ABSTRACT

Nowadays, technological advances perform a significant role in the healthcare systems development especially with the speedy increased number of elderly populations in the last years. Patient Health Monitoring Systems importance is gained from the growing demands for medical care systems to observe several medical parameters. This research aims to identify the major techniques and communication protocols that are used in the wearable sensor networks and to highlight their advantages and disadvantages. A significant number of research papers will be reviewed as a current state-of-the-art for each technique. A large diversity of components of wearable health monitoring system (WHMS) will be illustrated and analyzed such as biosensors, control units, wireless communication modules, processing units, medical shields, links, power supplies, wearable materials, software, and also the advanced algorithms that are used for decision making and data extracting. An architecture emphasizing the wireless communication modules for WHMS is also proposed.

The overall goal of a complex wearable healthcare monitoring system (WHMS) is to support design and development of the high impact personalized ICT healthcare services based on measurements of health state acquired by sensors capturing everyday physical, cognitive and social activities. The acquired data will be fed into the risk prediction model to perform personal profiling and to identify deviations from the expected baseline of each specific user groups. In this research, a robust comparison of different solutions of architectures dedicated to Wearable Health Monitoring Systems (WHMS) based on microcontrollers and FPGAs are presented and analyzed. It is also proposed a new architecture that uses all the advantages of its components. An embedded microcontroller will facilitate the communication. An eHealth specialized platform like MySignals Hardware Development Platform V2.0 will be used for recording and analyzing the data coming from the medical biosensors. For a critical analyze of the current state of the art, a set of relevant research papers will be reviewed.

The Electrocardiogram (ECG or ECG) is a semi-cyclic, rhythmically, and synchronous signal with a cardiac function through the passive sensory apparatus in which bioelectric signals are generated mimicking the function of the heart. The ECG signals are inherently weak and noisy, built of many variable components due to several environmental factors like changes in body temperature, body movement or in the line frequency of 50/60 Hz. The ECG signal cannot be conditioned, amplified, nor reproduced directly and therefore, digital filtering techniques with adjustable window are used in this work. The work analyses several models of Finite Impulse Response (FIR) filters of low-pass and high-pass and their aspects in terms of response time, gain, and harmonic distortion, and rejection to determine the best band-pass filtering model to reproduce an ECG signal that closely resembles the actual Heart function of a patient. A hybrid filtering model is proposed and experimentally tested. Mean square error (MSE) is used to estimate a signal robustness. MATLAB environment has been used for the experimental part to simulate the signals.

The research presents a robust deep learning approach for ECG automatic diagnose. For this purpose, Deep Convolution Neural Network (D-CNN) algorithm and a multiclass model for SVM classifier will automate the detection process of ECG images specific to atrial fibrillation cases. In this research work, a pre-built and pre-trained D-CNN model is

developed. It applies transfer learning which has been proved as a robust technique for computer vision. The early layers of convolutional network are frozen and only the last few layers are trained, identifying objects in images either through a database search or through real-time analysis and detection of the fetched image. Further, the study includes a comparison between the results of using data augmentation techniques and the results without using it. We achieved an average 99.21% of accuracy. The implementation environment of our work is based on MATLAB using Deep Network Designer toolbox.

Building an interactive healthcare environment became an essential need to improve and increase the effectiveness of professionals in the health field, along with the enhancement of security and confidentiality of medical data and the improvement of quality of healthcare services. This thesis presents the design and implementation of an enhanced healthcare monitoring system based on the web application framework and the cloud platform using four vital signs such as blood pressure, SPO2, body temperature, and electrocardiogram ECG. Advanced algorithms were utilized for the automated detection of abnormal vital signs. The designed HCare system adjust presentation on both desktop and mobile devices. The entire development process of HCare web-application has been presented in this work, emphasizing the main contributions brought to this domain. The design was based on different requirements that are determined based on a previous survey.

The system provides several functionalities for the patients and medical professionals (doctors and ambulance staff) such as monitoring the medical activities of the patients by the patients themselves and their doctors, and they will receive warning alerts as system notifications or SMS according to the severity of the medical condition of the patient. The application also includes modules for the previous developed filtering model and risk prediction and diagnose model in case of atrial fibrillation. The system offers various means of communication between the patients and the medical professionals via chats, emails, or phone numbers. Multiple functionalities are provided by the system to the patients such as a search for doctors based on the medical centers and the specialties of the doctors. Different security protocols were utilized in the designed HCare web-app system in order to maintain the integrity and confidentiality of sensitive medical data. HCare web application is developed by utilizing C#, ASP.net MVC, Jave Script (JQuery), Entity Framework, Bootstrap, and SQL Server technologies. The application has been implemented as a SaaS model.

The thesis ends by final personal conclusions, an objective overview on the main contributions related to the author’s publications and a future development plan.