Guest Editorial: Introduction to the Special Section on Biomedical Informatics

I. Introduction

THIS Special Issue is based on selected papers presented at the International Special Topic Conference on Information Technology in Biomedicine, held in October 2006, in Ioannina, Epirus, Greece. The event was technically cosponsored by the IEEE Engineering in Medicine and Biology Society and sponsored by the University of Ioannina, Greece, the National Technical University of Athens, Greece, the University of Cyprus, Cyprus, and SPIRIT, Greece. It marked the continuation of the previous five successful conferences held in Prague in 1997, in Washington, DC, in 1998, in Amsterdam in 1999, in Virginia in 2000, and in Birmingham in 2003, whereas two more successful conferences were held after Ioannina, in Tokyo in 2007, and in Shenzhen in 2008. The International Conference on Information Technology and Applications in Biomedicine (ITAB) 2009 will be held in Cyprus, November 2009 (see http://www.cs.ucy.ac.cy/itab2009/).

The works of the ITAB 2006 Conference were dedicated to the memory of two pioneers of information technology in biomedicine, namely, Prof. Swamy Laxminarayan, Idaho State University, USA, and Prof. Stelios Orphanoudakis, University of Crete, Greece. It is very difficult to describe their contributions in the field, but, simply, to say a few words, they have both played a catalytical role in both research and applications in biomedical information technology. Moreover, it should be mentioned that it was the idea of Prof. Laxminarayan to organize the first ITAB conference in Prague, together with the late Prof. Ian Krekule of the Academy of Sciences of the Czech Republic. Also, Prof. Laxminrayan was the Founding Editor of this journal.

The overall objective of ITAB 2006 was to cover the state of the art of information technology applications in biomedicine. A total of 138 papers were presented, with 48 on eHealth, 36 on biosignal analysis, and 24 on medical imaging. These papers originated from 27 different countries. Also, 38 papers were presented by students and a student paper competition took place. The first prize was awarded to Anna Karahaliou from the University of Patras, Greece (see paper [1]), the second prize to Verónica García-Pérez from the University de Valladolid, Spain (see paper [2]), and the third prize to Vaclav Gerla from the Czech Technical University in Prague, Czech Republic (see paper [3]).

The aim of this Special Issue is to provide a snapshot of emerging technologies in biomedical informatics, based on a selected number of papers and the finalists of the student's paper competition presented at ITAB 2006. A total of ten papers were accepted organized under the topics Computational Biology, Biosignal Analysis, Medical Imaging, and Virtual and Augmented Reality and Visualization, and with two, three, four, and one papers, respectively. Some of these papers have been published in previous issues of IEEE Transactions on Information Technology in Biomedicine. These papers are briefly presented in the following section.

II. Papers in This Special Issue

A. Computational Biology

The paper by Doukas *et al.* [4] proposes a method for assessing computer-supported angiogenesis quantification using image analysis and statistical averaging. Angiogenesis is a complex process, involving multiple crosstalk among tumor, endothelial, and stromal cells, in order to establish a biochemical network for oxygen and nutrients supply, necessary for the promotion of tumor growth. In this sense, measuring angiogenic activity is considered an informative marker of tumor growth or its inhibition. One of the most popular test beds for the study of angiogenesis is the developing chick embryo and its chorioallantoic membrane (CAM). In this paper, an automated image analysis and statistical processing method for the extraction of features informative for the angiogenic process is proposed and a Web-based tool that provides an unbiased quantification of the microvessel density and growth in angiogenic CAM images is described.

Pirogova *et al.* [5] investigate the interaction between oncogene and tumor suppressor proteins. It is known that cancer cells grow and divide with no order, they never differentiate into the specific tissue, and thus, they are functionally different from normal cells. However, there are some genes that help to prevent cells' malignant behavior, and therefore, are referred to as tumor-suppressor genes. In this study, the authors investigated the structural and functional relationships of p53 oncogene and interleukin 2 (IL2) proteins using the resonant recognition model (RRM), a physicomathematical approach based on digital signal processing methods. In addition, using the RRM methodology, they have designed the peptide analogs that would exhibit tumor suppression-like activity that can be used in anticancer vaccine development.

B. Biosignal Analysis

Gerla *et al.* [3] propose multivariate analysis of full-term neonatal polysomnographic data. This paper addresses the problem of polysomnography (PSG) noninvasive analysis for

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studying maturation of the child brain in differentiating between three neonatal behavioral states: quiet sleep, active sleep, and wakefulness. Multichannel signal analysis was carried out on 12 newborns on whom the following biosignals were recorded: electrooculogram, electromyogram, ECG, and respiration (pneumogram). Hidden Markov models were investigated for classifying features extracted from these signals, achieving a high success rate.

The paper by Hutten [6] presents ventricular intramyocardial electrograms and their expected potential for cardiac risk surveillance, telemonitoring, and therapy management. Although ventricular intramyocardial electrograms are recorded with electrodes directly from the heart either in intraventricular or epimyocardial position, the morphology of these signals differs significantly from that of body surface ECG recordings. There is increasing evidence that intramyocardial electrograms have a high potential for cardiac risk surveillance, e.g., for arrhythmia detection, recognition of rejection events in transplanted hearts, and assessment of hemodynamic performance. Employing implants with telemetric capabilities renders possible permanent and even continuous cardiac telemonitoring. Furthermore, the signals can be utilized for supporting therapy management, e.g., in patients with different kinds of cardiomyopathies.

The paper by Sakkalis *et al.* [7] investigates the assessment of linear and nonlinear synchronization measures for analyzing EEG in mild epileptic patterns. In this study, cognitive function is evaluated in children with mild epileptic seizures controlled with common antiepileptic drugs. A technical framework of combining and validating both linear and nonlinear methods is proposed to efficiently evaluate (in terms of synchronization) neurophysiological activity during a visual cognitive task consisting of fractal pattern observation. The results on the actual data suggest that there is a significant difference, mostly apparent in occipital–parietal lobes during fractal observation tests.

C. Medical Imaging

The paper by Karahaliou *et al.* [1] investigates texture properties of the tissue surrounding microcalcification (MC) clusters on mammograms for breast cancer diagnosis. Tissue surrounding MCs is defined on original and wavelet-decomposed images based on the redundant discrete wavelet transform. Gray-level texture and wavelet coefficient texture features at three decomposition levels are extracted from surrounding tissue regions of interest. The ability of each feature set in differentiating malignant from benign tissue is investigated using a probabilistic neural network, and classification outputs of most discriminating feature sets are combined using a majority voting rule. The proposed combined scheme achieved a high area under the receiver operating characteristic curve. Results suggest that MCs' surrounding tissue texture analysis can contribute to computer-aided diagnosis of breast cancer.

Coatrieux *et al.* [8] propose reversible watermarking for knowledge digest (KD) embedding and reliability control in medical images for applications such as in e-learning or in telediagnosis. The aim of such a KD is for it to be used for retrieving similar images as well as with either the same findings or differential diagnoses. It summarizes the symbolic descriptions of the image, the symbolic descriptions of the semiology, and the similarity rules that contribute to the importance of descriptors when comparing images. Watermarking also helps to convey reliability proofs (integrity and authenticity) of an image and its KD when used through open networks.

Athanasiadis *et al.* [9] investigate the segmentation ability of the fuzzy Gaussian mixture model (FGMM) clustering algorithm applied on complementary DNA (cDNA) real microarray images containing 6400 spots. The FGMM and GMM algorithms were applied to each cell, with the purpose of discriminating foreground from background. The FGMM was found to perform better and with equal processing time, as compared to the GMM, making the FGMM algorithm an efficient alternative for segmenting cDNA microarray images.

The paper by Iakovidis *et al.* [10] proposes a novel scheme for efficient content-based medical image retrieval, formalized according to the PAtterns for Next generation DAtabase systems framework for pattern representation and management. The proposed scheme involves block-based low-level feature extraction from images followed by the clustering of the feature space to form higher level, semantically meaningful patterns. Experiments were performed on a large set of reference radiographic images, using different kinds of features to encode the low-level image content. Through this experimentation, it is shown that the proposed scheme can be efficiently and effectively applied for medical image retrieval from large databases, providing unsupervised semantic interpretation of the results, which can be further extended by knowledge representation methodologies.

D. Virtual and Augmented Reality and Visualization

García-Pérez *et al.* [2] propose a new method for collision handling between 3-D deformable (organs) and rigid (surgical tools) objects that can be used for nonstructured interaction scenes and for laparoscopic surgery simulators. Experimental results show that the solution proposed in this paper that is based on fuzzy logic is able to avoid the interpenetration among the multiple colliding points efficiently with physically and spatially coherent results.

III. Concluding Remark

It is a fact that health services nowadays are facing a number of complex interacting and multifactorial challenges, which according to a recent paper by N. Saranummi [11], include: 1) healthcare costs that are increasing as people grow older, which is especially true in developed countries; 2) current lifestyles that contribute toward increased prevalence of chronic degenerative diseases; and 3) widely expanding coverage of the healthcare services based on new and innovative technologies. It is clear that to address the aforesaid challenges, major changes are needed in order to make it possible to offer a better service to the citizen [11].

To address the aforesaid issues from the information and communication technologies (ICT) perspective, the World Health Assembly (WHA) at its 58th session in May 2005 adopted resolution WHA58.28 establishing an eHealth Strategy for the World Health Organization (WHO). The resolution urged member states to plan for appropriate eHealth services in their countries. It also recognized that a WHO eHealth strategy would serve as a basis for WHO's activities in eHealth [12]. It was documented that the use of ICT for health is one of the most rapidly growing areas in health today. However, limited systematic research has been carried out to inform eHealth policy and practice.

In parallel with the WHO activities, the European Commission (EC) in 2004 adopted the eHealth action plan [13], which covers a wide spectrum of eHealth services, ranging from electronic prescriptions and health cards to new information systems that are targeting to reduce waiting times and errors to facilitate a more harmonious and complementary European approach to eHealth. The plan sets out the steps needed for the widespread adoption of eHealth technologies across the EU by 2010 and urges member states to develop national and regional eHealth strategies to respond to their own specific needs. In support of the EC eHealth action plan, several activities have been undertaken, including the more recent recommendation "on cross-border interoperability of electronic health record systems communications" [14], and communication "on telemedicine for the benefit of patients, healthcare systems, and society" [15].

Concluding, given the aging population, the increased burden of chronic diseases, the offering of innovative and demanding healthcare services, and the ever increasing healthcare costs, there is a huge and urgent need for the development, implementation, and deployment in everyday medical practice of eHealth systems and services in support of the citizen. Thus, in this context, ITAB conferences will continue contributing to these directions, and this Special Issue is simply a minute contribution.

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