Real Time Remote Monitoring of Vital Parameters in Emergency Situations

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Ivana Kozolovska, Bojana Koteska, Monika Simjanoska and Ana Madevska Bogdanova
Ss. Cyril and Methodius University
Faculty of Computer Science and Engineering
Rugjer Boskovikj 16, 1000 Skopje, Macedonia
Email: kozolovska.ivana@students.finki.ukim.mk
{bojana.koteska, monika.simjanoska, ana.madevska.bogdanova}@finki.ukim.mk

***Abstract*—Advances in telemedicine have resulted in the creation of medical systems that can wirelessly monitor the vital parameters of patients. These medical systems have significant role in saving people's life and reducing the death-rate, especially in cases of massive disasters, where there are large number of patients, limited resources, and insufficient information about their health state. This paper presents software solution for remote monitoring of vital parameters in real time, by using multiple reliable biosensors. The solution provides monitoring of several vital parameters: ECG, heart rate, respiratory rate, blood pressure and oxygen saturation. Collected data from the biosensors are stored locally on a mobile device and on the remote server which can be used for real-time monitoring of the patient state in the hospital. The solution is tested in the General Hospital in Celje, Slovenia.**

***Index Terms*—vital parameters, emergency, biosensors, telemedicine**

I. Introduction

Emergency situations pose immediate risk to people's health, life or environment. Regardless of the scope and the scale of the emergency scenario, the reaction of the medics are in the beginning the same. For example, the reaction of the medic in a case of an incident where a man was injured in a car accident or in a case when hundreds of people are injured in a train accident is basically the same. The first situation can be considered as a **small scale**, and the second as a **large scale** emergency scenario [1].

In the era of modern emergency medicine, a lot of wearable biosensors are available on the market. These sensors measure one or more vital parameters and some of them are able to transmit the vital data to nearby portable devices via Bluetooth or Wi-Fi. These biosensors are usually light weighted, long lasting and use low power protocols for data transmission. The low-cost biosensors have no or low memory capacity and their streaming frequency is usually from 100 to 1000 Hz. Wearable biosensors are very useful in emergency situations since they can provide crucial information about the patient's vital medical state and priority queue for further patient processing.

In the case of a large scale emergency scenario, the fast reaction of the first responders is crucial to save people lives. First responders are responsible for attaching the wearable biosensors to injured people. The data emitting starts immediately after the biosensor is attached to the patient. When hundreds of people are injured, the data from many injured patients can be collected on one first responder's portable device, for ex. smartphone. If Internet connection is available, selected data can be transferred to remote hospital server. Once they are transferred, the data become available to the authorized medical staff in the hospital responsible for further patient treatment.

Similarly, in small scale emergency scenario, a wearable biosensor is attached to the patient. For example, if car accident happens, during the transport to the nearby hospital, the medic in the reanimobile and also the medic from hospital can monitor the vital parameters for one or several injured persons.

The popularity of the biosensors and importance of enabling the noninvasive diagnosis of vital functions of the human body in emergency situations is presented in [2], where authors review the latest developments in body-worn wireless health-monitoring systems and their current challenges and limitations and to discuss future trends for such worn devices for these applications. The features and application of wearable biosensors in medical care are also explained in [3]. An ubiquitous emergency medical service system (UEMS) that consists of a ubiquitous tele-diagnosis interface providing ubiquitous accessibility of patients biosignals in remote areas where the ambulance cannot arrive directly is elaborated in [4].

In this paper, we propose a wireless system that enables real time remote monitoring of vital parameters in emergency situations. The goal of the proposed system is to provide continuous vital data transfer during the patient transport in the reanimobile. Authorized medics in the hospital can monitor the vital parameters of the patient in real time before the patient is transferred to the hospital which is useful for the further patient treatment. The system integrates three different biosensors to satisfy the requirements for measuring the needed vital parameters when performing first traige (heart rate, respiratory rate, blood pressure and oxygen saturation) [5]. It also provides options for checking the dynamics of these four parameters (history), marking the patient injured body parts, calculating the Glasgow Comma Scale value and storing data about the given medications during the transport. The system is tested in the emergency department of the General Hospital in Celje, Slovenia. In order not to violate the patient's ethic rights, prior consent was required for testing the system. The reliability is confirmed with comparison of the data measured with the sensors and the data measured with the standard operating machines in the hospital.

II. Technical solution

In the provided solution three different sensors are included in order to achieve real time remote monitoring of the needed vital parameters:

- **Zephyr BioHarness 3.0 sensor** [6] (shown in Fig. 1) - collects different vital parameters: ECG (electrical activity all over the heart), Heart Rate (number of heartbeats per minute), Respiratory Rate (number of breaths per minute), Temperature (skin temperature), Posture (body position), Activity Level (acceleration), Subject Status as well as the battery level of the device. The data are streamed at a frequency of 250 Hz.

Fig. 1. Zephyr BioHarness 3.0 sensor

- **MyTech Wrist Cuff Blood Pressure Monitor sensor** [7] (shown in Fig. 2)- measures the systolic and diastolic blood pressure (in mmHg) and pulse. The data are sent using the Bluetooth protocol.

Fig. 2. MyTech Wrist Cuff Blood Pressure Monitor sensor

- **Nonin Onyx ®9560 Saturated Blood Oxygen** [8] (shown in Fig. 3) - measures the oxygen saturation (SpO2) in range from 0 % to 100 % and pulse in range 18 to 321 beats per minute (BPM). The operating frequency is from 2.4 to 2.4835 GHz and it uses Bluetooth v2.

The data from these three sensors are transferred to the mobile device of the paramedic in the reanimobile. Received data are stored locally on the device as .csv files. If Internet connection is available, the data is sent to the remote SQL database hosted on a Windows server machine by using the android ksoap library and SOAP web services developed in C# which provide the communication between the android device and the SQL server. This is crucial action for remote monitoring of the vital parameters as the medical team in the

Fig. 3. Nonin Onyx ®9560 Saturated Blood Oxygen sensor

hospital can have insight in the patients health state during his transport. As to be completed the presented scenario, a mobile device or a tablet is needed to be included on the side of the medical team in the hospital. The communication between the sensors and tablet and the transfer of the measured vital data via Bluetooth and via SOAP services is shown in Fig. 4.

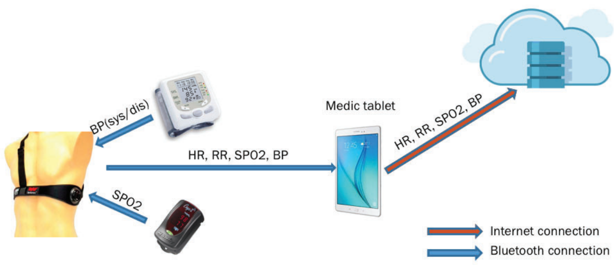

Fig. 4. Transfer of the measured vital data via Bluetooth and via SOAP services.

III. Software Solution

The Android application is intended to be used by both, the medical team in the ambulance vehicle and the medical team in the hospital. The user interfaces differs depending on the given role. Medical team interfaces in the ambulance vehicle possess more functionality unlike interfaces intended for the team in the hospital.

The solution is developed under Android platform and supports Android devices with operating system Android 4.4 (and higher). The data gathering from the Bioharness sensor is performed by using the Bioharness 3 SDK for Android platform.

Our solution enables simultaneous monitoring of four parameters: heart rate, respiratory rate, blood pressure and oxygen saturation. Fig. 5 presents a screen of the proposed solution. If the connection with the Zephyr BioHarness 3 is successful, the heart rate and respiratory rate will appear in the next screen. The MyTech blood pressure sensor must be put on the wrist on the patient. In order to get data for MyTech Blood pressure sensor the medical team in the reanimobile should manually turn on the sensor, measure blood pressure of the patient and press the Send button on the sensor. After this, the medic have to put the Nonin sensor on patients finger. The data from the Nonin Oxygen saturation sensor are streamed continuously. During the transport, the obtained measurements for these four parameters are transferred to the remote server in

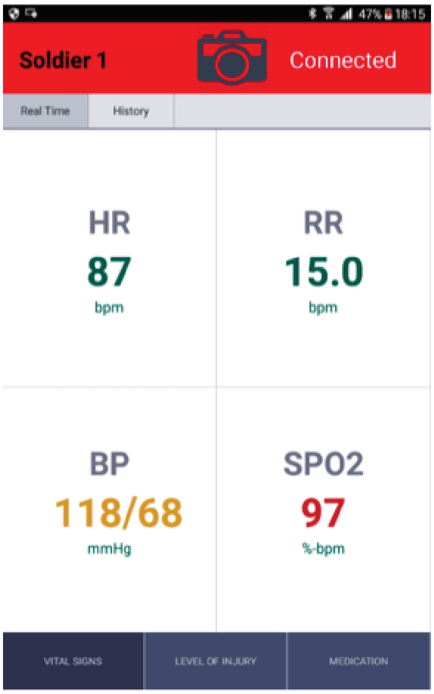

Fig. 5. Real time monitoring of the vital parameters.

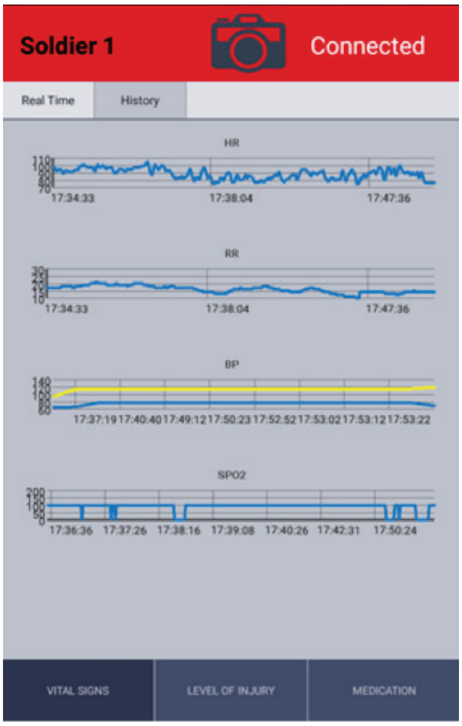

Fig. 6. History of the vital parameters.

hospital and the medical staff can monitor the vital parameters of the patient.

With tapping the history tab the user can see graphics of the biodata history for all four parameters. These graphs are also scrollable and zoomable which provides easy detection of potential abnormalities. (Fig. 6).

Other functionality, like capturing images of the wound, calculating the level of injury, marking the injured body parts, updating the list of the given medications, are also provided in order to capture a more realistic picture of the patient's health.

IV. Conclusion

In this paper we have presented a software system for real time vital parameters monitoring by using three commercially available biosensors. The application provides the ability to monitor the patient's heart rate, respiratory rate, blood pressure and oxygen saturation. In a case of an emergency scenario, during the transport in the reanimobile, the vital data can be sent to the remote hospital server. Another advantage is that the solution is wireless. This is very beneficial for the doctors in terms of the space available in the reanimobiles . There is also an opportunity to check the history (dynamics of the vital parameters) and also to zoom and scroll the signal for making deeper visual analysis by the doctors.

The database records created from the patitent's data are useful for further statistical analysis. The application is developed according to the doctors demands in the General Hospital in Celje, Slovenia where it is tested and confirmed to be reliable.

Acknowledgment

This research is supported by SIARS, NATO multi-year project NATO.EAP.SFPP 984753.

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