Editor's Corner

Biomedical Technology and Clinical Engineering in Greece after the Pandemic: Highlighted Works from the Panhellenic Conference of Biomedical Technology

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Statement: All papers submitted to the ELEVIT 10th conference were subjected to a peer review. The review was conducted by experienced and qualified members of the profession. Of the accepted papers the reviewers selected the best papers and recommended them to be published. The Conference was held in Thessaloniki, Greece from 6 to 8 October 2023. The Editor-in-Chief of the *Global CE Journal* communicated with the Guest Editors and participated in the selected paper review.

ABSTRACT

The period of COVID-19 dominated the biomedical and clinical engineering workflows, as researchers and front-line health practitioners raced against time to offer solutions to the disruption caused to global healthcare. The Hellenic Society of Biomedical Technology reacted to the challenge in accordance with European and global biomedical and clinical engineering societies, waging the information battle and engaging with the public and the research community. Nonetheless, as the globe was slowly returning to its usual pre-pandemic practices, biomedical technology also entered a transition period, evolving through the challenges of the pandemic and started resembling a sort of scientific normality. In that environment, this special issue constitutes a selection of works that were presented during the last two Panhellenic Conferences of Biomedical Technology. The articles were due to their scientific interest and excellence, but also to portray the transition of the biomedical audience's research interests from the pandemic to their more usual endeavors, albeit with the lingering influence of what transpired and how the biomedical and clinical engineering community reacted both globally and in Greece.

Keywords—*Biomedical technology, Clinical engineering, COVID-19 impact, Digital health transformation, COVID-19 transition.*

INTRODUCTION

The period of the COVID-19 pandemic, from 2020 up to 2023, disrupted societies worldwide including every aspect of everyday life.[1,2] Moreover, COVID dominated the biomedical and clinical engineering workflows, as researchers and front-line health practitioners raced against time to offer solutions to the disruption caused by global healthcare.[3] The pandemic of COVID-19 has caused over seven million confirmed deaths as of August 2024[4], leaving forever its mark on societies around the globe but also on the scientific communities that waged the battle for discovery, prevention, containment, and eventually treatment.[5] More specifically, it altered in both positive and negative ways[6] that the current generation of biomedical and clinical engineers are thinking with regard to communicable diseases, the urgency of research[7], and the importance of the fields as a whole.[8]

The Hellenic Society of Biomedical Technology (ELEVIT) reacted to the challenge in accordance with European and global biomedical and clinical engineering societies, waging the information battle and engaging with the public and the research community through webinars and other events.[9] During the last two conferences of Society, this swift was also evident both in the given directions by the organizers and in the submission of research works by the Greek biomedical community. Nonetheless, as the globe was slowly returning to its usual pre-pandemic practices, biomedical technology also entered a transition period, evolving through the challenges of the pandemic and started resembling a sort of scientific normality.[10] In that environment, this special issue constitutes a selection of works that were presented during the Panhellenic Conference of Biomedical Technology in 2021, a hybrid event due to the ongoing pandemic, and mainly in 2023, which marked the return to normal face-to-face scientific events for ELEVIT. The articles included in this collection were invited among the submissions of the two conferences due to their scientific interest and excellence, but also to portray the transition of the biomedical audience's research interests from the pandemic to their more usual endeavors, albeit with the lingering influence of what transpired and how the biomedical and clinical engineering community reacted both globally and in Greece.

CONTRIBUTIONS' OUTLINE

Education

The shift in medical education towards a student-centered approach has emphasized the importance of active learning and improving clinical reasoning skills over traditional passive learning and memorization.[11] Dratsiou *et al*. have explored the integration of Virtual Patients (VPs) into the medical curriculum, which simulates real-life clinical scenarios, allowing students to practice safely and repeatedly, anytime and anywhere, with resources available for mobile use called Mobile Virtual Patients (MVPs).[12] MVPs were incorporated into the H2020 SHAPES project[13] with a focus on assisting healthcare professionals and medical students in improving their abilities to handle, identify, and address symptoms in older patients, as well as enhancing their clinical reasoning and decision-making abilities. The researchers aim to investigate the experiences of healthcare professionals and students experience with Problem-Based Learning (PBL) using MVPs, particularly in terms of usability, technology acceptance, and clinical reasoning. The research emphasizes the importance of customizing MVPs to address the unique requirements of different groups in order to enhance their educational impact and support clinical reasoning development.

The path of health services towards a digital and value-based transformation is now a one-way street, with drastic and immediate effects that are capable of disrupting the sector and making it sustainable.[14] The most defining issue is how an organization adapts its organizational culture, strategy, and leadership and mostly prepares the staff to operate effectively in a digital world, adding value to users and sustaining prosperity.[15] This paper investigates the perceptions of health professionals regarding the usability and ease of use of digital transformation applications. Healthcare professionals who worked in various hospitals and health providers in Northern Greece were invited to fill in the USE questionnaire in a paperless format. The acceptance of digital transformation in healthcare professionals is based on understanding the concerns and feelings of insecurity that overwhelm healthcare professionals. Results can help the community better understand the factors that influence the adoption of new digital technologies. Likely, this will help to reduce

the time required to make all the structural changes that are necessary. As people accept change at different rates, there is no time for delay and their preparation should immediately begin to catch up with the post-COVID era.

Serious games (SG) incorporate learning and educational strategies commonly used in special education, and they have been proposed as assistive tools for people with developmental difficulties.[16] ID-GAMING e-training toolkit encloses an SG named "Qool City" available as a board and digital game, a game catalogue, and training materials on cognitive functions and quality of life. This paper describes the methodology and preliminary outcomes of the toolkit's validation actions. A four-step methodology was formed to specify the interaction of participants with the toolkit and a qualitative validation tool was developed to assess the participants' performance during the session. The target groups were young adults and adults with intellectual disabilities (PwID), professionals, and relatives. The ID-GAMING e-training toolkit seems to lead to improvement in various cognitive functions of PwID including memory, attention, language, and spatial orientation. Components of quality of life such as wellbeing and independence were also promoted. PwID remained engaged until the end of their interaction with the toolkit components while both PwID and educators were satisfied with the toolkit. SG's vigorous validation is of high potential for various strands of biomedical engineering spanning from rehabilitation, and training all the way to adherence and quality of life strategies.[17]

Services and Devices

Job applicants' skills evaluation has become increasingly difficult for companies and individuals especially in the tech industry due to its constantly evolving nature. This difficulty takes its toll with decisions of negative impact. As a solution to this problem, Bamidis *et al*. utilized a machine learning-based model that can effectively classify the software knowledge of developers, by recognizing the different technologies and programming languages implemented by them, thus assisting companies in managing their workforce based on acquired skills.[18] With previous work as their starting point, the authors implemented source code analysis by applying Natural Language Processing (NLP) techniques. The resulting model can be used as an effective tool for assessing the software knowledge of developers. The analysis helps obtain valuable insights into the effectiveness of neural networks and the benefits of transfer learning using pre-trained models. The potential for developing an assessment tool for developers of all flavors is of high value in the very demanding field of biomedical engineering.

Managing medical device data accurately is essential for patient safety and regulatory compliance in healthcare systems. Liontou *et al*. introduce a novel approach combining web scraping and API integration to streamline the retrieval and validation of medical device information.[19] By leveraging Unique Device Identifiers (UDIs) and the Global Medical Device Nomenclature (GMDN), the proposed method enhances device authentication, categorization, and data accuracy.[20] The research developed a code that integrates data from the AccessGUDID database with additional information obtained through web scraping. This hybrid approach ensures comprehensive data coverage, addressing the challenges posed by unstructured and disparate data sources. The results showed a 74% success rate in accurately matching medical device records, demonstrating the effectiveness of this system in improving data reliability. In the context of post-COVID healthcare, this study highlights the importance of advanced data management solutions in Greek biomedical engineering. By enabling more efficient device tracking and verification, these technologies support safer and more compliant healthcare environments, ultimately enhancing decision-making processes for medical professionals.

Neural Rehabilitation

Neurological diseases such as Cerebral Palsy, Parkinson's Disease, and Spinal Cord Injury greatly affect movement, balance, and posture.[21] Robot-assisted therapies have been created in the last few years to improve hand functionality for people with certain diseases, especially those that impact daily activities.[22] Sarra *et al*. focus on the mathematical analysis of human hand kinematics and dynamics to improve rehabilitation devices. A wearable soft robotic glove prototype with pneumatic actuators and sensors was developed incorporating a jacket, glove, and a neurorehabilitation serious game application. This study introduces a kinematic hand model and analyzes the

dynamic interactions. Personalized rehabilitation systems can be created by utilizing the Denavit-Hartenberg method to model robot-human interaction movements and forces.

People who have suffered from Spinal Cord Injury or have had a stroke often face difficulties in mobility, which can make their functional rehabilitation more challenging.[23] The lack of visible muscle activation in movement loss cases is causing difficulties for rehabilitation practitioners who need to find a solution. The issue was investigated by Lyssas *et al*. through the development of a Machine Learning model designed to identify and classify Electromyography (EMG) signals generated from skeletal muscle activation. This model replicates the state machine of the human skeletal muscle, identifying three key states: no activation state, activation state, and muscle fatigue state.[24] Three different machine learning models, including a Random Forest, a Support Vector Machine, and a Shallow Neural Network, were utilized and evaluated based on their speed and accuracy.[25] The authors conclude that in order to train the model effectively, a comprehensive database of EMG signals is required, which would improve the accuracy and efficiency of rehabilitation procedures.

The absence of basic rules and set procedures for building databases for surface electromyography (sEMG) signals, is a major challenge necessary for diagnosing and analyzing neuromuscular disorders. sEMG, a non-invasive method for evaluating muscle activity, is extensively utilized in clinical settings but lacks standardized databases for biometric comparison.[26] This obstacle limits its practical use in rehabilitation research, particularly in clinical settings. Arvanitidis *et al*. create a dynamic, scalable, consistent, available, and partition-tolerant NoSQL database. The database includes normative sEMG values from a diverse participant pool, covering both healthy individuals and those with spinal cord injuries or stroke, and also takes into account factors like gender, age, and BMI.[27] This scalable and flexible database seeks to improve accuracy in diagnosis and effectiveness in treatment in neurorehabilitation, providing researchers and clinicians with valuable tools for upcoming research.

Understanding the movement of humans is crucial, especially in cases of injury or illness, to develop successful rehabilitation techniques. Margaritis *et al*. explore this topic by providing a thorough analysis of lower limb kinematics and dynamics, while also outlining a plan for implementing a wearable device to assist in rehabilitation. Their main focus is on people who have tetraplegia or paraplegia to model the lower limbs using rigid links connected by joints with specific degrees of freedom and range of motion. The movement capacities of the hip, knee, and ankle joints are examined using the Rigid Body Segment Model Approach and the Denavit-Hartenberg convention to establish kinematic chains.[28] The matrices of these joints assist in determining the location and alignment of the end-effector, crucial for both forward and inverse kinematics. The study distinguishes between Geometric and Analytical Jacobian matrices, utilizing the former to convert joint velocities to Cartesian space velocities. Dynamic equations, based on the Lagrangian method, elucidate the connection between motion and force, facilitating the analysis of intricate systems. This comprehensive approach aims to improve rehabilitation strategies through precise modeling and analyzing lower limb movements.

Functional Electrical Stimulation (FES) is widely used in neurorehabilitation to aid recovery in patients with neurological conditions like stroke and spinal cord injury (SCI).[29] By synchronizing electrical pulses with natural movements, FES enhances neuromuscular adaptation and brain reorganization, leveraging neuroplasticity for improved functional recovery.[30] Arsenidis *et al*. explored optimizing FES parameters using conventional and AI-based techniques to maximize therapeutic outcomes. The authors developed an AI-driven system that adjusts stimulation parameters in real-time, considering individual patient responses to achieve optimal results. Preliminary in vivo experiments demonstrated the potential of these methods in reducing muscle fatigue and discomfort during therapy, paving the way for more effective rehabilitation protocols. This research underscores the role of innovative technologies in refining rehabilitation practices, particularly in the post-COVID era, where personalized, data-driven approaches are essential for enhancing patient outcomes in Greek biomedical engineering.

Novel Applications

Magnetoencephalogram (MEG) and consequently analysis of the images it produces[31] is at the forefront of research when it comes to implementing automated methods for the detection, diagnosis, and prediction of epileptic activity[32], with epilepsy being one of the most common neurological disorders with tens of millions of patients globally suffering from seizures. Such methods should help reduce human errors by specialized personnel while analyzing MEG images. Advanced models have been previously published for Electroencephalogram (EEG), however, the number of publications addressing MEG classification is scarce. Stylianou *et al*. tested, compared, and evaluated some basic models to build a solid understanding of the characteristics of the available data and gain insights into the model's behavior. The results corroborated the power of MEG as a diagnostic tool for epilepsy as even less sophisticated models performed well. In the post-COVID era, it is important to demonstrate results that will eventually find their way into everyday neurology clinic settings in Greece and beyond.

Astrocytes play a significant role in the pathogenesis of multiple sclerosis (MS), a chronic neurodegenerative disease affecting millions globally.[33] These glial cells are crucial for maintaining neural homeostasis but also contribute to the disease by influencing inflammation and neuronal repair.[34] Tsimperi *et al*. employed biophysically realistic models to simulate astrocytes' impact on MS, focusing on axonal conduction and sodium channel facilitation in demyelinated axons. By examining astrocyte morphology and its effects on cellular functions, the research highlighted the dynamic roles of astrocytes in both physiological and pathological conditions, offering valuable insights into their complex behavior. The results underscore the potential for advanced modeling techniques to deepen our understanding of MS and guide future therapeutic developments.[35] In the context of post-COVID Greek biomedical engineering, this study emphasizes the importance of innovative computational tools in enhancing our ability to explore complex biological processes and improve the management of chronic neurological conditions.

Accurate patient categorization is of vital importance, especially for those who suffer from cardiovascular diseases (CVDs), the leading cause of death worldwide. In the particular case of aortic valve stenosis (AS), the primary method used for categorizing, *i.e.*, assessing, the severity of AS is the non-invasive echocardiography.[36] Therefore, in recent years, there has been an increased demand for more effective assessment of individuals with AS and a deeper understanding of the flow field along the aortic valve.[37] In this context, Makropoulos *et al*. discuss the construction of a computational fluid dynamics (CFD) model for simulating the flow along the aortic valve, utilizing real patient data. Moreover, a comprehensive analysis is conducted of the impact of aortic valve stenosis on the flow field. In this manner, this research aims to analyze the flow along the aortic valve for various constriction configurations, thereby enhancing our understanding of the phenomenon and facilitating future investigations in the quest for an additional index that will serve as a supportive tool in patient categorization. Greek multidisciplinary research groups have focused on the challenging topics of our era, producing important results.

Skin conditions, from benign issues to severe malignancies like melanoma, pose a significant challenge in dermatology. Moraitopoulos *et al*. present the DermaSense device, utilizing Electrical Impedance Spectroscopy (EIS), which is a novel diagnostic tool designed to enhance the accuracy of skin condition assessments.[38] This mobile, cost-efficient device aims to differentiate between healthy and pathological skin through non-invasive impedance measurements, improving dermatological diagnostic decisions. The study tested the third prototype of DermaSense in both lab and clinical settings, showing its capability to distinguish skin conditions like actinic keratosis from healthy tissue. The results confirmed the device's precision, especially when using stainless steel electrodes, providing reliable data that supports clinical decisions. Future enhancements will incorporate machine learning for refined data categorization, further boosting diagnostic performance. This represents a significant advancement in Greek biomedical engineering, offering a more precise, accessible tool for dermatologists. Its development underscores the importance of integrating innovative technologies into healthcare to improve patient outcomes and streamline diagnostic processes.[39]

CONCLUDING REMARKS

Fourteen articles in total were included in this collection spanning a wide spectrum of biomedical and clinical engineering topics, ranging from education (e-training toolkits, software skills identification, virtual patients for digital problem-based learning), to services and devices management (digital health management services, medical device management), to rehabilitation (wearable robotics, kinematics, normative data, functional electrical stimulation) and novel applications (electrical impendence spectrography, vessel flow modeling, astroglial dynamics, magnetoencephalography for epilepsy). The variety of topics underlie the dynamic of Greek biomedical and clinical engineering communities and the perseverance of research and development directions through and after the COVID-19 pandemic. In the same spirit, we invite the readers to explore these dynamics, the topics, and the specific works included and hopefully to get inspiration for their own work and research endeavors.

CONFLICTS OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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