

Preface

Seamless monitoring of diverse physiological information in various daily life scenarios, whether asleep or awake, indoors or outdoors, is indispensable for long-term healthcare. Devices for such a purpose differ from conventional ones that are hospital-centered and aimed at short-term usage by professional personnel. Through scrutinizing the latest achievements in this realm, we classify the devices into three modalities: wearable, attachable, and invisible.

A wearable device is defined as a monitoring modality that is worn by a user in daily life. It is usually integrated into items used daily (watch, eyeglass, ring, vest, gloves, belt, shirt, brassiere, shoes, necklace, and barrette) as an inseparable component. An individual customized size is usually required. It often moves with the user ubiquitously without any apparent or obtrusive parts.

An attachable device is defined as a monitoring modality that should be attached onto the body noninvasively or can be touched occasionally by a user intentionally. It is not a necessary item but has an unnoticeable impact on daily life such as a tattoo, pad, pedometer, mobile phone, tablet, and other portable devices. It is usually “one-size fits all.”

An invisible device is defined as a monitoring modality that is embedded into ambient items (beds, chairs, desks, bathtubs, dressing mirrors, desk lamps, and ceiling lamps) completely without the user’s awareness. It is usually immobile and used in a fixed position. Automatic identification of users is indispensable.

In this book, active and prestigious worldwide researchers/scholars are invited to investigate the historical development in a relevant field extensively, summarize the latest advancements thoroughly, and envision future prospects ambitiously for further exploration. Each chapter generally comprises several main sections such as introduction/background, physical/chemical principle and instrumentation, signal processing and data analysis, achieved outcomes and application scenarios, and pros and cons, as well as future research topics.

This book consists of seven Parts in 14 Chapters with a wide coverage of various physical and chemical quantities such as electricity, pressure, flow, motion, force,

temperature, gases, biomarkers, physical activity and nutrition. Multiple professional disciplinary fields are involved from biomechanics to bioelectricity, biochemistry to biophysics, and bioelectronics to biomaterials.

Part 1 describes three typical bioelectric signals including electrocardiogram (ECG), electroencephalogram (EEG), and electromyogram (EMG). Insights are provided into three aspects of human functionalities: synchronization, central commander, and mechanical execution. Chapter 1 highlights the discovery of indiscernible information, such as health condition change, lifestyle change, biorhythmicity, and sleep stage, from ECG/HRV in different analytical domains and various temporal scales. Chapter 2 overviews the state of the art in EEG measurement and, in particular, recent developments in ear EEG and in conformal tattoo electrodes for long-term and emergent monitoring applications. Chapter 3 reviews wireless surface electromyography (SEMG) devices and their applications in medicine and sports. Specific conditions such as lower back pain, stroke, epilepsy, and Parkinson's disease are discussed in detail.

Part 2 describes two approaches for the monitoring of pressure signals in terms of blood pressure and ballistocardiogram. Both are convenient methods used for the evaluation of cardiovascular system dynamics. Chapter 4 provides the latest advances in the development of both cuff-based and cuffless sphygmomanometers. Intermittent and continuous measurements made in various modalities, such as a wristwatch, smartphone, car steering wheel, and chair, are summarized. Chapter 5 describes ballistocardiography (BCG) to observe longitudinal changes in human cardiovascular status and to offer meaningful information for disease diagnosis. Several symptoms and diseases are linked to the abnormal waveforms of BCG.

Part 3 describes the measurement of flow phenomenon in terms of pulse waves and blood flow. Photoplethysmogram and ultrasonic Doppler are commonly used in the evaluation of physiological significance. Chapter 6 reviews photoplethysmography (PPG) using recent optical technology, in particular, the use of high-intensity green LEDs for PPG, and the latest development in wearable monitors for pulse and respiratory rates. Chapter 7 focuses on the ultrasound approach in velocity measurement and imaging and describes the latest development in portable handheld ultrasound devices and their applications in point of care and daily healthcare monitoring.

Part 4 focuses on the latest wearable technologies for the quantification of human motions and forces, such as walking steps, walking strides, walking speed, energy expenditure, and physical performance. Chapter 8 examines the technological principle of wearable units using several types of sensors such as an accelerometer, gyroscope, magnetic sensor, and insole force sensor and assesses these sensors for patient rehabilitation in clinical practice and sports. Chapter 9 highlights a smart textile suit as a continuous daily monitoring platform to recognize posture, gesture, activity, and physical interaction with the environment, in combination with physiological signals, such as EMG, ECG/HRV, and respiratory signals, to provide a complete profile of the subject in terms of physical activity and energy expenditure.

Part 5 describes various forms of wearable thermometers, such as touch, patch, and invisible (radiometry), by contact and noncontact methods for the measurement of skin temperature, deep body temperature, heat flow, and evaporation intermittently and continuously in the environment of daily life. Most wearable thermometers can be connected to a smartphone or a tablet for data processing and visualization. Their applications include monitoring of fever, circadian rhythm, energy expenditure, mental stress, and sweat evaporation.

Part 6 focuses on gases and chemical substances produced in metabolism. The trace elements and biomarkers provide significant hints for accurate diagnostics at the molecular level in the early stages of changes in physiological condition. Chapter 11 reviews historical development and engineering principles in the monitoring of oxygen saturation by a pulse oximeter and monitoring of expired carbon dioxide (CO₂) by a capnometer and discusses their clinical application and limitation. Chapter 12 describes four categories of chemical sensors of gas/odor, glucose, trace elements, and biomarkers. These sensors work on different principles such as electrochemical reactions, optical interactions, and immune antigen–antibody reactions and are used to detect different kinds of chemical substances, such as ethanol, urine, glucose, DNA, and RNA.

Part 7 describes two aspects of metabolism-related monitoring of nutrition intake and energy expenditure in daily activities. Chapter 13 proposes a concept of automatic dietary monitoring (ADM) that intends to derive dietary activities, such as food preparation, intake, and digestion processes, by unobtrusive sensors and a knowledge-based physiological model. Chapter 14 introduces wearable devices targeted at analyzing human kinetics and profiling physical activities in daily life by several approaches such as inertial, biopotential, bioimpedance, and optical sensors and presents a systematic framework for quantitatively assessing energy expenditure and calorie consumption.

All of these dedications and commitments will help identify our common concerns, provide us insights into further endeavors, support seamless life-long healthcare monitoring from the womb to the tomb, formulate innovative business/services, foster a new discipline “metrology of health” or “healthology” based on a holistic view of health, and finally improve our health condition as well as quality of life.

This book can be considered a collection of treatises that provide an introductory tutorial for not only students and young scientists but also a wide range of readers, such as biomedical engineering researchers, computer engineers, healthcare entrepreneurs, administrative officers, policy makers, market vendors, and healthcare personnel, to perceive a whole picture and to ignite their passion and inspiration in this fascinating field.

We appreciate all the authors who have devoted their enthusiasm and shared their expertise on a variety of specialized topics to encourage more dedication and further exploration toward a bright and promising future. It was also our great pleasure to work with Ms. Marta Moldvai and Ms. Brinda Megasyamalan in Springer, and we thank them for their professional support throughout the

preparation of this book. Finally, we thank Nakatani Foundation for the Advancement of Measuring Technologies in Biomedical Engineering, Tokyo, Japan, that helped to make this book a reality.

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<http://www.springer.com/978-3-319-69361-3>

Seamless Healthcare Monitoring
Advancements in Wearable, Attachable, and Invisible
Devices

Tamura, T.; Chen, W. (Eds.)

2018, XVIII, 469 p. 191 illus., 135 illus. in color.,

Hardcover

ISBN: 978-3-319-69361-3