Preface

Sensors play a pivotal role in our everyday life. They gather data on environment, and information on weather, traffic congestion, air pollution, water pollution etc. is obtained; they gather data on human body, and information on health, treatment or therapy outcomes is obtained; they gather data on objects, and information for monitoring and control of these objects is obtained; they gather data on subjects or objects functions, and information for better decisions, control and action is obtained. For instance, the weather information is used to choose adequate clothes, the battery level sensor permits smartphone power management optimization, and the level of blood glucose allows better healthcare management. Data collected through sensors enhance our lives and our connections to each other and with our environment, allow real-time monitoring of many phenomenon around us, provide information about quality of products and services, improve the equipment control based on sensorized interfaces and contribute to increase knowledge on physical and chemical world.

The advances in electronics, embedded controller, technology for communication as well as the progress towards a better informed, knowledge-based society increase the demand for small size, affordable sensors that allow accurate and reliable data recording, processing, storing and communication. The work contains invited chapters from renowned experts, working in sensors' field, and it is split into two books that present several technologies and applications of sensors in *Environmental and Food Engineering* (ISBN 978-3-319-47322-2) and for *Healthcare Settings* (ISBN 978-3-319-47319-2).

In book *Sensors for Everyday Life—Healthcare Settings*, several sensors and their applications for healthcare setting are described.

It is approximately four centuries since human beings are developing sensors for healthcare purposes. The first instrument for sensing human health evolved from the thermoscope constructed by Galileo Galilei in 1593, to the clinical mercury thermometer developed by the Dutch Christiaan Huygens in 1665, with centigrade scale defined by the Swedish Anders Celsius in 1742 and the French Jean-Pierre Christin in 1743. In the last decades with rapid advances in materials, design, modelling and engineering, many sensors were developed for clinical diagnosis or health monitoring as well as for improving treatments or therapy interventions. Sensors were developed to detect and quantify structures and functions of human body as well as to gather information from environment in order to optimize the efficiency, cost-effectiveness and quality of healthcare services as well as to improve people health and quality of life. This book aims promoting the exchange of ideas and the discussion on current trends in technologies and concepts that help developing and integration in health monitoring or healthcare services of new sensors with one or more of these characteristics: contribute to relevant, reliable and accurate measurements; have low cost; small size; are affordable; support large-scale implementation of devices based on these sensors. Utilization of these sensors may improve public health, healthcare services and reduce medical expenditure. These sensors will expand personal data collected to include blood, saliva and bone composition, heart and respiratory functions, body temperature and activity monitoring as well as may contribute for real-time and/or remotely diagnosis of human health changes and more efficient therapies or devices for assisted living.

How this Book is Organized

In Chapter "FPGA Based Smart System for Non Invasive Blood Glucose Sensing Using Photoplethysmography and Online Correction of Motion Artifact" a low cost, portable system for continuous blood glucose sensing is described. Photoplethysmography and artificial neural network are the main characteristics of the proposed system for non-invasive estimation of blood glucose concentration. Neural network-based adaptive noise cancellation (adaline) is used to reduce the errors related to motion artefacts. Also, a predictive model based on artificial neural network, which estimates the glucose levels using the information gathered by photoplethysmography sensors is presented. This predictive model was implemented on field-programmable gate array (FPGA).

A system for osteoporosis diagnosis based on planar interdigital sensors is proposed in Chapter "Sensing System for Bone Health Monitoring". Planar interdigital sensors are made of comb-like or finger-like periodic pattern of parallel electrodes on a solid phase substrate. By applying an electric field through the test sample via excitation electrode, the signal received by the sensing electrode might carry useful information about the properties of skeletal bones such as impedance, density and chemical material. This system has several advantages comparing traditional osteoporosis diagnosis devices: low cost; no technical expertise is required; may be used in home healthcare setting.

In Chapter "Cavitas Sensors (Soft Contact Lens Type Biosensor, Mouth-Guard Type Sensor, etc.) for Daily Medicine", an update of various *cavitas* sensors—their techniques, advantages, challenges and future trends—is provided. *Cavitas* is defined as a new category of detachable medical sensors, different than implantable or wearable. While the implantable devices are applied and detached via the medical surgery, the wearable are applied and easily detached by subjects. The *cavitas* devices are those applied by health professionals or subject under investigations into body cavities (i.e. mouth) and are easily detachable. The chapter describes several *cavitas* devices that gather biophysical information on tear, saliva, body gas, etc. The main focus of the chapter is on *cavitas* sensors developed by the authors for saliva characterization (i.e. pH, salivary uric acid and non-invasive monitoring of saliva glucose).

In Chapter "Development of Novel Image Sensor for Root Canal Observation" a low-cost sensor for dental root canal observation, mainly fractures near the apex collateral of the root canal, is proposed. The system includes an 'external-irradiation system' and an 'internal-irradiation system'. The external-irradiation probe is composed of an image fibre with a diameter of micrometres and a gradient index lens (GRIN lens) with the same diameter as the image fibre. The internal-irradiation probe is composed of an image fibre, GRIN lens and five optical fibres for illumination.

Continuing with mouth theme, a low-cost speech recognition system is presented in Chapter "Frame-by-Frame Speech Signal Processing and Recognition for FPGA Devices" based on the developed algorithms by the authors of the chapter for speech recognition decoder (voice activity detection) and for field-programmable gate array as a hardware processor. The system was tested on a FPGA emulator.

Low cost, small size sensors for vital signs detection and monitoring are described in Chapters "Elderly Infrared Body Temperature Telemonitoring System with XBEE Wireless Protocol" and "Heart Sound Sensing Through MEMS Microphone". A real-time non-contact infrared body temperature telemonitoring system with XBee wireless protocol is described in Chapter "Elderly Infrared Body Temperature Telemonitoring System with XBEE Wireless Protocol". The authors describe this low-cost system as an instrument for early detection of the elderly patients illness outside the hospital. In Chapter "Heart Sound Sensing Through MEMS Microphone", a heart sound is detected by new MEMS microphone. The digital MEMS have been interfaced with microcontroller using I2S protocol. The authors proposed the characterization of heart pathologies as mitral regurgitation, mitral stenosis, aortic regurgitation and aortic stenosis by the spectral analysis of the heart sounds signal (i.e. analysis using fast Fourier Transform).

Contributions to the development of flexible sensors for activity monitoring and as human–machine interface are described in Chapters "Flexible Printed Sensors for Ubiquitous Human Monitoring", "Smart Textiles for Smart Home Control and Enriching Future Wireless Sensor Network Data" and "Smart Clothes for Rehabilitation Context: Technical and Technological Issues". A flexible sensors for limbs motion monitoring is described in Chapter "Flexible Printed Sensors for Ubiquitous Human Monitoring". Multi-walled carbon nanotubes (MWCNT) were chosen as the conducting material for the electrodes included in a planar interdigital sensor. MWCNT are mixed with organic polymer polydimethylsiloxane (PDMS) to form a nanocomposite layer. The organic polymer was cast over a poly (methyl methacrylate) (PMMA) template to form the substrate. The nanocomposite layer was patterned with CO_2 laser ablation to form interdigitated electrodes. Tensile and compressive stresses were tested on the sensor patches.

Smart textiles as human–computer interface are presented in Chapter "Smart Textiles for Smart Home Control and Enriching Future Wireless Sensor Network Data". Examples of smart textile for smart home, commercial spaces, automobile vehicles, personal or business-owned clothing, and toys are provided. A description of a system developed by the authors of the chapter that used electronic textile as human–computer interface is provided. The proposed system for smart home aims to control a lighting home system by a voice control of a wireless sensor network. Technical and technological issues, related to safety and privacy of data in this system, are discussed in this chapter. The machine learning algorithms are proposed to protect data and maintain the wireless sensors network efficiency in communicating data with minimal energy losses.

A review on technical and technological issues-related smart clothing for rehabilitation context is presented in Chapter "Smart Clothes for Rehabilitation Context: Technical and Technological Issues". Information on conductive textile, type of textile/fabric manufacturing, sensors based on textile, textile as antenna, textile as actuator, textile as computer interface, circuit board into textile are presented and described in this chapter. As an important challenge described by engineers on smart clothing is related to management of power supply, the authors described the relevant progress in this domain, particularly on energy harvesting by using electronic textile. Connectivity, integration of things in smart clothing, wearability, maintainability as well as issues related to design for durability and affordability of smart clothes were also discussed.

Chapter "Wireless Sensing Systems for Body Area Networks" reviews the sensing mechanisms, data detection and interpretation methods and several body area networks (BAN) applications for health monitoring, human–machine interaction and motion capturing. Two data detection and interpretation techniques for radio frequency (RF)-based sensing structures are also introduced. RF structures operating at high frequencies fabricated with flexible or textile materials have gained increasing attention in recent years. Due to the flexibility of these RF structures to conform to human body for comfortable fit, they are well-suited for BAN applications. In addition, the characteristics of these RF structures can naturally or technically be made to react to bodily phenomena such as temperature and humidity and function as sensors.

Concept and implementation of an indoor *passive* tracking system that use an array of Wi-fi transceivers and without any electronic device or tag attached to the object being tracked are presented in Chapter "Radio Frequency Sensing for Assistive Monitoring". The sensing of an object or a person described in this chapter is made possible by exploiting the fundamental characteristic of signal attenuation due to blocking, shadowing, etc. that is prevalent in a typical wireless communication system. The feasibility in exploiting Wi-fi signal as a proximity sensor was tested. This affordable system may be a solution to the concerns-related privacy when camera is used for monitoring activity of patients in healthcare settings.

A FPGA-based implementations of a Advanced Encryption Standard (AES) and Secure Hash Algorithm-3 (SHA-3) security algorithms that allow both data integrity and data confidentiality to be provided for high-speed Internet of Things (IoT) applications are presented in Chapter "Efficient and High-Speed FPGA Bump in the Wire Implementation for Data Integrity and Confidentiality Services in the IoT". The system enables low-cost Bump In the Wire (BITW) technology to be provided for Internet Protocol Security (IPSec) provision for all IoT applications. Using BITW technology, security mechanisms can be implemented outboard in a physically separate device so that the system that receives the protection does not need to be modified at all.

Summarizing, affordable, small size, reliable and accurate sensors, body area sensors networks, internet of things, internet of clothes have contributing to the implementation of user-centred and preventive overall lifestyle health management, high-quality preventive, predictive, personalized and participative healthcare.

Who Is It For?

This book is written for researchers and graduate students that work in the field of healthcare technologies, university professors and also for industry professionals involved in development of systems for human body structures, functions and activities monitoring, health monitoring, and healthcare services.

We would like to express our appreciation to our distinguished authors of the chapters whose expertise and professionalism have certainly contributed significantly to this book.

We are very happy to be able to offer the readers such diverse sensors technologies and applications. We hope that this book can shed light on various technological aspects-related sensors for healthcare context and stimulate further research in this field.

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