Real-Time Remote Patient Monitoring using Sensor Fusion and Cloud-Assisted Body Area Networks

Ph.D. Project

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Introduction

According to WHO, 31% of all global deaths are from cardiovascular diseases. Of this number, 85% are due to heart attack and stroke[1]. In the United States alone, heart attack affects more than 700,000 people every year[2], and the annual costs for the US healthcare system is estimated at around 45 billion dollars[3]. As histological cell death begins in as little as 20 minutes[4], it is often very difficult to provide necessary medical treatment on time after a heart attack happens. For this reason, it is of great importance to recognize heart failure symptoms quickly and take action before the heart stops working. The proposed research is aiming to help reducing pressure on the global healthcare system and increasing the frequency of health screening for early disease detection by providing a new diagnostic approach for remote patient monitoring. This diagnostic approach is to create a network of IoT devices (Body Sensor Networks) out of items of daily use like cars, chairs, mattresses to measure various physiological parameters of a patient and to estimate the patient's health status based on these measurements.

Aim

The worldwide growth in life expectancy and population puts pressure on the healthcare system. The primary aims of this research are:

- to help automate processes in hospitals, so that fewer healthcare workers can take care of more patients
- to reduce the number of hospitalization cases since many patients can progress in their home environment and can be monitored using telemedicine and remote patient monitoring approach
- to make health screening ubiquitous all around the world to detect diseases early and start treatment quicker. In this way we will be able to prolong lives of many people all around the world

Objective

The core objectives of the research are:

- improve quality of signals acquired through clothes in a non-invasive and possibly touchless way
- investigate various sensor fusion approaches to get hidden information from a bundle of signals and use these parameters to estimate the patient's condition
- create a prototype to look into various approaches for vital signs estimation and compare them to each other
- build up an IoT infrastructure for ubiquitous remote patient monitoring to prove the feasability of our approach

Methodology

In order to conduct the proposed research, we will build a prototype Body Sensor Network that will measure various type of signals from different sources like ECG, PPG, MI, etc. in order to make sure that the produced signals are of a high quality we will compare each of them with existing gold standard methods using commercial devices.

Our prototype will be built modularly, which gives us a bigger flexibility in experimenting with various approaches like electrode placement, sensor position and will allow us to use the same setup for various types of daily activities. We will be able to use the same setup for data collection in a car as well as during sleep. In this way we can compare the acquired data and accelerate the process of designing and building prototypes.

After building the prototype, we will run a measurement campaign with sensors implemented within the driver seat. Healthy volunteers will be asked to drive the equipped car on the real road while monitored with the novel noncontact devices as well as conventional sensors for reference. In another study, it is planned to acquire data under a laboratory environment in order to investigate design parameters of the sensor setup as well as to be able to potentially induce stress (or other events triggering autonomous responses) during driving situations. For the later study BilSim, a driving simulator located at HIT can be utilized. If possible, the developed sensors will also be used to acquire data from patients with actual cardiac diseases, i.e. arrhythmias.

Publication and dissemination

The core of this project has a high potential for several publications. During this Ph.D. project we plan to publish three papers in peer-reviewed journals and present one of them at Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC). The publication will be available to everyone to assure flawless knowledge transfer to broader public for massive adoption.
The required institute work for this project accumulates to 300 hours of knowledge dissemination, passing 30 ECTS courses and participation in active research environments. The plan is to gather all the necessary ECTS in the first two years of the project. Beyond that the Ph.D. student will take part in knowledge dissemination as a co-teacher in a M.Sc. course in M.Sc. course.

References

[1] 17 May 2017 WHO Cardiovascular diseases (CVDs)
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[3] G. W. Reed, J. E. Rossi and C. P. Cannon, "Acute myocardial infarction", The Lancet, vol. 389, no. 10065, pp. 197-210, Jan 2017
[4] D. Sopic et al., "Real-time classification technique for early detection and prevention of myocardial infarction on wearable devices" in Proc. Of BioCAS, vol. 1, no. 1 IEEE, Oct 2017, pp. 1-4

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