement classes. Secondly, we performed comparative analysis of the collected dataset using various correlation algorithms such as Pearson, Spearman, and Kendall, among others, to evaluate their effectiveness in differentiating between movements and states. The results demonstrated distinctive correlation patterns, as the selected indices effectively distinguished between real and imaginary movements, as well as between different lower limp movements in most cases. Moreover, the correlation schemas of certain individuals presented greater sensitivity in discerning nuances within the dataset. In this regard, it can be inferred that the chosen correlation indices can provide valuable insights into the aforementioned differentiation in EEG data. The results open up potential paths for improving BCI interfaces and contributing to more accurate prediction models.

Keywords: *Brain Computer Interface; EEG; Correlation Indices; Movement Differentiation; Signal Processing.*

Automatic Identification of Sleep Spindles Using Recurrent Neural Networks

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Aim: Sleep spindles are groups of rhythmic activity, with a waxing-waning morphology, and are considered a hallmark of stage 2 of the sleep electroencephalogram (EEG). Visual detection of sleep spindles in polysomnographic recordings is a time-consuming and tedious task. The objective of the current work was the investigation of the performance of deep learning algorithms in detecting EEG sleep spindles.

Material and Method: The publicly available DREAMS Spindles Database was used. 63 1-sec EEG segments were extracted corresponding to spindle activity, as well as 63 1-sec EEG segments free of spindle activity. The EEG segments were sampled with a sampling frequency of 200 samples/sec. The Long-Short Term Memory (LSTM) recurrent network was used, with three layers. The third layer had one sigmoid neuron, while various numbers of LSTM "cells" were investigated for the input and hidden layers. Each LSTM cell had 100 units, corresponding to consecutive samples of a 0,5-sec EEG window that was moved 1 sample at a time, from the start to the end of the 1-sec EEG segment, in order to produce the sequences of linked time series, as required by the LSTM technique. The dataset was divided into learning, validation and testing subsets. The Keras deep learning Application Programming Interface was used.

Results: The best results were achieved with the following hyperparameters: learning rate = 0.005, momentum = 0.5, decay rate = 10-6 and dropout rate=10%. If the learning and/or the decay rate was reduced, then instabilities occurred in the learning process. For the optimal hyperparameters, 100% accuracy was achieved for networks with 33/3, 33/4 and 43/4 cells in the input and hidden layers, respectively.

Conclusions: LSTM networks can successfully identify sleep spindle EEG activity, but the performance depended on the hyperparameters used. The methodology used in the present work has to be tested on much larger sets of data, in order to ascertain that the good performance is not a case of a reduced dataset overfitting.

Keywords*: Deep-learning Techniques; Neural Networks; Sleep Spindles; Electroencephalogram; Keras.*

Validation of a Pipeline to Measure Gait Cycle Asymmetry with Wearable Sensors

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Gait abnormalities in normal pressure hydrocephalus (NPH) and Parkinson's disease (PD) patients share similar characteristics. However, gait asymmetry, due to the difference between the movement of left and right limbs during walking, is more common in PD. To compare gait between PD and NPH, we used wearable sensors to measure data which we employ to compute gait cycle parameters (cadence, gait cycle duration, stance and swing phase). The wearable sensors consist of eight pressure sensors embedded in a shoe insole, a three-axis accelerometer and a three-axis gyroscope embedded in a housing connected to the insoles of each shoe. In order to quantify gait metrics, and in turn to analyze gait asymmetry, standardized clinical movement tests were performed on healthy subjects. We measured the gait of ten healthy subjects considered as controls, and of the same subjects performing the test with loads added to their lower limbs, to artificially introduce asymmetry in their gait in a controlled and reproducible manner. This had the goal to test the capability of our sensors and pipeline to detected asymmetry, to subsequently apply them to PD and NPH patients. The test consisted of three walks: control walk, weight load on right foot, and weight load on left foot. Asymmetry ratios were computed dividing each parameter value for the right foot by the corresponding value for the left foot. The symmetry ratios displayed a clear separation of the data points of healthy controls from healthy subjectswith loads on their limbs. In particular, control subjects displayed asymmetric ratios forswing phase that depart less than roughly 10% from the value of 1 which represents symmetry. Conversely, subjects with additional weights depart more than roughly 10%. This shows that the current sensors and computational pipeline have the potential to clearly detected asymmetry based on symmetry ratios from swing phase. Asymmetry ratios from PD and NPH patients were compared to the ratios from the healthy test subjects measured here to gain a better quantitative understanding of the asymmetry in their gait and to assess the potential influence of walking aids on gait in our patients.

Keywords: *Wearable Sensors; Gait Cycle Parameters; Gait Asymmetry; Symmetry Ratios; Parkinson's disease; Normal pressure hydrocephalus.*

Time-Dependent Adaptations of Brain Networks in Driving Fatigue

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Fatigued driving is a major contributor to traffic accidents and is closely linked to the central nervous system functions. To investigate the evolution of brain dynamics during simulated driving under different EEG rhythms, we conducted an experiment in which participants performed a 1-hour driving task while their EEG signals were recorded. We used complex network theory to analyze the data derived from the driving stimulation, and found that as fatigue deepened, small-world metrics, namely the path lengths, clustering coefficients and measures of efficiency (global, local, nodal) showed alterations against driving time. Additionally, a major correlation (corr = 0.98) was observed between the cluster coefficient with the local efficiency in all frequency bands (theta, alpha, beta). Our findings suggest that driving fatigue can cause significant trends in brain network characteristics, such as path length (m = -103: -93), (m = 98) for specific rhythms (beta, alpha, theta band respectively) and their related brain functions, which may serve as objective indicators for evaluating fatigue level and in the future, preventing fatigued driving and its consequences.

Keywords: *EEG; Functional Connectivity; Network Reorganization; PLI networks; Small-world Metrics.*

Exploring the Impact of Gene Selection on Single-Cell Sequencing Data Integration

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Cancer remains a pervasive and formidable disease within modern societies, necessitating the utilization of advanced techniques in both diagnosis and therapy. Molecular biology has emerged as a crucial tool in deciphering the underlying biological mechanisms that contribute to various types of cancer. Notably, single cell sequencing has garnered significant attention as a state-of-the-art method for profiling gene expression in individual cells, unveiling previously concealed mechanisms and biological phenomena. With the abundance of single cell datasets available, there is a pressing need to integrate related datasets into larger ones to enhance our understanding of biological processes and augment predictive capabilities. This paper aims to investigate the impact of gene selection, achieved through the implementation of feature selection techniques, on the integration of single cell datasets. By systematically exploring the effects of gene selection, we aim to enhance the integration process, leading to improved biological insights and enhanced predictive power. The findings of this study contribute to the advancement of single cell sequencing analysis and offer valuable insights into the integration of disparate datasets for comprehensive understanding of cancer biology.

Keywords: *Cancer; Data Integration; Feature Selection; Scrna-Seq; Machine Learning.*

Development of Fluid Dynamics Simulation Models and Uncertainty Quantification Algorithms for Ophthalmic Hemodynamic Flows

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The subject of this work is the implementation of Uncertainty Quantification (UQ), a recently developed mathematical method, in the broader field of Biomedical Sciences. More specifically, this research, moving within the framework of Computational Fluid Dynamics (CFD) and Vascular Engineering, focuses on modeling, simulating, and investigating disturbances in ophthalmic blood flows. Human hemodynamic flows are influenced by uncertainties resulting from the substantial lack of data related to boundary conditions and physical parameters used in mathematical models. Quantifying the effect of these uncertainties on numerical results along vascular network is a demanding process, due to morphology of the network and conditions of local dynamics. To address all these difficulties, UQ proves to be an ideal tool, due to its mathematical formalism and utilization of a probabilistic distribution for the physical quantities involved. For the past few decades, UQ has been widely applied in Biomedical Sciences, in both research studies and clinical practice. Although UQ applications are numerous, throughout most areas of human pathophysiology, it is, to our knowledge, the first time in international literature, it is implemented in ophthalmic vascular network. In this approach, physical quantities of interest and critical parameters affecting hemodynamic stability are identified. Then, a "low cost" algorithm for calculating steady state flows under conditions of uncertainty, is developed. To form the generalized problem described by the uncompressed Navier-Stokes equation, standard methods, such as Polynomial Chaos (PC) expansions and Monte Carlo simulations, are used. In addition, since nonlinear terms are involved, a gradually increasing iterative process is adopted. The algorithm is then applied to some common flow topologies (typical arteries, bifurcations, aneurysms) and its dependence on uncertainty parameter space and size of the numerical field is studied. The results of the UQ model prove to be quite promising: they are able to satisfactorily describe the field flow and compatible with previous time-dependent ones, while simultaneously providing the mean distribution of the blood flow parameters, as well as upper and lower bounds. Finally, it is concluded that these overall predictions can be extremely valuable, in applications such as non-invasive health monitoring predictions and investigation of possible safety margins in these critical natural quantities.

Keywords: *Computational Fluid Dynamics; Ocular Hemodynamic Flows; Uncertainty quantification; Vascular Mechanics.*

Brain Signals to Actions using Machine Learning

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This research presents a machine learning model that predicts left, right, or no action using electroencephalography (EEG) signals extracted from two different wearable EEG headsets. The research aims to develop an accurate and efficient model by following a rigorous and effective process divided into two parts. In Part I, the Constant Features approach is employed, which involves data loading, feature extraction, preprocessing, model selection, and tuning the best model for optimal performance. The performance of classification algorithms (Support Vector Machine (SVM), Decision Tree Classifier, and Random Forest Classifier) is evaluated using root mean squared error metrics. In Part II, the Multivariate Time Series approach is utilized to improve the accuracy and robustness of the model. The approach involves data loading, preprocessing (such as normalizing the data), modeling, results analysis, and deployment preparation. A neural network architecture consisting of Convolutional filters followed by a long short-term memory neural network (LSTM) is used in the proposed approach. The Convolutional layer performs a convolution of an input series of feature maps with a filter matrix to extract high-level features. The LSTM network is specifically designed to capture long-term dependencies and overcome the issue of vanishing gradients. The proposed approach achieves an accuracy of 98% and can be used for real-time testing. The model can be utilized in various fields where accurate and real-time prediction of Brain-Computer-Interfaces (BCI) actions is crucial. Overall, the proposed approach provides a promising solution to the problem of action prediction using EEG signals, and further research can be conducted to explore its potential applications and optimize its performance.

Keywords: *Brain-Computer-Interfaces (BCI); Constant Features approach; Feature extraction; Long short-term memory (LSTM); Support Vector Machine (SVM).*

Dental Phantom for X-ray Imaging

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Dental X-ray imaging is commonly used to identify teeth pathological abnormalities. However, further research is required on real teeth phantoms since the existing phantoms are limited to show realistic problems in clinical routine, such as cracked or clipped teeth, number of teeth roots, teeth root depths etc. To address this issue, a custom phantom was constructed to simulate realistic teeth and jaws with the scope to predict the image quality optimization under various irradiation conditions. The basic structure of the phantom was based on a female silicone mold for the creation of the jaw shapes, resin for the simulation of the soft tissue X-ray beam attenuation natural anterior and posterior teeth of the mandible and maxilla as well as two iron molds and plasticine for the implementation of the teeth within the resin. In our phantom we selected a variety of different characterization teeth provided by the Dental Clinic under the guidance of an experienced dentist. The differentiation of teeth was in terms of their anatomy and particular pathological features such as caries, fractures, fillings, root canal fillings etc. We performed measurements within the common range of dental X-ray imaging (X-ray voltage: 50-70 kVp, Current: 2.8-8 mA). The medical images produced were of excellent quality, showcasing strong image contrast when using an X-ray voltage value of 60kVp. In summary, our phantom could serve as a valuable tool for future research on dental X-ray imaging for various teeth pathological abnormalities.

Keywords: *Dental imaging; Image Quality; Phantom.*

Prediction of Parkinson's disease using Machine Learning and Statistical Analysis Algorithms

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Voice disorders such as dysphonia and dysarthria are very common symptoms in Parkinson's disease (PD) as a result of the dysfunctional muscles in the larynx. Dysphonia can be detected in vocal speech with simple sustained phonation tests that are widely used to identify PD, even in its early stages. The aim of this study was to process voice features using statistical analysis and machine learning algorithms in order to discriminate patients from healthy people. We used a CSV datasheet that consists of 195 sustained vowel phonation signals derived from 31 subjects, 23 of whom were diagnosed with PD. The features of the datasheet were acquired through the application of traditional and non-standard measurement methods. Main traditional measurements include F_0 (fundamental frequency), jitter, shimmer, and NHR. As for the non-linear methods, the applied tools are recurrence period density entropy (RPDE), detrended fluctuation analysis (DFA), and pitch period entropy (PPE). In the statistical analysis, the individual features that sustained statistically significant differences between healthy and disordered voices were isolated and their diagnostic ability was assessed by the ROC-AUC curve using classification algorithms. Results showed that the Linear Discriminant Analysis and Logistic Regression classifiers achieved better discriminatory ability for most of the features, with maximum ROC-AUC accuracy 0.88. Moreover, the correlation between the features was calculated, and the significance of the highly correlated features was explained. In machine learning, by combining features to design different classifiers, we have concluded that CART, KNN, and Random Forrest Classifiers were the most accurate (92.9%, 92.4%, and 93.8%, respectively), employing the Bootstrap Evaluation and RFE Wrapper feature-reduction methods. The results were satisfactory in determining whether a voice signal is normal or abnormal with high sensitivity, accuracy, and specificity. Considering all this, both statistical analysis and machine learning are useful diagnostic tools for PD.

Keywords: *Dysphonia; Machine Learning; Parkinson's disease; Statistical Analysis; Voice measurements.*

Discriminating Between Schizophrenic Patients and Healthy Controls Using Functional Network Connectivity Features from fMRI Examinations

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Schizophrenia is a mental disorder that leads a person to perceive things that do not actually exist. Connections between brain regions are thought to be impaired in schizophrenia, but currently, there are no direct measurements of Functional Connectivity in the brain. The disease affects people of all genders, usually starting in early adulthood. For this study we used the dataset from (https://www.kaggle.com/competitions/mlsp-2014-mri/data) that comprises 405 young adults at rest (mean age 21 years, range: 12-35 years, 200 women and 205 men). Participants kept their eyes open during the scan and focused on a presented cross. The study was performed using fMRI, Siemens Trio 3-T with a 12-channel radio frequency coil. Through the study of functional network connectivity (FNC), flexibility in functional coordination between different neural systems can be revealed and exploited. This can improve understanding of behavioral changes and adaptive processes. We tested the ability of each individual FNC-feature to be a predictive marker in discriminating between patients and healthy subjects using the ROC-AUC metric different classifiers (8 FNC-features with ROC-AUC > 0.7). We applied the Wilcoxon statistical test to each feature for isolating those features sustaining high statistical significant differences between healthy people and patients (22 features with $p < 0.01$). We also determined highly correlated FNC-features (8 FNC_features $r > 0.88$) and their association was analyzed. Finally, we selected a subset of most informative features using the RandomForestRegressor function, we formed combinations of features to design a Supervised Machine Learning (SML) system, testing the performance of available classification algorithms. We evaluated the accuracy of the SML-system using various evaluation methods such as Bootstrap and k-Fold (accuracies>80%). Ultimately, through the SML process, we identify the best model that maximizes the differentiation between the patients and healthy subjects (CART classifier, k-Fold evaluation, 5 FNC-features, accuracy 82.56%). Through the statistical analysis and machine learning processes, we conclude that FNC-features may be used for differentiating between healthy and schizophrenic patients.

Keywords: *Brain; Functional Connectivity; Machine Learning; Schizophrenia; Statistical analysis*.

Source Based Morphometry (SBM) Analysis in Schizophrenia using Statistical Analysis and Machine Learning

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Schizophrenia is a complex, long-term mental health disorder characterized by continuous or relapsing episodes of psychosis. Despite researchers' efforts, the actual causes behind its appearance have yet to be determined, although the majority of them agree that it is linked to genetics and influences from the patient's environment. In this study, based on data by Segall et al. (doi: 10.3389/fninf.2012.00010), we present a different model based on statistical analysis and machine learning classification in order to discriminate healthy people from schizophrenic patients with the use of structural components of their brain in a relaxed state. More specifically, structural MRI scans of 46 healthy controls and 40 patients, diagnosed with schizophrenia, were processed by Source Based Morphometry (SBM) analysis. We used the resulting SBM-features to (a) study differences in Gray Matter Density (GMD) maps and (b) to discriminate between patients and healthy individuals. From the statistical analysis aspect, a Mann Whitney Wilcoxon U test was chosen and a p=0.001, to determine brain maps with statistically significant differences. For these maps, the AUC (ROC curve) was calculated using Logistic Regression, in order to confirm the degree of separability of individual features. From the machine learning classification aspect, it turned out that with the use of correlation ranking for feature-reduction method, Bootstrap evaluator, and CART classifier best discrimination accuracy was achieved (>82%). All of the structural components were, finally, compared using correlation (Pearson's coefficient), to detect the existence of associations between structural components of the brain. The ROC-AUC analysis showed good class separation in the temporal lobes (AUC=0.638) and the brainstem (AUC=0.764). The correlation approach showed a correlation of ~0.6, regarding areas located in the cerebral cortex. The results show a significant degree of schizophrenia detection that could apply to future research, in order to understand the human brain.

Keywords: *Machine-Learning; SBM; Schizophrenia; Statistics; Structural-Connections.*

A Theoretical Study Regarding the Effect of the Inverse Diffusion Length on $YAlO_3$:Ce and $Y_3Al_5O_{12}$:Ce Scintillator Materials Absolute Luminescence Efficiency

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Cerium-doped Yttrium Aluminum Perovskite ($YAlO_3$:Ce) is a powder scintillator used in various applications because of its high light output and fast decay time. Cerium-doped Yttrium Aluminum Garnet (YAG:Ce) is also known for its high electron conversion efficiency and good resolution. The absolute luminescence efficiency (AE), measured in efficiency units (EU, 1 EU =1μWm^{-2}/mR) expresses the intrinsic physical processes occurring within the screen that affect the light output of the phosphor. The aim of the present study was to evaluate the effect of optical parameters such as the inverse diffusion length (σ), on the absolute luminescence efficiency (AE) of these two materials, and to study their dependence on the X-ray tube voltage and surface density. Thus, a theoretical model of AE, already described in the literature was employed. The model takes into consideration the X-ray tube voltage, the X-ray absorption and optical photon propagation properties, by means of the X-ray energy (E), the mass attenuation coefficient (μ/ρ) of the scintillator, the intrinsic conversion efficiency of the scintillator (n_c), i.e. the percentage of absorbed X-ray photon power that is turned into optical photon power and the inverse diffusion length. The phosphors' surface densities used in the calculations were 53, 70, 88 and 110mg/cm^2 for $YAlO_3$ and 63, 107, 166mg/cm^2 for $Y_3Al_5O_{12}$ while σ ranged from 91-104.3cm^2/g for $YAlO_3$ and 27.1-27.7cm^2/g for $Y_3Al_5O_{12}$. The model was applied to published experimental AE data and for each kVp and surface density combination, a suitable σ was obtained through a trial-and-error method. For the value of σ used, the highest theoretical AE was calculated for 53mg/cm^2 at 50kVp and for 107mg/cm^2 at 60kVp, for $YAlO_3$ and $Y_3Al_5O_{12}$ respectively. In addition, the average energy absorbed by the material $\bar{E}$ (keV) was calculated. The highest value of $\bar{E}$ (keV) absorbed was 8.8keV and 22keV for $YAlO_3$ and $Y_3Al_5O_{12}$ respectively. The $\bar{E}$ (keV) absorbed was observed to be gradually decreasing for higher X-ray tube voltages. Both phosphor materials present a slight increase of $\bar{E}$ (keV) around 90kVp for high surface densities. This can be attributed to the combined effect of high X-ray penetration and the optical photon propagation properties.

Keywords: *Imaging Performance; Light Emission Efficiency; Phosphors; Powder Screens; Radiation Detectors.*

Designing a 3D-Printed Mammographic Image Quality Phantom

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Image quality phantoms are used in medical imaging for quality control procedures. 3D printing is an easy and straightforward method to manufacture quality control phantoms. The purpose of this work is to design a 3D printed based phantom for the evaluation of contrast in mammographic examinations. A contrast evaluation phantom for digital mammography applications was designed with the use of Tinkercad software. More particularly, the phantom consists of two similar patterns of holes. One of the two groups of holes is composed of confectionery gold while the other one consists of aluminum. The diameter of the holes has been designed to range from 0,08cm to 0,5cm, while their thickness varied from 0,1cm to 0,5cm. The gold and aluminum were placed after the printing procedure. The printing material was PLA, since its X-ray attenuation properties have been found comparable to these of normal tissue. In addition, a theoretical study of the attenuation of radiation of the two materials in its holes occurred. In the study, a tungsten (W) anode and four X-ray filters: Rhodium (Rh), Aluminium (Al), Silver (Ag) and Molybdenum (Mo), created by the TASMIP spectra calculator were considered. The tube voltages assumed were 30 and 35 kVp for W/Rh, W/Mo and W/Ag, while for the W/Al it was taken equal to 50kVp. For the calculation of the contrast, the values of the attenuation coefficient of confectionery gold and aluminum, were acquired with XmuDat program. Finally, the image of the phantom was obtained by irradiating it at digital mammography system with W/Rh target filter combination. It was found that the best theoretical contrast was for the W/Rh target filter combination at 30 kVp was close to 100%, due to the lower energy of the X-ray spectrum and the Z of aluminum and confectionery gold. The experiment showed that the Aluminum and confectionery gold-filled holes were visible with the W/Rh combination, but the experimental contrast was different than the theoretical. In conclusion, a phantom has been created via 3D printing for the assessment of image quality in mammography.

Keywords: *Mammography; Phantom; 3D Printing; Contrast; Image Quality*.

Drug Repurposing in Glioblastoma Multiforme: The Case of CARD11-BCL10-MALT1 Signalosome Complex

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The CARD11-BCL10-MALT1 (CBM) signalosome complex triggers the adaptive immune response in lymphocytes and lymphoma cells via the integration of various receptor-induced signaling pathways that result in NF-kB activation. Its aberrant activation has been associated with many NF-kB signaling-dependent neoplasms and immunodeficiencies. Herein, we mine the chemical space for MALT1 allosteric inhibitors as the MALT1-dependent cleavage of HOIL1 modulates canonical NF-kB signaling (negative feedback termination), while the protease activity of MALT1 itself also controls NF-kB signaling. Glioblastoma multiforme (GBM) serves as a paradigm. We employed a modular strategy; a. pharmacophore-based virtual screening, b. molecular docking-based virtual screening, both on a commercially available database of 7 million compounds and c. drug repurposing on existing approved and investigational drugs. Upon data filtering on the top performing compounds, data analysis was performed with Datawarrior v.5.2.1 with clustering and similarity calculations on the basis of the FragFP descriptor, in which the similarity between two molecules is calculated as the number of fragments that both molecules have in common, divided by the number of fragments being found in any of the two molecules. All molecules are then randomly positioned on 2D space, locating most similar neighbors, assuming attractive forces, which increase with calculated similarity and distance and are all relocated in a stepwise manner, parallel to the mean vector of perceived forces, thus providing the final clusters, from which representative molecules are selected. Blood-brain barrier permeability was predicted by LightBBB. Datasets were enriched by drug repurposing data coming from DrugBank (~8.5k drugs). Virtual screening and cheminformatics results were filtered based on scoring, blood-brain barrier permeability and chemical diversity. Out of the final 13,178 candidate allosteric inhibitors, 55 chemical entities survived all strict criteria, while 48 of them were selected for efficacy and ADME-Tox screening in patient-derived glioblastoma cell lines. CYP450-mediated metabolism and metabolic stability were also determined. All chemical entities of prime interest were ranked accordingly.

Keywords: *Immunomodulation; Allosteric Inhibition; Molecular Docking; Pharmacophore Modelling; Virtual Screening, Cytochromes P450, ADME-Tox.*

Structure-Based Computational Drug Repurposing using Interaction Fingerprint Data: A Machine Learning Approach

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Drug repurposing is the process of uncovering new target proteins or indications of approved or abandoned drugs for use in a different disease. As computational tools continue to advance, their integration into drug repurposing workflows becomes more prevalent. Such a tool is the Cloudscreen platform, a 'one-stop-shop' platform for drug repurposing. In silico cheminformatics tools together with machine learning algorithms, are integrated to eliminate false positive pose results of molecular docking methodology. In this study, a dataset of approximately 11,000 protein structures with a co-crystalized ligand from the Protein Data Bank (PDB) were obtained, and molecular docking simulations with their respective ligand were performed, generating 10 docking poses for each protein-ligand interaction. The root mean square deviation (RMSD) of each docking pose's co-crystallized ligand was calculated, along with an interaction fingerprint capturing the ligand-protein interactions. By training and evaluating various machine learning algorithms using the interaction fingerprint data, the best-performing model was identified. This model was then employed to enhance confidence levels in the docking algorithm's results for calculated lig and protein complexes. The application of this machine learning approach has the potential to improve the reliability of molecular docking methodologies in drug discovery and drug repurposing, leading to more accurate predictions and advancements in the field.

Keywords: *Artificial Intelligence; Chemoinformatics; Drug Repositioning; In silico; Molecular Docking.*

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Development and Evaluation of a Portable Gamma Radiation Detector with Spectroscopic Capabilities

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The aim of this study is to present the development and the evaluation of a portable gamma-radiation detection device with spectroscopic capabilities. For this purpose, two silicon photomultipliers of Hamamatsu Company with equal dimensions of 3x3mm^2 were compared, optically coupled to a $Gd_3Al_2Ga_3O_{12}$:Ce (GAGG:Ce) scintillator crystal (3×3×8 mm^3 dimensions). Both detector apparatus were exposed to a gamma radiation using a radioactive source of cesium-137 (^{137}Cs, activity R=0.811 μCi), emitting at 662 keV. Each detector was coupled to a suitable amplifier circuit based on two operational amplifiers and placed inside a black box at room temperature conditions for the experimental evaluation. Two power supplies were used providing the working bias voltage of the SiPMs (~71V) and the operating voltages of both amplifiers (5V). The pulses produced from our detector were digitized with a four-channel desktop digitizer (CAEN DT5720, Italy). The digital pulse processing software of the same company was used for setting the acquisition parameters. The duration of the experimental measurements was approximately 30 min in order to achieve sufficiently accurate statistical evaluation. From the recorded gamma-ray energy spectra, it was observed that the most efficient photomultiplier is S10362-33-100C in terms of energy resolution achieving R=5.1% at 622 keV. With this small field of view we can detect efficiently the existence of the radioactivity and to determine its source (up to the energies of isotopes emitting at 662keV), in order to understand the cause and severity of any possible radioactive contamination.

Keywords: *GAGG:Ce; Gamma Ray Detector; Gamma Spectroscopy; Inorganic Scintillators; Silicon Photomultiplier.*

Detection and Identification of Radioisotopes via Silicon Photomultiplier-Based Scintillation Detector

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The purpose of this study is to manufacture and test a device capable of detecting and identifying radioisotopes. To this aim, three radioactive sources were utilized: Cesium-137 (137Cs, R=0.811 μCi), Cobalt-60 (60Co, R= 0.31 μCi) and Barium-133 (133Ba, R= 0.55 μCi). These sources were placed inside a blackbox next to the detector, which consists of crystal scintillators (Gd3Al2Ga3O12:Ce, GAGG:Ce) of three different dimensions (3×3×5 mm3, 3×3×6 mm3, 3×3×8 mm3). The scintillators are connected through optical coupling to the active area of a Silicon Photomultiplier (SiPM, model: PM3350 by KETEK). The device also consists of a circuit which supplies power to the photomultiplier, amplifies the exit signal and then digitalizes it with an Analog to Digital Converter (ADC) (model: DT5720 by CAEN). The ADC includes a digital pulse processing software. The energy resolution, photofraction and detector sensitivity parameters were studied after examining the Gamma radiation spectra of the radioactive sources, in order to choose the scintillator with the most suitable dimensions. The best energy resolution was achieved while using the 3×3×8 mm3 scintillator and was equal to 2.6 % at 1.332 MeV. This energy resolution performance along with the low cost of the device components and its small size, sets this specific device as a possible replacement for existing detection devices (Photomultiplier Tubes-PMTs). The introduction of this device to the market may have implications not only in the field of Nuclear Medicine but also in commercial portable detector applications and even in wearable technology.

Keywords: *Gamma Ray Detector; Gamma Spectroscopy; Inorganic Scintillators; Silicon Photomultiplier.*

Automated Curation of Alphafill Generated Models for Computational Simulations

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Alphafold is a deep learning software that, given an amino acid sequence, it can predict 3D structural models of proteins. However, Alphafold models contain only information about the amino acids when there are many proteins that contain heteroatoms such as metal ions to function properly. Here comes Alphafill, which adds missing ligands, cofactors and (metal) ions to Alphafold models based on homologous experimentally resolved structures of proteins. Such entities from the protein are inserted by aligning the amino acids of the alphafold model and the experimental model around the ligand. The confidence for each addition is evaluated by certain scores regarding the structural similarity and the Van de Waals overlaps. However, those structures cannot be subjected to molecular docking calculations. Since, only the ligands with structural and functional relevance for the protein must be retained, we created a python-based pipeline, that removes all the heteroatoms added except Fe, Mn, Co, Ni, Mg, Zn, Ca, K, Cu, Na, and retains the ones that had appropriate scores. Then, structural models are automatically prepared, and energy minimized, using Gromacs, a molecular dynamics software, to avoid unnatural repulsions and steric clashes. The automated pipeline was performed on a selected representative dataset of ~1100 Alphafill generated models, which contained metal ions to produce a curated database of models, ready for molecular docking or dynamics simulations. Statistical analysis before and after minimization showed a globally small but locally significant difference, as expected. We conclude that this methodology could provide a helpful tool for using Alphafill information, especially when dealing with a large number of models that need to be automatically curated and prepared for molecular simulations.

Keywords: *Alphafold; AlphaFill; Metalloproteins; Molecular Simulations; Python*.

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Data-Driven Drug Repurposing in Diabetes Mellitus through an Enhanced Knowledge Graph

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The CARD11-BCL10-MALT1 (CBM) signalosome complex triggers the adaptive immune response in lymphocytes and lymphoma cells via the integration of various receptor-induced signaling pathways that result in NF-kB activation. Its aberrant activation has been associated with many NF-kB signaling-dependent neoplasms and immunodeficiencies. Herein, we mine the chemical space for MALT1 allosteric inhibitors as the MALT1-dependent cleavage of HOIL1 modulates canonical NF-kB signaling (negative feedback termination), while the protease activity of MALT1 itself also controls NF-kB signaling. Glioblastoma multiforme (GBM) serves as a paradigm. We employed a modular strategy; a. pharmacophore-based virtual screening, b. molecular docking-based virtual screening, both on a commercially available database of 7 million compounds and c. drug repurposing on existing approved and investigational drugs. Upon data filtering on the top performing compounds, data analysis was performed with Datawarrior v.5.2.1 with clustering and similarity calculations on the basis of the FragFP descriptor, in which the similarity between two molecules is calculated as the number of fragments that both molecules have in common, divided by the number of fragments being found in any of the two molecules. All molecules are then randomly positioned on 2D space, locating most similar neighbors, assuming attractive forces, which increase with calculated similarity and distance and are all relocated in a stepwise manner, parallel to the mean vector of perceived forces, thus providing the final clusters, from which representative molecules are selected. Blood-brain barrier permeability was predicted by LightBBB. Datasets were enriched by drug repurposing data coming from DrugBank (~8.5k drugs). Virtual screening and cheminformatics results were filtered based on scoring, blood-brain barrier permeability and chemical diversity. Out of the final 13,178 candidate allosteric inhibitors, 55 chemical entities survived all strict criteria, while 48 of them were selected for efficacy and ADME-Tox screening in patient-derived glioblastoma cell lines. CYP450-mediated metabolism and metabolic stability were also determined. All chemical entities of prime interest were ranked accordingly.

Keywords: *Immunomodulation; Allosteric Inhibition; Molecular Docking; Pharmacophore Modelling; Virtual Screening; Cytochromes P450; ADME-Tox.*

Acknowledgements: *This research is supported by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH—CREATE—INNOVATE (project code: T2EDK-03153).*

φ-eye: High Sensitive Imaging of Fluorescent and Bioluminescent Probes In-Vivo

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Background: Molecular imaging in animal models speeds up the mean time from synthesis to market, in drug development process. Tissue observation with light (i.e. Fluorescence, Bioluminescence) is probably the most common practice, as alternative techniques are often very costly and time consuming to implement. In this work, we present "φ-eye", a highly sensitive, low noise in vivo preclinical optical imaging system.

Materials and Methods: The "φ-eye" enables non-invasive visualization and tracking of fluorescent and bioluminescent probes within a living organism in real time. The system hosts up to 3 mice and covers dyes over the range from 400-800 nm, with extension capability to SWIR imaging. In vitro fluorescence sensitivity has been determined using the following dyes: Fluorescein (486 nm/ 523 nm), Sulphorhodamine 101 (565 nm/ 586 nm) and Nile blue (647 nm/ 664 nm). In vivo fluorescence evaluation has been performed with OsteoSense 680 and TdTomato fluorescent probes in a spondyloarthritis and a cutaneous neurofibromas mouse model respectively. In vitro and in vivo bioluminescence evaluation has been performed using different concentration of U87MG-Luc2 cells.

Results: The minimum detection limit was found to be 200 nm for fluorescence studies and 100 cells for bioluminescence. In vivo fluorescence and bioluminescence imaging prove that performed studies can shed light on the prompt understanding of the accumulation of the relevant tracing molecules highlighting essential features of the examined diseases such as associated inflammation or tumor growth.

Conclusions: In vitro and in vivo experimental results show that "φ-eye" platform may constitute a valuable tool in preclinical research as it combines high performance characteristics, high throughput and small footprint.

Keywords: *Fluorescence; Bioluminescence; Optical imaging; In vivo preclinical studies.*

Acknowledgements: *This research has been co-financed by the European Regional Development Fund of the European Union and Greek national funds through the NextGeneration EU, project code: ΤΑΣΦΡ-06387 with acronym EYES.*

Bimodal Active Shape Models for Cervical Vertebrae and Spinal Canal Boundary Extraction

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Cervical spine pathologies often stem from deformations of intervertebral disc (IVD) and spinal canal (SC). This work introduces a computational method for boundary extraction of these structures. The proposed method employs an active shape model (ASM) and is bimodal, in the sense that computed tomography (CT) images are used for ASM training and magnetic resonance (MR) images are for ASM testing, in the area of cervical vertebrae from C3 to C7. The proposed method is less dependent on large amounts of training samples than deep learning methods, whereas it involves limited user intervention. Still, it is comparable to state-of-the-art methods in terms of segmentation quality, as demonstrated in our experimental comparisons. In this current study uses sagittal images from two modalities, in order to extract vertebrae, SC and IVD boundaries. For this, vertebrae shape statistics are extracted from a training set of CT images and are encoded by means of an ASM model. This shape information is transferred on MR images. This process aids an accurate extraction of vertebrae borders on T1-weighted images. In addition, the extracted vertebrae boundaries are used to guide subsequent steps of SC and IVD boundary extraction. The proposed method consists of three main stages: 1) ASM training on CT sagittal cervical images in order to obtain a model that is informed on the statistics of vertebrae shapes, 2) ASM adjustment on T1-weighted MR images and projection on T2-weighted, 3) SC and IVD boundary extraction. The proposed method is applied on six sets of MR images, with 20 sagittal images, using different scanners. ASM training is performed on 1 CT dataset with 5 sagittal images. As evaluation metrics, we use Dice similarity coefficient (DSC) and Hausdorff distance (HD). Both metrics compare the structure delineated by the proposed method and the ground truth structure. The ground truth for all CT and MR images used in the experiments has been obtained by an expert radiologist, who performed manual annotations of the structures of interest (vertebrae, SC and IVD).

Keywords: *Active Shape Models; Boundary Extraction; Image Segmentation; Spinal Cord; Spinal Canal.*

Image Analysis on Chest Radiographs for COVID-19 Identification

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Aim: Chest X-rays can help identify specific imaging patterns and abnormalities in the lungs that are indicative of infections, as in the case of COVID-19. The present work aims to discover the potential of lung texture quantification in chest radiographs for COVID-19 identification.
Material and Method: We used the third update of the COVID-19 Radiography Database. We randomly selected 1000 images, 500 from Normal cases (NRM) and 500 from COVID-19 cases (CVD), and their corresponding masks with the segmented lungs. We considered the lungs as the Region of interest (ROI) for each image. From each ROI, thirty-five (35) features were calculated; seventeen (17) from the ROI's histogram expressing global textural characteristics, eight (8) from the Gray Level Co-occurrence matrices (GLCM) expressing the spatial texture alterations, and ten (10) from the Run Length matrices (RLM) expressing variations in structural texture. All features were tested for normal distribution employing the Lilliefors test. Data were randomly split into Train (70%) and Test (30%) sets. The sequential feature selection method with cross-validation repetitions and a quadratic discriminant criterion applied on the Train set. Classical supervised machine learning algorithms were tested for their classification performance. Data management and the user interface were handled by an app developed in C# using Visual Studio as the integrated development environment. Feature extraction was performed based on built-in MATLAB functions.
Results: Twenty-seven (27) features appeared statistically significant differences ($p<0.001$) between NRM and CVD cases based on Wilcoxon and Student's t-test and, after Benjamini and Hochberg correction. Cubic Support Vector Machine classifier achieved the highest performance (87.7%) in terms of accuracy, on Test data, with 87.3% sensitivity and 88% specificity.
Conclusions: Texture analysis of chest radiographs based on machine learning methods may have an assistive role in accurate and efficient COVID-19 diagnosis.

Keywords: *Medical Image Analysis; Machine Learning; Chest X-Ray; COVID-19; Programming.*

Predictive Models Utilizing Machine Learning for the Ecotoxicity Assessment of Pharmaceuticals

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Ecotoxicity refers to the biological, chemical or physical stressors which affect ecosystems. Pharmaceutical ecotoxicity is a growing concern due to the widespread use of medications and their potential to disrupt ecosystems, accumulate in certain organisms and alter microbial communities. Developing predictive models to assess ecotoxicity of drug molecules and their metabolites can be remarkably valuable as they allow for early identification of potentially toxic substances, enabling better decision-making in the early stages of drug development, the pharmaceutical production processes as well as the environmental management. Here we present the development of a robust classifier, capable of predicting the potential impact of pharmaceutical compounds on acute ecotoxicity in the fish trophic level. Training was based on a careful selection of chemicals with known experimental activities. Extensive experimentation confirmed that the random forest algorithm, employing 150 estimators, emerged as the optimal classifier for this specific task. The classification accuracy of the proposed machine learning model reached 91%, with an F1 score of 82%. Importantly, this algorithm demonstrated robustness in dealing with imbalanced datasets, as attested by the test results obtained. As expected, the use of a particular training dataset limits the scalability of the model to structurally similar categories of compounds which is a certain drawback. Overall, our model not only demonstrates high performance as a classifier, but also covers a wide range of physicochemical descriptors, surpassing other relevant studies by more than 1.3 folds. However, further enrichment of the training dataset has the potential to enhance the scalability of our model even further.

Keywords: *Environmental Toxicity; Ecosystem; Data Mining; Supervised Learning; QSAR.*

Acknowledgements: *This research has been financed by the European Commision through the Horizon Research and Innovation Actions, under the call "A competitive health-related industry (2021)" (project code: HORIZON-HLTH-2021-IND-07).*

Experimental Construction and Evaluation of a Geiger Muller Gamma Ray Radiation Detector

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The aim of the present study is the construction and thereafter the evaluation of a Geiger-Muller type (Geiger counter), gamma-ray detector within the framework of several combined scientific domains, such as physics, electronics, programming and radiation protection precautions (Time-Distance-Shielding). A "Voltage Booster" was developed to transform the voltage from +9V to +400V for a high voltage potential supply of the Gus Tube (SBM-20 type) in order to work as a Geiger counter. Then the tube anode was connected with the two other sub circuits, the Detection Pulse Circuit and finally the Pulse Stretcher Circuit. The Detection Pulse Circuit was responsible "catching" the pulses arising from the gamma-photons while the Pulse Stretcher circuit converted them into a square form with lifespan of about 1,5 ms (the time that pulse could been detected). The detector was evaluated by monitoring the count rates produced from the ionization (the number of the charged ions per minute) by several gamma-ray radioactive sources e.g., Cs-137, Ba-133 and Co-60, which are held for educational purposes at the BME department of the University of West Attica. In addition, an Arduino device and an LCD screen were combined in order to record and illustrate the amount of the count/rates on a screen. Three different source-detector distances were tested (0cm-3cm-6cm) for the three irradiation sources and the inverse square law was verified in all cases. Finally, all counts per minute (CPMs) were estimated into Equivalent Dose Rates (μSv/h). The dose was measured in low levels (<20μSv/h) due to the very low radioactivity of the radiation gamma- sources and a possible application of this detector could be in the field of surgery as a γ-probe for the localization/surpass of the sentinel lymph node.

Keywords: *Dosimetry; Geiger-Muller detector; Radioisotopes monitoring; Gamma-Ray; Nuclear Medicine.*

An Arduino Based Portable Ultraviolet Radiation (UV-C) Sterilization Device

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The aim of this study was to design and develop a portable ultraviolet radiation (UV-C) sterilization device using an Arduino Uno microcontroller. The device consisted of a lightweight Styrofoam box, containing a white plastic grid as a base, two UV-C fluorescent lamps, a 5V relay module, two 220V/60Hz AC to 5V DC voltage transformers, a terminal switch, and a 5V button module. On the exterior of the box, an Arduino Uno microcontroller was connected to a microprocessor control display (LCD module), a red LED for visual indication and a buzzer for audio alerts. The device ensured user safety by triggering an audible and visual alert on the LCD screen if the top of the box was opened during the sterilization process. Additionally, a terminal switch cut off the power supply to the lamps as a safety measure. Users could set the sterilization time accurately in minutes and monitor the remaining time on the LCD screen. To test the sterilization capability of the device, experiments were conducted at Aglaia Kyriakou Children's Hospital under the guidance of Dr. Agaristi Lamprokostopoulou, a Senior Research Scientist at Virometix AG. Pneumococcal virus samples (Streptococcus pneumoniae serotype 23b) were cultured in Petri dishes and exposed to varying durations of UV-C radiation within the device. This virus was selected due to its genetic structure, which closely resembles that of the Covid-19 coronavirus. The results of the sterilization experiments were positive, as the irradiated samples were completely sterilized within 5 minutes, and the virus did not grow in the subsequent culture. The portable UV-C sterilization device developed in this study will be utilized by the Biomedical Instrumentational Laboratory of the Department of Biomedical Engineering at the University of West Attica. Its purpose is to sterilize breadboards, multimeters, and accessories used in student laboratory exercises, which cannot be effectively sterilized using alcohol or chlorine solutions.

Keywords: *Arduino Uno; UV-C, Portable Device; Sterilization; Coronavirus*.

In-silico Evaluation of a Pinhole Portable SPECT System Dedicated for Lu-177 Applications

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Aim: The objective of this research concerns the development of a portable gamma-camera using a pinhole collimator to increase the accuracy of image-based dosimetry clinically derived data of Lu-177. Several parameters of the pinhole collimator were tested using Monte Carlo simulations to investigate the effect of minification and to achieve better images in terms of resolution.
Material and Methods: The investigation of the pinhole collimator design was based on the GATE MC toolkit. For our purpose, a FOV 10x10cm^2 and a 5x5cm^2 SPECT knife-edge aperture camera were modelled. In each case, the tungsten pinhole collimator's height and aperture were modified since tests with height of 8mm and 5mm were implemented while the inner size of the hole was tested for 1.2mm and 2mm and the outer size of the hole was set at 7mm. In addition, the crystal size of the detector varied from 1x1mm^{2}to 2x2mm^2 with 0.2mm septa. In our experiments, we apply 1:5 scale minification with object-to-pinhole distance equal to 100mm, while the detector-to-pinhole distance is 20mm. A typical fillable Derenzo phantom with pixel size 1.43x1x1.43, and rods of diameter varied from 15mm to 7mm was simulated, while each rod was filled with Lu-177 activity. All the simulations were executed in an HPC centre for speeding-up their computational time. 112 jobs/simulations were running in parallel, significantly reducing the time consumption.
Results: The intrinsic spatial resolution of the system is ~2 mm and thus we expect to see two separate objects at 10mm distance when we apply 1:5 scale. With FOV 10x10cm^2 camera and pinhole collimator of height 8mm, inner hole of 1.2mm and crystal size of 1.5x1.5mm^2 we are able to observe spheres with 11.4mm distance between them, while the rods with diameter 10mm are barely depicted. Identical results were collected also with the FOV 5x5cm^2 camera using 1x1mm^2 crystal.
Conclusions: In this abstract the design of optimized pinhole collimator for Lu-177 therapy is presented. The next step of our objective will be to construct the 5x5cm^2 device, in order to act as an assistant tool for the clinicians acquiring more post-therapy images at different time points.

Keywords: *Pinhole; Lutetium; MC Simulations; GATE; SPECT.*

Acknowledgements: *The European Regional Development Fund (ERDF), Greek General Secretariat for Research and Innovation, Operational Programme "Competitiveness, Entrepreneurship and Innovation" (EPAnEK), under the frame of ERA PerMed (project POPEYE T11EPA4-00055).*

Statistical Analysis of a Questionnaire-Based Survey for Assessing the Impact of Taiji on the World Health Organization Definitions Regarding Quality of Life (QoL)

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Aim: To evaluate the impact of Tai Ji on the Quality of Life (QoL). Tai Ji might be considered a Traditional Chinese mind-body approach, involving repetitive, and often symmetrical, exercise patterns (forms), which include slow and gentle body movements, natural breathing, and mental participation.
Method and Material: An anonymous online questionnaire was designed to investigate the effect of Tai Ji on QoL in terms of body health, body function, social life, emotional status, and stress. The questions were formed based on the guidelines of the World Health Organization regarding the definition of QoL. The questionnaire was implemented on the Microsoft Forms platform, using multiple choice questions, short text answers, and Likert-based scales, The questionnaire was made public to practitioners of the Flow Tai Ji Center in Greece. The sample comprised 70 replies, 56% women and 44% men. The median age group was 41-50 years old with a university education (77%). The median experience in Tai Ji was 3-5 years.
Results: Most participants declared that Tai Ji greatly improved all aspects of their QoL. Most significant improvements were observed in the reduction of pains in the neck (96.2%), the enhancement of flexibility (96.1%), the increase of social contacts (82.1%), the increase in vitality (89.9%), and the reduction of agitation (93.3%). Very few participants declared negative effects in muscle pains (3.2%) and agitation (3.3%). The main reasons that participants identified as most important for choosing to practice Tai Ji were a/ to cultivate the feeling of calmness, b/ to improve their body health level, and c/ to improve their cardiovascular function. Most of the participants perceive Tai Ji as a/ philosophy, b/ therapy, and c/ physical exercise.
Conclusions: Traditional mind-body exercises, such as Tai Ji, seem to greatly improve the subjective perception of QoL of practitioners.

Keywords: *Tai Ji; Quality of Life; Health Improvement; Questionnaire-based Survey; Statistical Analysis.*

Higher Education of Biomedical Engineering in Greece: Undergraduate students' outcomes from 1989 to 2019

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Biomedical Engineering (BME) has become one of the most rapidly growing fields (research and development) in recent decades. This study aims to present students' academic achievements from the BME Department at the University of West Attica in Greece, formerly known as the Department of Medical Instruments Technology (till 2013) and as the Department of Biomedical Engineering Technology (till 2019) at the Technological Educational Institute of Athens, Greece. The results of the study focus on two aspects: (i) the graduation grade of the diploma and (ii) the duration of studies over the course of 30 years (1989-2019), for a total of 1845 students that successfully graduated. Analyzing the numerical data reveals several key findings: (i) Male students tended to achieve both the highest and lowest graduation grades in the majority of cases. (ii) The average grade throughout the entire period was approximately 6.5 (grading scale of 0-10, with minimum passing grade 5), (iii) About 59% of students completed their studies in 7.4 years, with an average grade of 6.1. Additionally, around 41% of students graduated after 5.7 years of study, with an average grade of 5.7. (iv) Optimal grades appear to be associated with completing the degree within a duration of 5-6 years.

Keywords: *Biomedical engineering higher education; Students' outcomes; Graduation grades; Department of Medical Instruments Technology; Technological Educational Institute of Athens.*

The Profession of the Biomedical Engineer in Greece: A Questionnaire-based Survey

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Aim: To evaluate career prospects, real-world employment conditions, and satisfaction in the biomedical engineering (BME) sector in Greece for graduates of the Biomedical Engineering Department of the University of West Attica, Greece.
Methods and Material: An anonymous questionnaire-based survey was designed with multiple-choice questions, short text answers, and Likert-based scales on the Microsoft Forms platform. The questionnaire was made public to the graduates of the Biomedical Engineering Department of the University of West Attica, Greece.
Results: On a total of about 12% of the Department's graduates from 1985-2022, results revealed that more than half found their first job placement even before completing their BME studies during their internship period, whereas the BME job was perceived as very interesting in a good environment (72-74%) with noticeable career prospects (46%), and satisfactory net salary (44%). Most participants declared that they work in Service and Sales domains (61%). Highest-paid participants (earning >1500 euros net salary) were predominantly PhD holders (72%), followed by MSc holders (25%) and BSc holders (16%). Highest-paying jobs were found in R&D, Sales, and Management.
Conclusions: There is a significant demand for biomedical engineers in the labor market in Greece.

Keywords: *Biomedical Engineering and Technology; Job Placement; Career Prospects; Working Conditions; Biomedical Engineering Department.*

Towards the Characterization of Schizophrenia by Acoustic and Temporal Analysis of Speech

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Currently, there are no established objective biomarkers for the diagnosis or monitoring of schizophrenia. Studies have shown that there are noticeable differences in the acoustic and prosodic patterns in speech of schizophrenics. The primary goal of the current study is to examine possible acoustic differences in vowel production between Greek speakers with schizophrenia and healthy controls. Eleven Greek speakers with schizophrenia and twelve healthy controls participated in the study. A wide range of speech features, covering time and frequency domains but also segmental and suprasegmental units, have been extracted and evaluated using the Praat software. The results showed significant differences between the two groups in F1 and F2 frequencies, in jitter, shimmer as well as in the total length of pauses in spontaneous speech. Statistical analysis based on the preliminary evaluated showed a good discrimination between the two groups ($p<0.01$). These can pave the way to future developments toward the detection of disease patterns using inexpensive and non-invasive methods.

Keywords: *Schizophrenia; Speech; Acoustic Features; Phonetic Features; Classification.*

Masking Emotions: Benchmarking Emotion Classification While Wearing Face Masks

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Human communication is undoubtedly one of the most fundamental aspects of our society, and emotions play a pivotal role in it. As technology advances at a staggering pace, it is only natural that we look to machines to interact with us in more human-like ways. The ability to recognize and interpret facial emotions is a crucial step towards this goal, and DeepFace has emerged as the most popular and effective library for this task. However, the COVID-19 pandemic has brought a new challenge to this field. With the widespread use of facial masks, both humans and machines struggle to perceive emotions accurately. In this article, we focus on the latter and present a comprehensive benchmark of the DeepFace library's performance when dealing with artificially generated masks. Our study, based on 30k images of the FER2013 dataset, includes a wide range of contextual factors, allowing us to expose the algorithm to various real-world scenarios. Our findings reveal a severe reduction in performance when facial masks are present, with some emotions being more affected than others. The F1-Score for "Disgust," for instance, drops to a mere 22.6% compared to the unmasked performance, while "Surprise" remains the least affected emotion, with a reduction of 48.7% for the F1-score. These results are crucial for improving dynamic and personalized human-machine interfaces in situations where masks are present. As we continue to navigate the challenges brought on by the pandemic, it is essential to keep in mind the impact on technology and its ability to interact with us in meaningful ways. By addressing these issues, we can pave the way towards a future where machines can communicate with us more naturally and empathetically.

Keywords: *Emotion Recognition; DeepFace Library; Facial Masks; Performance Reduction; Human-Machine Interaction.*

Prediction of Heart Wellness Based on the Analysis of Skin Color

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Heart-rate monitoring is crucial in scientific and technical fields as it provides essential information about cardiovascular health, exercise performance, and stress levels, enabling early detection and intervention for potential cardiac abnormalities or risks. Traditional methods for measuring heart-rate often require direct contact with the body, which can be invasive and inconvenient. In this analysis, we have studied the remote-photo plethysmography(rPPG) techniques for predicting heart wellness using different machine algorithms. To evaluate the effectiveness of different rPPG methods, we conducted a study with a diverse sample of 20 participants. We considered factors such as gender, skin texture (based on participants from India and Sierra Leone), and age group. By collecting data from various ppg and rppg methods, we aimed to determine the most accurate technique for heart-rate prediction. To accomplish this, we employed two machine learning algorithms: Lasso regression and Random Forest regression. These algorithms were trained on the collected heart-rate data to predict and compare the performance of different rPPG methods. Our research findings indicate that both Random Forest Regression and Lasso Regression models exhibit promising results in accurately predicting heart-rate non-invasively. The Random Forest Regression model achieved an average mean square error of 3.193 and coefficient of determination value of 0.885, while the Lasso Regression model achieved an average mean square error of 33.336 and coefficient of determination, R2, value of 0.086. The relatively low MSE and high R2 values obtained from the Random Forest Regression model demonstrate its superior predictive performance compared to the Lasso Regression model. This suggests that the Random Forest algorithm is better suited foranalysing the collected heart-rate prediction dataset using rPPG features. Our research findings underscore the potential of remote-photoplethysmography(rPPG) and machine learning algorithms in predicting heart-rate non-invasively. We have successfully analyzed the effective method across different genders, region, and skin color. Moreover, our study emphasizes the significance of considering factors such as skin color pigments and their impact on the accuracy of heart-rate predictions. By recognizing the influence of these factors, we can further refine and improve the performance of rPPG-based heart-rate monitoring systems.

Keywords: *Heart Rate; Skin Color; Remote-Photoplethysmography; Machine Learning; Color Pigments.*

Acknowledgements: *Thankful to VGST infrastructure support and the college administration for the moral support.*

Antimicrobial Resistance profiles of Escherichia coli from diarroeic weaned piglets in two Greek Regions over a five-month period (March-July 2021)

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Aim: In Greece, a National Monitoring Plan for Antimicrobial Resistance in sick pigs was recently launched within the 'One Health' context. We aimed at surveying the antimicrobial resistance profiles of 71 and 29 pathogenic Escherichia coli (E.c.) isolates obtained from weaned piglets with coliform bacterial diarrhoea (CBC) in the Regions of Central Macedonia (CEM) and Eastern Macedonia-Thrace (EMT), respectively, from 1st March to 31st July 2021.
Material and Methods: By using the disk diffusion method (according to the CLSI guidelines), we tested susceptibility of E.c.-isolates to six antimicrobials (ampicillin, ceftiofur, tetracycline, trimethoprim-sulfamethoxazole, gentamicin, enrofloxacin) selected following the marketing amounts of animal use in Greece.
Results: In the study, all E.c.-isolates were found to be resistant to ampicillin; 92/100 were resistant to tetracycline [CEM:69/71(97.2%) vs. EMT:23/29(79.3%), p=0.010] and 76/100 were resistant to trimethoprim-sulfamethoxazole. Of E.c.-isolates studied, 99/100 were susceptible to ceftiofur, 77/100 were susceptible to gentamicin [CEM:49/71(68.9%) vs. EMT:28/29(96.6%), p=0.016)] and 64/100 were susceptible to enrofloxacin.
Conclusion: In CEM and EMT, third-generation cephalosporins were the antibiotics of first choice for CBC, in contrast to penicillins and tetracyclines, for which a high rate of resistance was displayed. E.c.-resistance rate against the trimethoprim-sulfamethoxazole combination model was quite high. The difference in E.c.-resistance rates against penicillins and tetracyclines in the two Regions were attributed to different antibiotic consumption rates. Optimal treatment and prudent use of antimicrobials for pigs is imperative to secure animal health and prevent development of AMR. Monitoring AMR trends in bacteria from food animals is an important step in the 'One Health' approach.

Keywords: *Antibiotic Consumption; Monitoring Plan; One Health; Prudent Use; Susceptibility*.

Machine Learning Analysis of Nanodrug Delivery in 2nd Order Blood Flowing Through Porous Blood Vessels

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This study provides a framework to strategize localised efficient drug delivery in second order blood flowing through porous blood vessels using machine learning algorithms. With the assumption of long blood vessels, the flow governing equation, Navier-Stokes equation, is reduced to a simpler model which is consistent with the lubrication theory. We have solved this equation analytically with slip condition and obtained the analytical expression of the velocity profile for the Newtonian model. We modelled the concentration of nanodrugs with advection diffusion equation, to analyse the effect of nanodrug concentration on the localised disease. The particle concentration at the blood vessel wall has been evaluated using the finite difference method. To analyse the results, we have implemented machine learning algorithms including Gradient Boost, XG Boost, Regression tree, MLP Regressor, and Catboost Regressor. Our conclusion predicts the optimum machine learning in transferring the delivery of the nanoparticle drug.

Keywords: *Machine Learning; Drug Delivery; Nano Particles; Navier Stokes Equation; Advection-Diffusion Equation; Non-Newtonian Flow; Finite Difference Method; Fluid Dynamics.*

Optimization of X-Ray techniques with a physical phantom

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Aim. Dual-energy mammography refers to a specialized imaging technique used in X-ray radiology for screening pathological conditions in the breast. This technique allows for enhanced tissue characterization and improved image quality compared to the traditional single-energy radiography. In dual energy radiology, two X-ray spectra are generated, typically by using different X-ray beam energies or filters. These spectra are then simultaneously or sequentially acquired and processed to produce dual-energy images. To find the optimal energy spectra, we developed a physical phantom, to be used with an X-ray radiography machine. The aim of this study is to evaluate the performance of this phantom in increasing visibility in low and high-contrast objects.

Materials and methods. This study used a 3D printed model, mimicking compressed breast, made from Clear resin with 10 cylindrical holes on the top surface. The thickness of the phantom is 40 cm. The phantom was scanned at Canon radiography system twice: (a) the cylindrical holes were filled with iodine-based contrast; and (b) the cylindrical holes were filled with magnesium oxide. The phantoms were scanned at 6 different energies in the range 50 kVp - 120 kVp.

Results. Fifteen subtraction images were calculated by performing a pixel-by-pixel subtraction of each possible image pair. For each image pair, the contrast was evaluated. The results indicated that the best contrast rates for both phantoms are achieved for 50 kVp and 100 kVp, as the low and high energy, respectively. Images were subjectively evaluated by a radiologist, supporting the improvement of the image contrast of both low and high-contrast objects.

Conclusions. The study shows initial promising results of using the presented phantom in optimising appearance of objects in dual-energy mode, with strong suggestions for the usefulness of this technique for future clinical applications. Future work is focused on assessment of incident dose for the registered optimized exposures.

Keywords: *Contrast, Phantoms; X-ray Imaging; Optimization; 3D printing.*

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Monitoring and Tracking Output Parameters of a Radiological Unit

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Aim: Quality assurance plays a vital role in the effective operation of a medical X-ray unit. However, the widespread utilization of these systems combined with the limited number of medical physicists in Bulgaria presents a challenge in ensuring the continuous optimal performance of radiological systems. Nevertheless, one potential solution is to empower X-ray technicians to perform certain quality assurance tasks on a regular basis. This study aims to assign responsibility to an X-ray technician for dosimetry and image quality assurance of an X-ray unit.
Materials and Methods: The study was conducted using a planar digital X-ray system, Philips Juno DRF. The measurement of the dose was performed using the DOSIMAX Plus I with an RQA detector, while a test device called Primus L from Iba was employed to visually assess the image quality. No patient equivalent attenuator was used. Three distinct energy settings were selected for the measurements. More precisely, 95 kV with 400 mA for 9 ms, 70 kV with 250 mA for 52 ms and 60 kV with 125 mA for 225 ms. The position of the measuring equipment and other imaging conditions were kept constant throughout the study. The measurements were conducted on a weekly basis over a span of four weeks.
Results: The results indicated that the X-ray unit maintained consistent dose output and image quality throughout the evaluation period. The average dose with standard deviation for the four weeks was as follows: 95 kV - 261±9 mGy, 70 kV - 592±16 mGy, 60 kV - 991±19 mGy. The average measured milliseconds from the dosimeter were 8.8±0.3 ms, 51.5±1.6 ms and 224.8±6.0 ms, respectively. The visibility of the objects in the low and high contrast verification areas of the phantom remained constant, no change in their detection by visual inspection was observed.
Conclusions: The study demonstrated the preparedness and capability of an X-ray technician to carry out quality assurance tasks as part of their routine duties. This included evaluating the dose for a specific imaging protocol and ensuring the assessment of image quality.

Keywords: *Dosimetry; Image Quality; Quality Assurance; X-ray Imaging; X-ray Technician.*

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Detecting Changes in the Optic Nerve of Early Glaucoma Patients Using the RETeval System

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The present study was carried out at the Ophthalmology Clinic of the "Elpis" General Hospital of Athens between October 2022 and April 2023 through a memorandum of cooperation with the Biomedical Engineering department of the University of West Attica in Greece. We evaluated a sample of 140 eyes (59 with early glaucoma - case group, 63 healthy eyes - control group and 18 due to other pathological findings) in total with the aim to determine possible changes in the structural and functional level of the optical nerve in early glaucoma patients. Our test involved examinations and comparisons between the retinal nerve fiber layer (RNFL) and the electroretinogram (ERG) test obtained by the spectral-domain optical coherence tomography (OCT) system and the RETeval portable device, respectively. The parameters RNFL, awave, bwave and PhNRmin and W-Ratio were statistically analyzed using the SPSS software package and further examined for possible correlation between them. Our results showed statistical differences in the time response of ERG parameters between age interval subgroups (30-54 and 55-80 years old) for the control group. Additionally, a statistical difference appeared between the control and case group for both OCT and the RETeval parameters, some of which were highly correlated (e.g., the RNFL was found to be correlated to bwave (ms) and Wratio parameters). In summary, this research demonstrated the clinical supplementary valuable utility of the RETeval portable device in the diagnosis and management of glaucoma disease, especially in early stages.

Keywords: *Electroretinography; Glaucoma; Ophthalmology.*

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Effect of an Interventional Movement Program on Mechanical Gait Characteristics of a Patient with Dementia

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Purpose: To investigate the possible effect of an occupational therapy movement program (OTMP) on specific mechanical characteristics of walking, under different walking conditions in a person suffering from dementia.
Methodology: The hip joint of a dementia patient (dominant limb) was selected for study and determined in terms of flexion, extension, adduction, abduction and internal or external rotation movements. The conditions under which the study took place were simple gait and dual-task gait: motor (walking while holding a tray with an empty glass) or cognitive task in parallel (walking while talking for specific object categories). The patient was assessed with neuropsychological scales and through the Gait analysis system (Vicon), pre and post the motor intervention program that aimed at enhancing functional gait. 30 gait attempts were performed and analyzed under all tasks.
Results: The OTMP consisted of exercises based in Activities of Daily Living. After the implementation of OTMP, it was found in Flexion# Extension: simple gait: pre/post: 17.22°/21.93°, dual task: +motor-pre/post: 18.13°/24.58°, +cognitive task: 17.27°/22.66°, in Adduction#Abduction: simple gait: pre/post: 2.55°/3.45°, dual task: +motor-pre/post: 3.49°/4.10°, +cognitive task: 1.15°/3.25° and in Internal #External rotation: simple gait: pre/post: -15.78°/-20.35°, dual task: +motor-pre/post:-14.93°/-25.07°, +cognitive task:-15.45°/-22.10°.A statistically significant increase in values in hip movements was observed ($p<.05$).
Conclusion: As hip motion is a necessary component for successful gait, the improvement in hip mechanical gait characteristics, is being translated as an extension in functionality. Working through an OTMP could contribute in functional independence of persons with dementia.

Keywords: *Angle; Dementia; Gait Analysis; Hip; Occupational Therapy.*

Regulation of the Phagocytic Activity of Astrocytes by Neuroimmune Mediators Endogenous to the Central Nervous System

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Aim: The phagocytic activity of glial cells is essential for maintaining normal brain function. Dysregulated phagocytic activity may contribute to various central nervous system (CNS) pathologies, including neurodegenerative diseases. Microglia are well known as the primary neuroimmune cells involved in phagocytosis. However, emerging evidence indicates that astrocytes can also function as CNS phagocytes in humans and rodents. Despite this recognition, our understanding of the molecular mechanisms regulating astrocyte phagocytosis remains limited. We hypothesized that 1) astrocyte phagocytosis is regulated by lipopolysaccharide (LPS) and neuroimmune mediators endogenous to the CNS, and 2) there is a correlation between the modulation of the phagocytic activity of astrocytes and their other immune functions by neuroimmune mediators.

Methods: We studied the modulation of the phagocytic activity of murine primary astrocytes and human U118 MG astrocytic cells by four CNS inflammatory mediators and bacterial endotoxin LPS. The phagocytic activity of astrocytes was assessed by utilizing fluorescent latex beads and synaptosomes, and the engulfment was verified by confocal microscopy.

Results: LPS and cytochrome c (CytC) upregulated, but interferon (IFN)-γ downregulated, phagocytosis of latex beads by human astrocytic cells and phagocytosis of synaptosomes by murine primary astrocytes. Interleukin (IL)-1β and tumor necrosis factor (TNF)-α had no effect on the phagocytic activity of human astrocytic cells, but upregulated this function in murine astrocytes. Varying effects of combinations of the above inflammatory mediators were observed in these two cell types. LPS- and CytC-induced phagocytic activity of human astrocytic cells was partially mediated by activation of toll-like receptor 4 (TLR4). By observing other functions of astrocytes, we concluded there was no apparent correlation between the effects of the mediators studied on astrocyte phagocytic activity and their secretion of cytokines, cytotoxins, or glutamate.

Conclusions: We identified four candidate CNS regulators of astrocyte phagocytic activity. We confirmed TLR4 as one of the receptors modulating the phagocytic function of astrocytes. Further exploration of the molecular mechanisms underlying this regulatory process holds promise for identifying novel therapeutic targets enabling the manipulation of astrocyte-mediated clearance mechanisms in the context of CNS pathologies.

Keywords: *Alzheimer's disease; Damage-associated Molecular Patterns (DAMPs); Cytokines; Particle Uptake Regulation; Neuroinflammation.*

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Effect of Structure and Biomaterial on the Mechanical Properties of 3D Printed Nanocomposite Scaffolds

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In the current study, the effect of the infill pattern of 3D-printed nanocomposite scaffolds as well as the biomaterial's compositions with respect to their mechanical properties were studied. The bioresorbable thermoplastic polymer chosen as the matrix was polylactic acid (PLA) reinforced with chitosan (CS) containing 4% of chemically modified oxidized multiwall carbon nanotubes (MWCNTs). These biomaterials were chosen in an effort to develop scaffolds with the suitable structure, chemical composition, and stiffness to trigger signals to enhance osteogenesis and angiogenesis. The weight fraction of the CS-MWCNTs hybrid in PLA was 5%. Both the pure PLA and reinforced PLA nanocomposite were used to manufacture 3D-printed scaffolds with 3 different infill patterns. The 3 different patterns were: rectilinear 0°-90°, rectilinear ±45° and gyroid. The final specimens were cube-shaped with dimensions of 5x5x5 mm3 and were tested under compression and in all cases, a constant crosshead velocity of 10mm/min was applied. It was concluded that the compressive properties of the gyroid infill pattern were subpar when compared to the rectilinear infill patterns. Also, it was observed that the strength of the scaffold decreased when CS-MWCNTs were introduced in the PLA matrix.

Keywords: *Biomaterial; 3D-printing; Chitosan-MWCNTs; Nanocomposite; Polylactic Acid (PLA); Scaffold.*

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Towards Green Affordable Bone Scaffolds: Preparation and Physicochemical Characterization of 3D Printed PCL/Eggshell Biodegradable Bone Scaffolds for Maxillofacial Reconstruction

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Nowadays global attention is directed towards converting to a more sustainable and greener life. Focusing on bone tissue engineering (BTE), finding greener alternatives to both conventional materials and fabrication techniques is indispensable. From this perspective, this paper proposes fabricating green yet affordable 3D-printed bone scaffolds with potential application in maxillofacial bone reconstruction. The proposed green material is a biodegradable poly ε-caprolactone (PCL) based composite reinforced with Eggshell (ES) bioceramic particles at different weight percentages (i.e., 0, 10, 30). The scaffolds were 3D printed by employing our previously proposed in-lab-built Heated Inductive-enabled Syringe Pump Extrusion (HISPE) multifunction open-source module that enables printing without employing any non-green additives e.g., toxic organic solvents. The mechanical and physicochemical characteristics of the 3D-printed scaffolds were investigated. The SEM images showed that these scaffolds have a fully open interconnected porous network with an actual pore size of 350 µm. Moreover, it was noted from these morphological investigations that increasing the ES wt% increased the surface roughness. Besides, the results of the in vitro water absorption and biodegradation tests proved that the surface wettability and biodegradability of the PCL-based composite scaffolds substantially improved by the incorporation of the 30 wt% ES. Mechanically, increasing the wt% of ES up to 30% notably improved the mechanical properties with the scaffolds reinforced with 30 wt% ES having a compressive strength and modulus of 6.1 MPa and 71.5 MPa which are absolutely comparable to those of the mandibular trabecular bone that ranges from 0.22 MPa to 10.44 MPa and 3.5 to 125.6 MPa, respectively. Hence, these results proved that these green scaffolds are capable of competing

Keywords: *Biodegradable biomaterials; Eggshell; Bone Tissue Engineering; Green Scaffolds.*

Advancing Neurological Disease Diagnosis and Prognosis through State-of-the-Art Machine Learning Models and Three-Dimensional Particle Reconstruction

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In clinical neuroscience, state-of-the-art technologies such as MRI and CT scans have transformed diagnosis and prognosis of complex neurological conditions. To build on these advancements, a novel methodology integrating advanced machine learning models for rapid and accurate three-dimensional reconstruction of particles was developed. These models assist healthcare professionals in crafting more effective treatment strategies. An interpretive simulation was proposed, grounded on the accumulated results for model assessment. This methodology incorporates potent imaging pipelines like generative adversarial networks (GANs), along with precision-tuned deep learning networks, featuring a densenet-41-based backbone architecture in conjunction with CornerNet. For the conduct of the study, a sample set was chosen from MICCAI 2020 dataset, consisting of brain MRI images. A total of 100 images were selected for the training set, with an additional set of 10 images earmarked for validation. Findings from the experiment exhibited an effective classification rate of 91.2% for the densenet-41-based backbone and 89.8% for CornerNet. To further refine classification, a Time-Lapse analysis was incorporated for sequential analysis. A Long Short-Term Memory (LSTM) layer was introduced to process voxels in sequence, enhancing the accuracy of tracking from voxel to voxel. Results from this study validate that the approach significantly improves both speed and accuracy in diagnosing and prognosing neurological conditions. The empirical findings adhere to relevant standards, enabling quantitative analysis for classifying multiple types of brain tumors.

Keywords: *Brain; Cancer; MRI; 3D Reconstruction; Time-Lapse.*