Chapter 47
An IoT-Based Platform for Rehabilitation Monitoring and Biosignal Identification

Volkhard Klinger
Department of Embedded Systems, FHDW Hannover, Hannover, Germany

ABSTRACT

This article describes how as a result of technological advances of the embedded system, the Internet-of-Things (IoT) has created a wealth of new applications and tailored solutions, even in the area of health and medical technology. The integration of state-of-the-art IoT-systems in an existing prototype platform for biosignal acquisition, identification, and prosthesis control provides new applications for prevention and rehabilitation monitoring. This article concentrates on an IoT-based platform for rehabilitation monitoring and biosignal identification. The IoT-characteristics for the application in the area of medical technology are discussed and the integration of such IoT-modules in the given architecture is introduced. Based on this extended architecture, new applications in the field of biosignal measurement, signal processing and biosignal monitoring are presented. Some results of a rehabilitation monitoring system, based on a self-designed IoT-module, integrated in the whole platform, are shown.

1. INTRODUCTION

New technologies allow more powerful, smaller, and more energy efficient embedded systems. Based on these systems, the Internet of things has emerged. Legio of applications are existing taking benefit of the IoT-evolution (Lee and Lee, 2015). New services and applications, new business models and ecosystems are arising with this application domain. Apart from the financial aspects of IoT, where the increased focus on value-based care shifts financial incentives to a model in which providers are compensated based on how their patients fare, rather than by the number of tests, visits, or procedures performed, new challenges are existing in the area of medical technologies due to architectures, big data, process modeling, machine learning, cloud services and, last but not least, security and energy harvesting (Al-Fuqaha et al., 2015; Kumar et al., 2017). In this paper the focus is on the integration of IoT-devices into the prototype

DOI: 10.4018/978-1-7998-3432-8.ch047

platform of a biosignal acquisition, identification and control system and on new application scenarios using IoT-devices and smart devices, like smart phones (Islam et al., 2015). The IoT-devices provide mobile and flexible sensor and actor nodes, while the smart device provide enough power to perform a number of computing activities and provide communication and positioning (Global Positioning System, GPS) characteristics. The integration of these technologies offers new application scenarios and a powerful extension for example of the platform for biosignal acquisition, identification and prosthesis control. In particular, a mobile application become possible, providing continuous measurement of biosignals and therefore in many cases a better diagnosis, treatment and rehabilitation process. In addition, these mobile applications take care of the personal life situation (Ahmed et al., 2017).

The objectives of the present work pass in the integration of IoT-devices in a HW- and SW-platform solution. The development of intelligent sensors and actors by using IoT technology enables to integrate a variety of sensors and actors into the existing platform. Besides, in particular the radio communication plays an important role which allows a flexible positioning of sensors according to the individual user's needs.

Due to the flexibility of the platform, different use cases with application-specific solutions, based on adapted platform-related modules, can be realized.

So, new application scenarios, in particular continuous measurements, providing better prevention and rehabilitation monitoring, can be developed.

The central objective of the present work is the sensor fusion of the integrated sensor data to improve the identification based on a machine learning method. The sensor fusion allows new therapy procedures, for example to improve the gait analysis (see subsection 4.2). Furthermore, the fusion of sensor data also supports already the identification of the so-called zero space movements from the prosthesis control (Klinger, 2015).

In this article, first, the characteristics of Internet of Things-systems (IoT) are introduced and some examples for medical applications, based on IoT-modules, are described. Then a brief overview of the smart modular biosignal acquisition, identification and control system (SMoBAICS) is given, describing the integration of IoT-components into its architecture. Subsequently two IoT-based applications are introduced. Before concluding, some results are shown, using a self-designed IoT-module for the rehabilitation monitoring system, introduced in subsection 4.2.

2. THE INTERNET OF THINGS

The Internet of Things (IoT) covers the use of connected devices and systems providing intelligence based on computing capabilities to leverage information acquired by embedded sensors and actuators integrated in smart clothes, technical components and other physical objects. The Internet of Things creates new opportunities to link sensors, actuators or intelligent decentralized systems either with each other or with other systems (Bajaj et al., 2017; Bassi et al., 2013; Streitz and Markopoulos, 2017). The IoT-Roadmap promotes new technologies and, therefore, new challenges.

To establish an IoT-System, a system of devices, functions, and services is required. Without any type of quality of service, such an IoT-system is not applicable.

The IoT-system has to provide the following capabilities: