Development of a Vital Signs Monitoring System Using Radio Frequency Communication

Fábio Ferreira, Vítor Carvalho
School of Technology
Polytechnic Institute of Cávado and Ave (IPCA)
Barcelos, Portugal
vcarvalho@ipca.pt

Filomena Soares, José Machado, Filipe Pereira, Vítor Carvalho
Algoritmi Research Centre, CT2M (2nd author)
University of Minho
Guimarães, Portugal

***Abstract*—In this paper, the data transmission of an acquisition system for biomedical vital signs via Radio Frequency (RF) communication is explored. It was developed a platform capable of recording the patient´s physiological signals to check if any medical evolution/change occurred. The system allows also acquiring the environment data, as for example the room temperature and luminosity where the patient is. The main achievement of this paper is the patients' real-time health condition monitoring by the medical personnel or caregivers that will contribute to prevent health problems.**

Keywords—ambient asssisted living (ALL); radio frequency (RF); medical care terminal (MCT)

I. INTRODUCTION

This work is part of a research and development project in Ambient Assisted Living (AAL) topic. Continuous monitoring of biomedical signals is crucial in diagnosis and clinical monitoring of patients. Nowadays, several biomedical signals are analyzed. The health assistant needs to have information of the patient's vital signs in order to be permanently informed about the patient heath status [1][2]. However, this procedure is not easy to accomplish. Regarding the acquisition of biomedical signals various sensors are placed on the patient including a series of cables to connect the sensors, which could be invasive and uncomfortable for the patient and his/her mobility [3]. At this moment, the commercial cost associated to the remote monitoring of biomedical variables in bedridden systems is expensive and unaffordable for most of families [4]. An example of a Medical Care Terminal (MCT) from BioPlux can be observed in Figure 1 [4].

Figure 1. Bioplux clinical biofeedback software GUI [4]

BioPlux clinical biofeedback software Graphical User Interface (GUI) is used in muscle rehabilitation allowing a more efficient medical intervention as well as a faster patient recovery. It is a web-based application, supported also by mobile operating systems.

The main objective of this work is the development of an electronic system using wireless transmission capable of registering the patient's vital signs. Moreover, this project gives also the possibility to the health aide to access the database of the patient, including the medical records and personal information. This project is a first step in order to achieve a minimum invasive biomedical data acquisition system, as it is further expected to integrate the sensors in the patients' clothes and/or in other common daily life tools.

This paper is organized as follows: Section II presents the biomedical sensors principle of operation used in the project; Section III presents the developed system, Section IV presents some results. Section V presents the conclusion and future perspectives of work.

II. BIOMEDICAL SENSORS

In this section, we describe some of the biomedical sensors used in this project.

A. Electrocardiogram (ECG)

During the electrical activation of the myocardium, the heart is swept by a "front activation" whose meaning and direction are modified in fractions of a second. The ECG detects the electrical activity of the heart, reflecting its activity, Figure 2 [5].

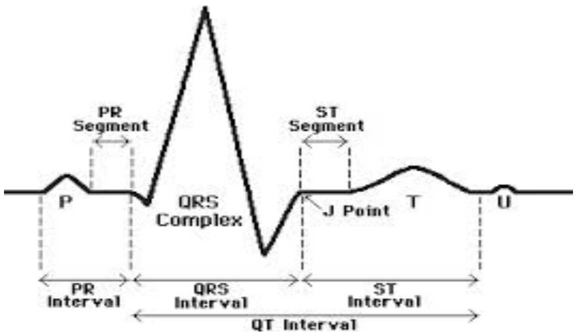

Figure 2. Electrocardiogram wave [5]

B. *Body Temperature Sensor*

The junction of two metals generates a temperature difference. The principle of operation of the temperature sensor is based on this process (thermocouple). Two materials of two different types are attached; the potential difference is measured between two points. Through this potential difference, it is possible to obtain the temperature. Figure 3 shows an example of the structure of the temperature sensor (thermocouple) used [6].

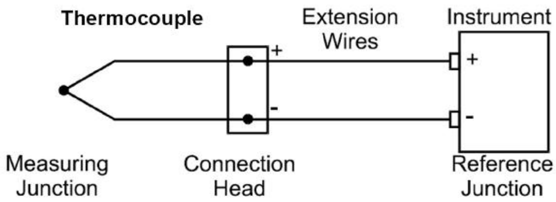

Figure 3. Thermocouple [6]

C. *Airflow Sensor*

The airflow is obtained by heating a wire by an electric current. The resistance of the wire increases as the temperature of the wire increases as a consequence of the airflow variation. Thus, it is possible to measure the airflow through the amount of current passing through the wire; see Figure 4 [7].

Figure 4. Airflow sensor [7]

Apart from these sensors, other sensors are considered in the project as the oximeter, the galvanic skin response, the patient position and the glucometer.

III. SYSTEM DEVELOPED

Figure 5 presents the overall block diagram of the system developed. This system registers the patient´s physiological signs; it allows the medical personnel to access the patient´s personal information and medical condition, as well as the applied treatment. Moreover, it also allows the remote access to monitor the patient's condition.

The database can store the data of the patient, medical personnel, health aid and health unit.

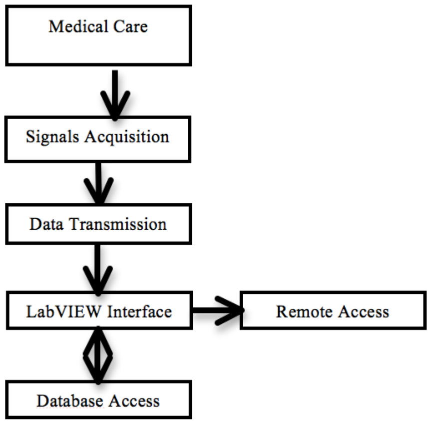

Figure 5. Block diagram of the program

A. *System Hardware*

The system hardware is based on the Arduino platform, including an Atmel microcontroller AVR [8]. The programming languages used are C and C++. Figure 6 presents an example of the connection between the room luminosity sensor, i.e., Light Dependent Resistor (LDR), the Arduino and the Radio Frequency (RF) module.

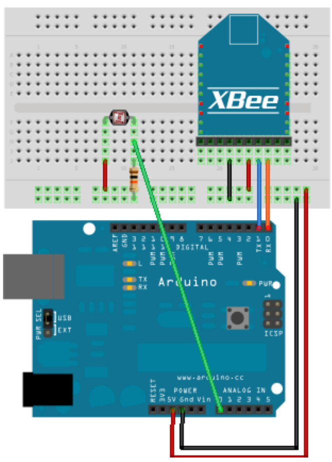

Figure 6. Room luminosity sensor (LDR) physical connection

The sensor (Figure 6) is plugged into the Arduino Analogue to Digital Converter (ADC) input (with a resolution of 12 bits [9]). After reading the sensor, the value is transmitted via the Arduino serial port (RX, TX) to the XBee and then to the acquisition system. This procedure is also used for the other system sensors.

B. *Developed Database*

The software used for data modeling was the Microsoft Access [10]. Figure 7 shows the developed database for data storage considering seven main tables plus one auxiliary table.

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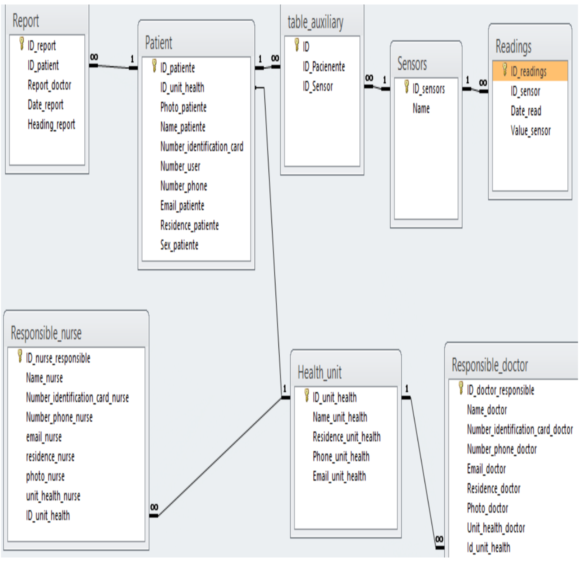

Figure 7. Data modeling

The developed database records the data associated to the patient (tables Patient, Report, Sensors and Readings), the data associated to the medical personal responsible (tables Responsible_nurse and Responsible_doctor) as well as the data associated to the health unit (table Health_unit).

C. *LabVIEW Interface*

Figure 8 shows an example of the user interface developed in LabVIEW to consult information about a patient [11]. The database is accessed via a Universal Data Link (UDL) connection. UDL was created to store connections with databases. The serial port establishes the connection between LabVIEW and Xbee. A time period is defined for each sensor reading. The value is stored in the database along with the date and time when the acquisition was performed.

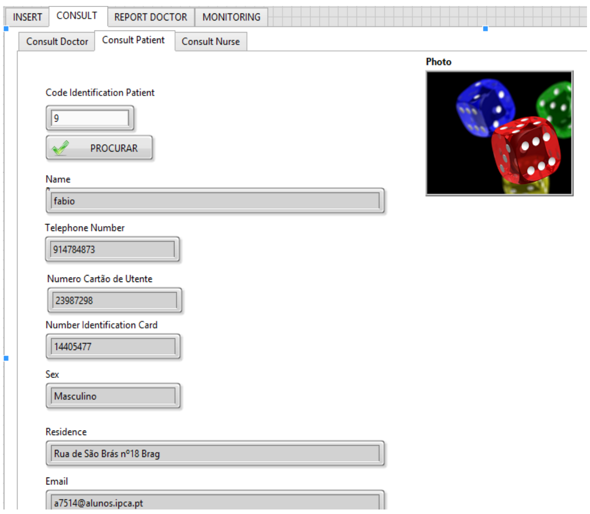

Figure 8. LabVIEW user interface – patient database consult

Figure 9 shows an example of the interface developed to register the light present in the patient's room [12].

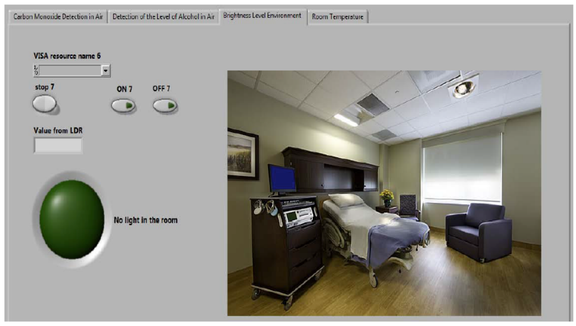

Figure 9. Light sensor LabVIEW interface [12]

Apart from the light intensity in the patient's room, the system also registers the air carbon monoxide level, the air alcohol level and the room temperature.

IV. EXPERIMENTAL RESULTS

In this section, three examples of the experimental results are presented, namely the temperature monitoring of the patient room, the access to the patient´s data and also the patient´s body temperature.

A. *Temperature Room Sensor*

In the menu from Figure 10, the medical personnel may choose to monitor the room temperature throughout the day by selecting the overall time of the acquisition. By observing Figure 10, it is verified that the patient room temperature was around 30ºC during the system measurement (one hour).

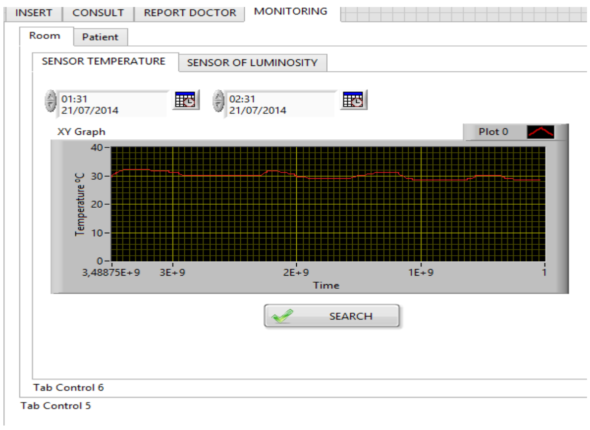

Figure 10. Room temperature monitoring

B. *Medical Reports*

As it is seen in Figure 11, the medical personnel can select a time interval and list the patient reports. To accomplish this, it has to insert the code of the patient and click on the "Search" button.

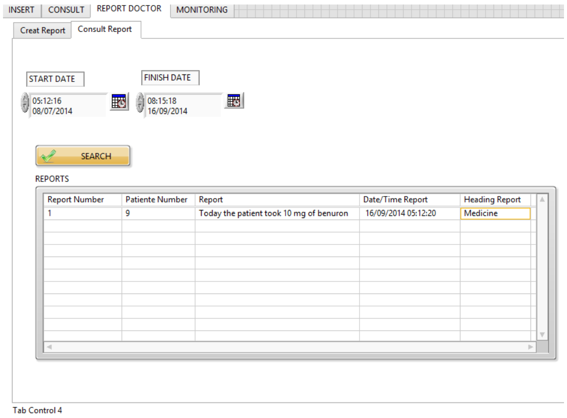

Figure 11. Consult reports

C. *Biomedical Sensors*

The system was first tested with two healthy persons: a) 28 years old, female, measuring 1.73 m and weighting 62 kg; b) 31 years old, male, measuring 1.76 m and weighting 79 kg. The first test was carried out to obtain the value of body temperature. Figure 12 refers to the sensor placement and Figure 13 shows the user interface where the temperature is acquired through wireless communication and registered in a chart.

Figure 12. Placement of the body temperature sensor in the patient [12]

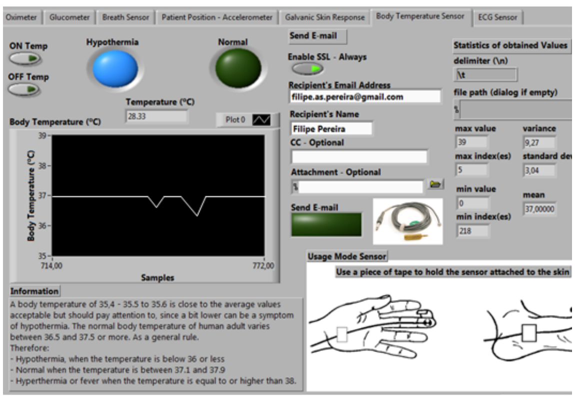

Figure 13. Obtaining the body temperature profile in the MCT [12]

The conjunction of the biomedical sensors and the environmental sensors allows obtaining a very useful profile of the patients heath condition as well as the environment were he is exposed. The transmission of this information via RF allows a less invasive system to the users (patients and caregivers).

V. Conclusion and Further Work

This paper described a system based on a medical care terminal using data transmission via RF. The physiological and environment data are acquired. An added value of this project is the real-time monitoring allowing the medical personnel to observe the patient healthcare condition at anytime and anywhere. All the data in registered in a database, allowing the physician to monitor the patient´s evolution over time.

So far, the system was tested in laboratory. In the near future, we aim to integrate all the sensors and test the system in clinical environment.

This work aims to develop a minimum invasive vital signs data acquisition system including the biomedical sensors either in the patients' clothes and/or in other common daily life tools.

Acknowledgment

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