EDITORIAL

New Trends in Biomedical Signal Processing: A Crossroads Between Smart Sensors in E-Health and Virtual Physiological Human Initiatives

We are happy to present this special issue of The Open Biomedical Engineering (TOBEJ) focused on the converging field of smart sensors and virtual physiological human (VPH) initiatives, in the framework of biomedical processing for e-health.

Biomedical knowledge is one of the pivots of e-health research. This is oriented to the discovery and management of customized and adaptive biomedical information concerning the assisted users, organizational workflows, and living situations. Signal processing in e-health is deployed by means of layers of distributed components from smart sensors to mathematical models in computing provider centers. Mathematical models have been typically considered as pertaining to data-driven category in this field, notwithstanding there is a recent trend to use also structural mathematical models like those of VPH initiatives in e-health systems.

This special issue tries to present this new research scenario by means of a set of articles addressing several aspects of the crossroads.

Chronic pathologies are one of the main targets of telehealthcare systems. Cardiovascular diseases are among those with highest prevalence rates, and many efforts have been addressed towards this healthcare domain in e-health.

In this regard, the paper published in this special issue by Pinheiro *et al*. presents an outstanding review of ballistocardiography. This is a method for measuring the heart beat induced movements of human body, due to forces related to heart contraction. This technique has been proved to be very useful in the evaluation of the global state of the cardiovascular system.

Ballistocardiography reached its first golden age in mid 20^{th}, but some difficulties in the interpretation of signals, together with restrictions of electronic technology, avoided the expected clinical diffusion. Current advances in piezoelectric sensors and signal processing methods, together with advantages of ballistocardiographs, which could be embedded in daily life objects, like a bed or a chair, in line with trends of ambient assisted living and unobtrusive monitoring, are boosting ballistocardiography.

Authors propose a new concept of ballistocardiograph monitoring in the area of telehealthcare as an alternative to traditional electrocardiograms. This is in agreement with the current trend in the development of non-invasive sensors, unobtrusive and ubiquitous care, allowing the users themselves to take part in the monitoring of their disease and pushing personal care at home.

In additions to developments in signal processing and ubiquitous computing able to integrate ballistocardiographs within the environment, there is a new interest to focus the physiological interpretation of measured signals. Advances in this research line suggest that multilevel biomedical knowledge from initiatives in the systems biology domain like Physiome and VPH should have an important influence. Advances performed in other biomedical processing signal areas such the study of heart rate variability (HRV) and blood pressure variability (BPV) are helping in this task.

The electrocardiography (ECG) is one of the first successful paradigms in biomedical engineering. It started in the beginning of 20^{th} and the contributions to the knowledge in this field has evolved together with other relevant areas, providing methods and technologies to the telehealthcare arena, both in sensors and signal processing techniques, as well as to the Physiome and VPH initiatives.

The paper of Bakul and Tiwary published in this special issue proposes an efficient method to identify the risk of myocardial infarction early from 12-lead ECG. The incorporation of automatic methods to support medical diagnosis is extremely important to ensure the best interpretation from biomedical signals acquired, such as electrocardiogram. Nowadays, there are a large amount of available data, more precision and less noise in sensors and devices, which provide high quality and an increasingly quantity of items to be analyzed.

Current sensors allow the estimation of changes in the amplitude and frequency of the samples, providing a method with accurate results and, the most relevant, discarding the influence of the particular subject under study. In this work, authors present a method based on new features from the ECG to reduce the influence of the subject's body composition. They show how a Support Vector Machine (SVM) classifier based on a sigmoid kernel, working over these new features, gives a better accuracy, sensitivity and specificity than previous features-based methods. It is important to realize the potential of extending the proposed technique for other uses in the pathologies diagnostic.

Magnetoencephalography MEG is an imaging technique for mapping brain activity with both high spatial and temporal resolution. Its emergence to the biomedical market started in 1980's, once superconducting quantum interference devices (SQUID) were available. There are currently whole-head helmets with more than 300 sensors. Advances in signal processing methods and microelectronic devices, together with its non-invasive character, suggest that this measurement technique can be very relevant in many brain-diseases diagnostics and prognosis.

The study by Gómez and Hornero published in this special issue presents a very relevant finding in this direction. They performed a MEG study over 36 Alzheimer's disease (AD) patients and 20 controls, analyzing the complexity of brain activity

by six entropy and complexity measurements. Their results showed that MEG recordings are less complex in AD patients than in controls. In additions, it was possible to design a classifier based on the Shannon spectral entropy index with an accuracy of 77 %.

AD is the main cause of dementia among the elderly in western countries. The inversion of demographic pyramid and the growing incidence of dementia have propelled the research in this area of e-health. The major interest is focused on the prognosis of dementia and the delay of more severe stages. The non-invasive character of MEG, together with current fusion imaging modalities and advances in mathematical neurophysiological models, suggest the relevance of this technique to validate reduced models that could be used as a basis of smart sensors in telehealthcare systems for the elderly.

The connection between smart sensors and VPH has been analyzed with detail in the paper by Fernández-Peruchena and Prado-Velasco published in this special issue. Authors present a novel paradigm for addressing the design of personalized therapies in diabetes mellitus (DM). DM is also one of the chronic pathologies in modern societies with highest growing rates of prevalence and incidence, particularly in the case of type 2 DM.

Diabetes mellitus has a high influence on the growing of other chronic pathologies like renal disease, hypertension, and cardiovascular diseases. Authors perform a detailed review of DM pathology from different perspectives, and suggest the way in which VPH initiatives together with smart sensors, in the framework of e-health, can help to design a personalized, preventive, and predictive healthcare model that improves the low quality of life of patients suffering this pathology.

Conclusions of the last study are not restricted to DM. A relevance suggestion is that this converging approach should help to exploit the existing synergies among knowledge generation and management in e-health and knowledge generation and management in VPH, using different methodologies and perspectives.

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