Journal of
Sensor and Actuator Networks

MDPI

Editorial

Special Issue: Empowering eHealth with Smart Internet of Things (IoT) Medical Devices

Abbes Amira [1,*], Nazim Agoulmine [2], Faycal Bensaali [3], Amine Bermak [4,5] and George Dimitrakopoulos [6]

1 Department of Computer Science and Engineering, Qatar University, P.O. BOX 2713, Doha, Qatar
2 IBISCLab, Universite d'Evry Val d'Essonne, 91000 Evry, France; nazim.agoulmine@univ-evry.fr
3 Department of Electrical Engineering, Qatar University, P.O. Box 2713, Doha, Qatar; f.bensaali@qu.edu.qa
4 Department of Electronic and Computer Engineering; Hong Kong University of Science and Technology; Clear Water Bay, Kowloon, Hong Kong; abermak@qf.org.qa
5 Division of Information and Computing Technology, Hamad bin Khalifa University, Doha, Qatar
6 Department of Informatics and Telematics, Harokopio University of Athens, 17676 Kallithea, Greece; gdimitra@hua.gr
* Correspondence: abbes.amira@qu.edu.qa

Received: 30 May 2019; Accepted: 31 May 2019; Published: 4 June 2019

The use of Internet of Things (IoT) with medical devices within a connected health environment promotes the quick flow of information and enables easy access to it. In such an environment, the patient's vital parameters are transmitted by medical devices onto secure cloud based platforms where they are stored, aggregated and analyzed. IoT helps to store data for millions of patients and perform analysis in real-time, promoting an evidence-based medicine system.

This Special Issue has focused on pioneering future directions and innovation in smart wearable embedded solutions and IoT with applications in connected health, biomedical signal processing and smart environments. More specifically, it aimed to gather research papers that emphasize the challenges for medical devices caused by the IoT, that highlight the main research gaps in the area of connected health and smart wearable devices and eventually to respond to the following questions:

Q1 What recent advances have been made in intelligent real-time health data collection?
Q2 What important advances have been made to empower eHealth with novel IoT devices?
Q3 Has data interpretation and fusion improved significantly in recent years?
Q4 How did we improve the security and reliability of medical data communication?
Q5 How has IoT technology been used to make the eHealth environment smarter?
Q6 How will recent progress in smart biosensors improve future eHealth?
Q7 How is Cloud Computing power improving our capacity to manage patients and diseases whilst delivering innovative eHealth services?

Six papers have been selected in this special issue that respond to questions raised [1–6].

The first paper, entitled "Design, Fabrication, and Testing of an Internet Connected Intravenous Drip Monitoring Device" submitted by researchers from German universities, presents a monitoring system retro-fittable for existing Intravenous (IV) infusion setup that leverages human based estimations of time required by an IV bottle to empty, which makes the IV therapy vulnerable to human error [1]. The paper proposes an internet connected monitoring platform for IV drip chambers that enables doctors and nursing staff to monitor the drip parameters wirelessly. The platform is composed of two main units. A chamber unit that houses two types of sensors, optical based for drop detection and capacitive based for level detection. A pole unit that consists of a microcontroller and a GSM-based (Global System Mobile Communication) communication module that allows to send securely and

reliably, the monitored data to commercial cloud service for remote visualization and from nurses and doctors. This paper has provided interesting responses to questions Q2, Q4 and Q7, highlighting the advantages of connected medical devices to increase the Quality of Life of patients while ensuring security and reliability of the transmitted medical data. In addition, it highlights how Cloud Computing technology can improve and facilitate access to the medical data and the execution of novel data analysis applications on a large scale [1]. The second selected paper is entitled "Symmetric Encryption Relying on Chaotic Henon System for Secure Hardware-Friendly Wireless Communication of Implantable Medical Systems", submitted by researchers from US and Qatar universities, presents a contribution to the wireless Implantable Medical Devices (IMDs) security. Indeed, these devices play a critical role in healing and even saving lives however, particular attention should be placed on their security [2]. The authors explore, in this paper, a new scheme that creates symmetric encryption keys to encrypt the wireless communication portion. The solution is based on chaotic systems to obtain a synchronized Pseudo-Random key that is necessary to avoid a wireless key exchange to avoid their theft [2]. This paper provides a good response to Q4 that is central to the large deployment of IoT devices and more particularly, in the area of eHealth. In particular, it addresses the crucial point, that is, the security of medical data transfer [2]. Paper 3 is entitled "An Interface for IoT: Feeding Back Health-Related Data to Parkinson's disease Patients" and submitted by authors from Sweden. It presents a user-centered design (UCD) process of an interface for Parkinson's disease (PD) patients to help them better manage their symptoms [3]. The system aims to provide useful information to patients related to their symptom and medication. This information is collected from different connected wearable devices (wrist sensors, smartphone) and IoT devices (electronic dosing device, bed sensor) deployed in their homes. Data related to some of the main health-related quality of life aspects such as motor function, sleep, medication compliance, meal intake timing in relation to medication intake, and physical exercise are collected using the connected devices [3]. The results from this work indicate that the proposed system can be considered as a tool for assisting patients in better management of the disease by giving them insights into their own aggregated symptoms and medication information which provides responses to questions Q1–4. While the progress is significant, the authors highlight that the actual effects of providing such feedback to patients on their health-related quality of life should be investigated more deeply in a clinical trial, especially whether all patients would like to be informed in real-time about their health status or if it is desirable to do it. The following Paper 4 entitled "Opportunities and Challenges for Error Correction Scheme for Wireless Body Area Network—A Survey" was submitted by researchers from Australian universities. This paper presents a review of different schemas to improve the quality of communications in The Institute of Electrical and Electronics Engineers (IEEE) standards for Wireless Body Area Network (WBAN). Hence, it presents how to deal with different types of reliability and delay requirements for different applications [4]. It presents future research challenges and opportunities on Error Correction Scheme (ECS) design and the implementation for WBAN when considering computational complexity and the energy-constrained nature of nodes that are related to questions Q1 and Q4. Paper 5 is entitled "Compressive Sensing-Based IoT Applications: A Review" is another review paper submitted by researchers from Qatar University. The aim of this paper is to highlight emerging trends and venues to optimize data transmission while optimizing energy consumption in IoT [5]. In particular, it advocates the compressive sensing (CS) as an attractive paradigm to be incorporated in the design of IoT platforms. CS is a novel signal acquisition and compression theory that exploits the sparsity behavior of most natural signals and IoT architectures to achieve power-efficient, real-time platforms that can grant efficient IoT applications [5].

The last paper 6, entitled "Moving Towards Body-to-Body Sensor Networks for Ubiquitous Applications: A Survey", presents the evolution of the single WBAN concept to the cooperative network of multiple WBANs, giving rise to the Body-to-Body network (BBN) concept [6]. A synopsis of the WBAN and BBN respective standards and applications is given, and the emerging BBN challenges are highlighted. Following this, the existing WBAN proposals are discussed, with particular reference to the candidate WBAN protocols that could be adapted and used in BBNs, which focuses on four

intrinsically related axes of great importance for BBN design, that is, energy efficiency, mobility prediction, quality of service (QoS) and security. Further BBN open issues are also investigated, namely, the wireless propagation between humans carrying wearable devices, the interference, storage and privacy issues, as well as the heterogeneity of BBN devices and traffic [6].

This special issue has proposed several contributions that highlighted more recent research activities and innovation to empower connected devices to build innovative solutions that use wearables and IoT technologies with application in connection with health. This paper has presented seven questions which are considered important to be addressed by authors in their contributions. Most questions have been addressed by the selected papers with different views. Hence, the review papers presented a comprehensive state of the art of the most recent advances in the area in terms of reliability, energy consumption optimization and quality of service.

It is hoped the readers will appreciate this special issue enhancing their knowledge in the area and helping them advance their on-going research and innovation activities in IoT and healthcare technologies.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Sardana, P.; Kalra, M.; Sardana, A. Design, Fabrication, and Testing of an Internet Connected Intravenous Drip Monitoring Device. *J. Sens. Actuator Netw.* **2019**, *8*, 2. [CrossRef]
2. Belkhouja, T.; Du, X.; Mohamed, A.; Al-Ali, A.K.; Guizani, M. Symmetric Encryption Relying on Chaotic Henon System for Secure Hardware-Friendly Wireless Communication of Implantable Medical Systems. *J. Sens. Actuator Netw.* **2018**, *7*, 21. [CrossRef]
3. Memedi, M.; Tshering, G.; Fogelberg, M.; Jusufi, I.; Kolkowska, E.; Klein, G. An Interface for IoT: Feeding Back Health-Related Data to Parkinson's Disease Patients. *J. Sens. Actuator Netw.* **2018**, *7*, 14. [CrossRef]
4. Kadel, R.; Islam, N.; Ahmed, K.; Halder, S.J. Opportunities and Challenges for Error Correction Scheme for Wireless Body Area Network—A Survey. *J. Sens. Actuator Netw.* **2019**, *8*, 1. [CrossRef]
5. Djelouat, H.; Amira, A.; Bensaali, F. Compressive Sensing-Based IoT Applications: A Review. *J. Sens. Actuator Netw.* **2018**, *7*, 45. [CrossRef]
6. Meharouech, A.; Elias, J.; Mehaoua, A. Moving Towards Body-to-Body Sensor Networks for Ubiquitous Applications: A Survey. *J. Sens. Actuator Netw.* **2019**, *8*, 27. [CrossRef]