Title: Introductory chapter: data acquisition

Author: Bartłomiej Płaczek

Citation style: Płaczek Bartłomiej. (2021). Introductory chapter: data acquisition. W: B. Płaczek (ed.), "Data acquisition : recent advances and applications in Biomedical Engineering" (S. 1-4). [Rijeka] : Intech Open.

Chapter

Introductory Chapter: Data Acquisition

Bartłomiej Płaczek

1. Introduction

New biomedical technologies can support faster development of disease treatments, prevention, and diagnostic procedures. They are expected to make significant contributions to the quality of life, improve patient healthcare, and reduce the related costs. Advancement of data acquisition techniques is a key prerequisite for the development in biomedical engineering. Recent advances in data acquisition systems, sensor design, and sensor networks allow collection of large volumes of detailed biomedical data. For instance, body area networks with wireless sensors can be used to non-invasively and continuously monitor several physiological parameters and recognize human activities [1]. Other examples are visual sensor networks for supervision of patients during rehabilitation and Internet of Things (IoT) systems with medical devices connected to the internet that can collect valuable data, enable detailed analysis of symptoms and facilitate remote healthcare. Valuable biomedical data can be also acquired using image processing methods for micrographs analysis [2]. This book intends to provide the reader with an insight into the current state-of-the-art in biomedical data acquisition and focuses on the most important developments in this highly important area.

Few examples of the aforementioned data acquisition techniques are discussed in the introductory chapter. In particular, this chapter concisely reviews the selected approaches that utilize network-connected sensors.

2. Wireless body sensor networks

Different types of sensors can be connected by a wireless body area network (WBAN) in order to monitor various body functions. Usually, the sensors in WBANs are placed on the body. Another approach is to implant small sensors inside the human body. Such approach reduces the impact of WBAN on normal activities of the monitored person. Operations performed by the WBAN sensors include collecting data readings of physical body parameters as well as preprocessing and transmitting the data. The preprocessing operations can be implemented to aggregate, compress or denoise raw sensor readings. A wireless communication is used to transmit the preprocessed data from sensors to a remote destination for further processing or storing. The general concept of WBAN operation is illustrated in **Figure 1**.

The WBAN platforms enable development of ubiquitous medical records in the cloud and on-line healthcare services with disease-alert systems. This technology can contribute to early diagnosis and personalized treatment of patients. It allows the

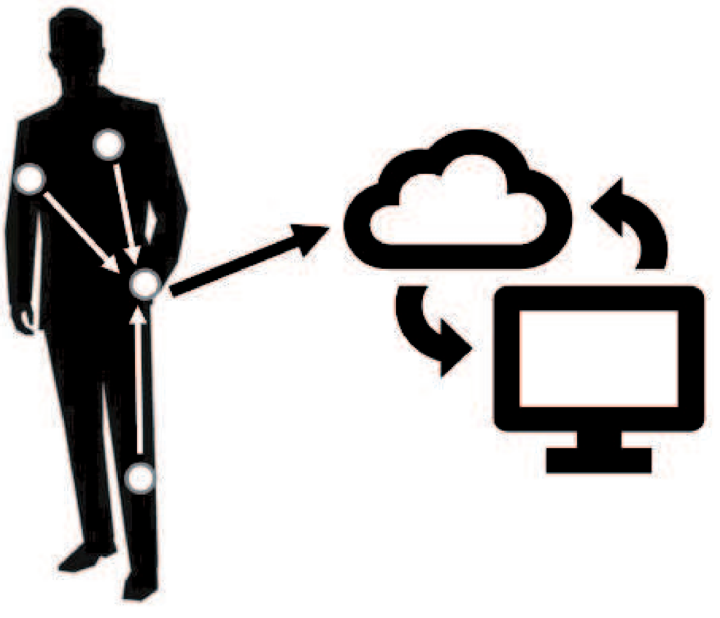

Figure 1.
Wireless body area network (white circles depicts sensors, arrows correspond to data transfers).

patients to be continuously monitored in all locations. In case of health emergency, an alert can be immediately generated to inform the medical staff that urgent intervention is necessary. The data collected by WBANs can also be used to localize person [3] and analyze movement of the body and recognize human activities. On this basis it is possible to develop systems that provide care and security for elderly persons. Moreover, the WBANs found applications in sports for performance monitoring of training activities, rehabilitation, disability assistance, and human–machine interfaces [4].

3. Smart sensors

The above-discussed wireless sensor networks are usually built up with sensors that have the ability to sense physical parameters, perform basic processing tasks and transmit the collected data. More sophisticated solutions are equipped with smart sensors that have extended data processing capabilities. The smart sensors are capable of performing advanced data processing in order to make decisions and recognize relevant events [5]. This kind of sensors may use embedded machine learning algorithms to learn from collected data and to autonomously make assessments or predictions. In case of smart sensors, the data are processed locally. The sensor transmits results of information processing instead of the collected data. This approach leads to reduced data traffic, lower power consumption and latency, as well as to enhanced data privacy.

An example of smart sensor is the solution discussed in [6] which uses a modified support-vector machine classifier for arrhythmia detection based on electrocardiogram signals and for seizure detection based on electroencephalogram signals. It was shown that the above-mentioned detection tasks can be performed by low power wearable sensors in real time.

Another wearable smart sensor was proposed in [7] to detect and categorize cardiac arrhythmias from electrocardiogram readings. A convolutional-recurrent neural network was used in this solution. The neural network was adapted to perform the detection and classification tasks on embedded low-power processors with a small memory footprint.

4. Visual sensor networks

A special type of smart sensors are visual sensors, i.e., camera nodes equipped with embedded processor, and wireless communication module. The smart visual sensors have a number of potential applications, from security and patient monitoring to rehabilitation. For instance, in [8] a visual sensor was introduced for baby behavior monitoring in healthcare centers. This sensor detects abnormal motion of a baby and sends alerts to a user.

Visual sensors can be connected in visual sensor network (VSN). The camera nodes in VSN process image data locally, extract useful information, and exchange the information with other nodes. Using multiple camera nodes in the VSN provides different views of a monitored object, which improves the reliability of the recognized events [9].

In [10] a wireless VSN was proposed for supervision of patient rehabilitation. Results reported in the literature confirms that the VSN concept enables a low cost, light-weight and easy to use monitoring applications that meets tracking and localization needs of rehabilitation centers. An interesting example is the VSN, which was used to collect data for robot automation in rehabilitation of young children [11].

Author details

Bartłomiej Płaczek
Institute of Computer Science, University of Silesia, Sosnowiec, Poland

*Address all correspondence to: placzek.bartlomiej@gmail.com

References

[1] Lewandowski M, Orczyk T, Płaczek B. Human activity detection based on the iBeacon technology. Journal of Medical Informatics & Technologies. 2016:25

[2] Płaczek B, Bułdak RJ, Polaniak R. Automatic immunogold particle detection in transmission electron micrographs of cancer cells. Journal of Medical Imaging and Health Informatics. 2015;**5**(6):1350-1357

[3] Bernas M, Płaczek B. Fully connected neural networks ensemble with signal strength clustering for indoor localization in wireless sensor networks. International Journal of Distributed Sensor Networks. 2015;**11**(12):403242

[4] Meharouech A, Elias J, Mehaoua A. Moving towards body-to-body sensor networks for ubiquitous applications: A survey. Journal of Sensor and Actuator Networks. 2019;**8**(2):27

[5] Lewandowski M, Płaczek B. An Event-Aware Cluster-Head Rotation Algorithm for Extending Lifetime of Wireless Sensor Network with Smart Nodes. Sensors. 2019;**19**(19):4060

[6] Lee KH, Kung SY, Verma N. Low-energy formulations of support vector machine kernel functions for biomedical sensor applications. Journal of Signal Processing Systems. 2012;**69**(3):339-349

[7] Faraone A, Delgado-Gonzalo R. Convolutional-recurrent neural networks on low-power wearable platforms for cardiac arrhythmia detection. In: 2020 2nd IEEE International Conference on Artificial Intelligence Circuits and Systems (AICAS). IEEE; 2020. pp. 153-157

[8] Hussain T, Muhammad K, Khan S, Ullah A, Lee MY, Baik SW. Intelligent baby behavior monitoring using embedded vision in IoT for smart healthcare centers. Journal of Artificial Intelligence and Systems;(15):1, 2019

[9] Soro S, Heinzelman W. A survey of visual sensor networks. Advances in multimedia. 2009

[10] Idoudi M, Bourennane EB, Grayaa K. Wireless visual sensor network platform for indoor localization and tracking of a patient for rehabilitation task. IEEE Sensors Journal. 2018;**18**(14):5915-5928

[11] Kokkoni E, Mavroudi E, Zehfroosh A, Galloway JC, Vidal R, Heinz J, et al. GEARing smart environments for pediatric motor rehabilitation. Journal of NeuroEngineering and Rehabilitation. 2020;**17**(1):16