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Review Article

Real-Time Healthcare Monitoring System Using Locally Made Device

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Abstract

In the field of human health, collecting and analyzing the real-time data is vital. New facilities and advanced tools give health service providers and their patients more choices to readily access and use health information, collect and store real-time health data. With this modern communication technologies and intelligent systems, patients will be able to monitor their own vital health signs from home and communicate the results to their health providers wirelessly. This will increase the ability to address a problem before a patient requires acute care. The ability to remotely monitor vital signs of a patient in real-time using a simple, low-cost and compact device with a minimum training time is highly desirable in a society with an increasing aging population. This research outlines the design and development of a cost effective and reliable wireless sensing device for collecting real-time health vital signs such as human body temperature and heart beat rate. A software system, written in C-Language (C) is also developed to provide two-way communications with the remote sensor device in order to receive and store the collected data by the sensor device in a central database. The developed software system (Temperature, pulse-heart beat rate, TP-HBR) is capable of receiving the data from the remote device and storing the data to a central database. The TP-HBR allows health professionals such as Medical Practitioners (MPs), nurses and healthcare providers to be able to collect the real-time data, see the patient's history, issue a new prescription and send it to the patient, other GPs or nurses by e-mails or text messages. The software can be a component of an individual system or can be used within a network connected to a central database.

Keywords: Temperature; Pulse; Heart beat rate; Monitoring; Sensor

Introduction

In the health care industry, there are different machines and equipment involved to track a patient's health parameters and as such can be improved [1]. Technology is improving, and so the healthcare applications. Health care is a critical science to deal with because it involves a human life which cannot be risked for lack of advanced healthcare devices.

In an hospital, medical workers have to move physically from one patient to another for health check, and vast amounts of time are invested in updating information about each patient's health by measuring values such as body temperature, heart rate, pulse oximetery, glucose levels [2]. This manual method is not efficient for real time monitoring of the patient's health condition especially for patients in intensive care. Also, attending to a large number of patients at the same time posses a difficult challenge leading to inacurate information about the physical state of all patients. Hence, real-time health monitoring has a great potential for the care of patients.

The advantage of remote monitoring programs provides a potentially feasible option for dealing with the expanding population of patients who are unable to access clinics due to either a lack of resources, location, or infirmity. Because of this benefit, patients can be treated in a timely fashion, before some deadly event happens by constantly monitoring the condition of patients and informing both the patients and medical professionals of any abnormalities. In this pursuit, there are many e-healthcare devices developed employing various ideas and techniques for public health institutions.

The development of a patient-friendly medical equipment at a low price to provide the effective health care is a challenging task for medical service providers, although various system employing several technologies to provide great applications have been developed. This challenge attracts many researchers to invent a new design and deploy comprehensive patient monitoring solutions for hospital health care system [3].

Tolar *et al.* [4] observed that monitoring of vital signs such as body temperature, pulse and blood pressure on a regular basis detects important to early of chronic clinical symptoms as well as for the effective treatment and management of illnesses. Baker [5], also discusses five wireless health prototypes for purposes such as infant monitoring, alerting the deaf, blood pressure monitoring, and firefighter vital signs monitoring. The five prototypes employs two sensor network mote technologies. One is the Tmote Sky, the latest derivative of the Berkeley Telos motes from Moteiv. The other one is the Corpand SHIMMER, Intel's Digital Health Group's platform for Sensing Health. In their Heart@Home blood pressure monitoring project, a SHIMMER mote is located on the wrist cuff which is connected to an electronic pressure sensor, which then broadcasts this time stamped readings over a radio network. The prototype's PC-

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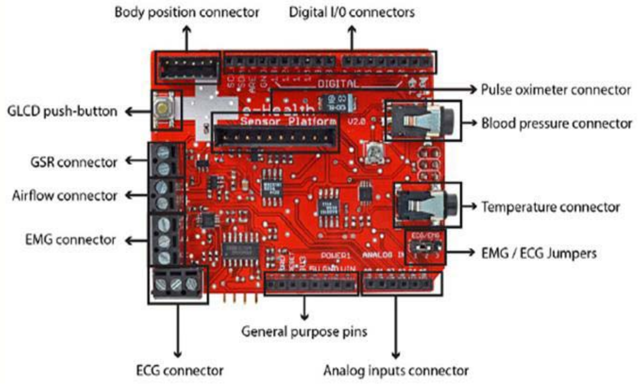

Figure 1: The biometric shield [1].

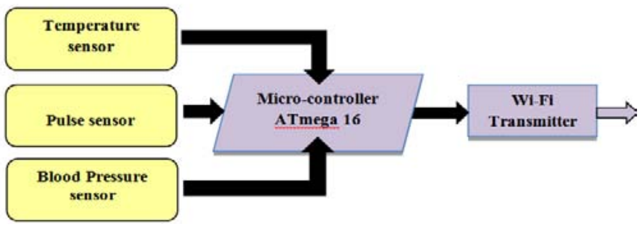

Figure 2: Block diagram of Patient's sensor node.

based software application, then provides a graph of the user's blood pressure and pulse rate over time. Sherrill [6], previously developed a wearable sensor network, which helps remotely monitor the activity of patients with Chronic Obstructive Pulmonary Disease (COPD). This system manipulates 2-axis or 3-axis accelerometers, which are attached to the arms and legs in order to monitor a person's activity in their own home and community, allowing lifestyle flexibility.

Advances in wireless networking have opened up new opportunities in a variety of applications including healthcare systems [7-11].

Many patients who require constant health monitoring prefer the comfort of at-home healthcare compared to costly and inconvenient hospital care. The main difficulty with home healthcare is enabling patients to provide accurate and timely health data to the healthcare professionals.

In order to solve this problem, a simple and efficient system is required to monitor and report the vital signs of the patients in real time [12,13]. A smart monitoring system could measure the patients' progress in real time, providing continuous feedback on the improvement in the health of patients who are undergoing treatment. Hence, in order to deliver reliable and accurate results, this study has been designed that can effectively read a patient's health parameters in order to save the person's life.

The objective is to create a cheap, reliable, lightweight and wearable wireless heart rate and temperature sensor. The sensor is expected to be able to transmit data wirelessly to the host computer or healthcare service robot. but still there is always a need to provide a more efficient and an intelligent system because of the limitations of the above developed systems.

Figure 3: Prototype of system hardware unit.

System components

This section focuses on the functionalities and the construction of the hardware mobile platforms. The mobile platform is essentially a wearable device that would be worn by a patient in order to offer continuous monitoring of the patient's vital signs.

The e-Health Sensor Shield V2.0, as shown in Figure 1, allows Arduino and Raspberry Pi users to perform biometric and medical applications where physiological data monitoring is needed. The designed sensor node for each patient employing three sensors temperature sensor, blood pressure and pulse meter as shown in Figure 2. ATmega 16 development board is used to embed the sensors and Wi-Fi module as a transmitter.

The following sensors were connected to this e-Health Sensor Shield: For body temperature measurement, LM35 temperature sensor is used in the designing of patient sensor node that gives an analog output, this voltage is measured by microcontroller using Analog to Digital Converter (ADC). The LM35 gives its output in degree Celsius.

A pulse sensor is used to measure the rate of flow of blood in patient's body per minute which is also called as heart beat. Pulse sensor works on the principle of Near-Infrared spectroscopy (NIR). NIR involves using light in wavelength of 700-900nm to measure blood volume. At these wavelengths most of tissues do not absorb light other than hemoglobin which is actually required to monitor the pulse rate. It measures the volume change in the flow of blood using infra red LED. An Accelerometer (ADXL 213) was used to detect the body position. Its gives output in two-axis response horizontal vales and vertical values. It provides a digital voltage; the amplitude of voltage is directly proportional to the acceleration.

Figure 3 shows the prototype hardware. The prototype was powered with a 9 V battery. The prototype is comprised of one pulse sensor, one temperature sensor, blood pressure sensor and one Wi-Fi module. The system is developed on ATmega-16/32 (microcontroller) development board. At portA all three sensors are interfaced and at port-D Wi-Fi module is attached using USART. After initializing the Wi-Fi module, server-client model is created where a central hub works as a server and both sensor nodes worked as clients.

System operations, results and validations

The analog processing circuitry and the sensors were assembled on PCBs which were placed within the wrist strap.

Preliminary analysis of the accelerometer signals and the

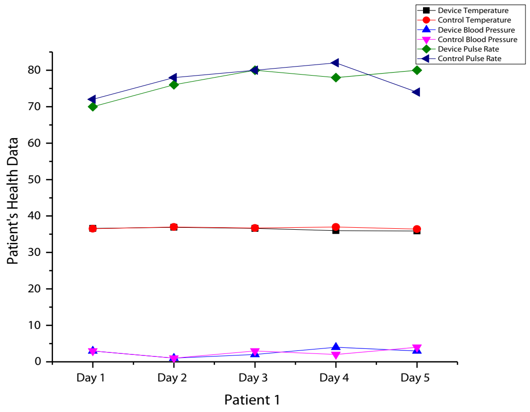

Figure 4: Output Signal Display on Patient 1.

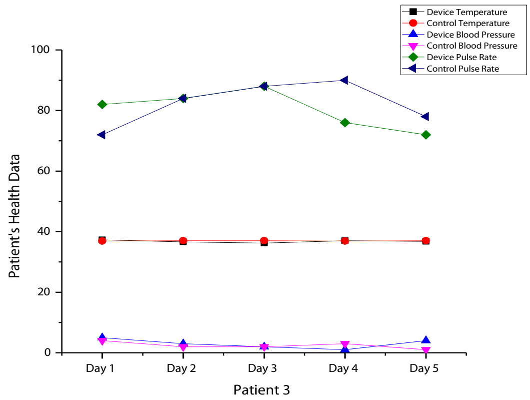

Figure 6: Output Signal Display on Patient 3.

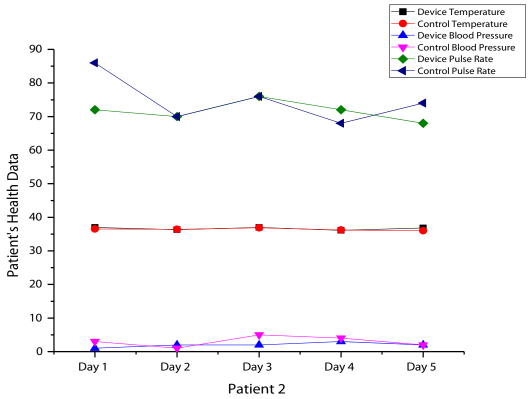

Figure 5: Output Signal Display on Patient 2.

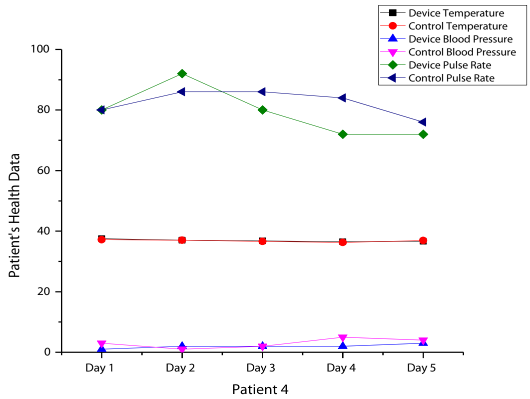

Figure 7: Output Signal Display on Patient 4.

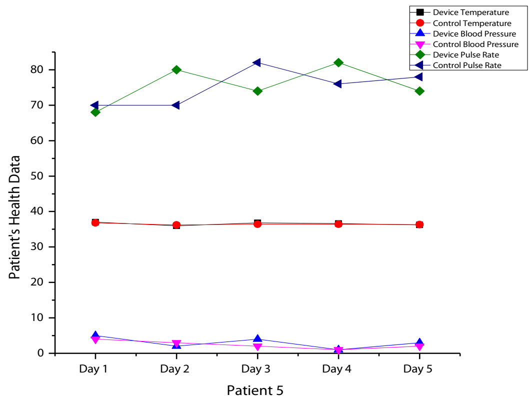

Figure 8: Output Signal Display on Patient 5.

improved signal processing algorithm proved very promising for real-time detection and intervention. Although the original signal processing algorithm from which this work is derived uses a very long window (six seconds), we were able to receive very promising results with a much shorter window (320ms). Although, a clinical study was conducted to demonstrate the sensitivity and specificity of the developed device.

The outputs of the device when tested on five (5) different patients for five (5) days are presented in Figures 4-8 below.

Conclusion

The purpose of this research was to create a wireless sensor device for monitoring some of the vital signs of health and communicate with a remote computer or a service robot.

The research project was successful in developing the wireless sensor network hardware and software which can be used in health monitoring applications. The hardware device is ready to be used in health organizations to monitor the patient temperature and heart rate. The use of TMP36 analogue sensor to measure the skin body temperature, gives a good estimation of a human's mean body temperature by using the Burton's equation with a maximum error of less than 1.33°C.

The heart rate sensor uses the combination of an infra-red LED and a phototransistor. It gives a good estimation of heart rate with maximum error between -1 and +1 beat per minute.

Experimental results obtained from the device showed that the sensor worked fine as long as the object is not moving rapidly. These types of heart rate devices are very sensitive to any special material on the measuring site, body motion, ambient lights and blockage in blood flow on arms or fingers. The sensor device still has room for improvement to deliver the capabilities of traditional electro-cardiograms.

The development of the buffered communication methodology for micro-controller increases the reliability of communication and security as well as saving power. It also reduces the transition synchronizations of packets by transmitting a whole packet at once which requires only one synchronization.

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