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Smart System for Monitoring Cardiac Patients Using Wireless Sensor Networks

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Abstract

The health monitoring system is one of the most predominant research areas in Wireless Senor Network (WSN) which uses various sensors to sense the physiological activities of the patients and the acquired information is used to alert the caretakers of the patients. The advancement in enduring healthcare monitoring can stop or rapidly reply to the incidence of illnesses and accidents. Ordinary sensors have limitations such as locations; wired communication among sensor modules does not allow patients to move freely from one place to another place and conventional techniques have more complications in monitoring rural and urban area heart patients however by using WSN it is possible by implementing internet/intranet. The proposed system concentrates on reducing the stress level and strain of doctors/patients and also reduces the medical errors, man power and increases the overall flexibility of staffs and doctors. The main objective of the proposed system for the insensible heart patients is monitor the oxygen saturation rate and blood pressure by using SPO_2 sensor and pressure sensor. The sensor data of the each patient will be sent to the smart phones of the caretakers (receiver and doctor) and to the cloud network (private network) to monitor effectively even though when the patients are in unconscious state.

Keywords: SPO_2 Sensor, Temperature sensor, Pressure Sensor, PIC microcontroller, WSN

INTRODUCTION

After 20 years, the elderly population in the world will be growing quickly and it may reach approximately 20% of total population. As the age of the people increases it leads to the increase in health care requirements in addition to chronic conditions [1].

Intensive Care Unit (ICU) Patients need to be observed carefully and this type of monitoring system involves the usage of huge cables, which impede nursing methods and make complications in patient transfers. For instance, when a patient is shifted from ICU to take MRI, CT or X-ray, these cables turn into obstacles delaying the efficient movement of the patient [2]. Generally, wireless technology in patient monitoring is an important remedy for this problem, providing the means to facilitate the mobility of patients while also improving their safety and increasing their autonomy. Patient monitoring system using wireless technology has become a frequently investigated research topic in present years [3].

Wireless sensor network is a wireless network comprises of spatially independent distributed devices using sensors in attempt to monitor physical and environmental conditions. WSN is built of several nodes from few to hundreds or even thousands and node is connected to one or sometimes several sensors if required. The physiological signals of various body parts will be transmitted to the WBAN. These data from wireless body area network is given to the cloud network and from the cloud any physician anywhere in the world can access the data and provides solutions to the patient's [4].

On the other hand, conventional wireless sensor networks are data-centric, and it has sensor that takes initiative procedures to transmit data to receiver which combines all the information and then the data will be forwarded to the computer for later analysis. For instance, when a health monitoring or medical sensor senses variations in appropriate signals, such as heart rate, temperature and blood pressure levels, it takes initiative actions as transmitting these abnormal patients information to the computer (server) for emergency diagnoses [5].

Throughout the diagnosis process, if physician requires additional real-time information for further analysis, it is difficult for the physician to attain real-time sensing by using conventional sensors. Additionally, if there is a larger interval among data gathering and analysis, then it is tough to attain real-time health monitoring. Moreover, in some emergency cases, it is hard to perform real-time therapy because physicians cannot acquire current location information of the patients. Hence, it is mandatory for physicians to obtain real-time sensing parameters and current location of patient at any time period and place. The motivation and the main objectives of our present study is to offer a system architecture where physicians can take initiative actions of any patients physical parameters at any time and any places to obtain real-time health monitoring. The rest of this paper is categorized as follows. In Section 2, we briefly introduce short range WBAN technologies and review the previous research works on mobile application and cloud network in patient monitoring. In Section 3 we describe the system architecture of wireless heart monitoring system, as well as different types of medical sensors. In Section 4 we lay out the real time demonstration of transmitter, receiver section and the information to the cloud network and android app of the wireless heart monitoring system and Section 5 provides a summary of the results from observations and future scope.

RELATED WORKS

The health monitoring application of WSNs delivers an efficient resolution for patient monitoring. This segment evaluates the related work on patient's health monitoring based on WSN, and it includes introduction to conventional sensor networks, deliberates the advantages and key issues in health monitoring and in addition to this part analyze the patient monitoring based on different sensing parameters. The body-sensing sensor module measures the body's physiological signals; the body wireless network collects the information and sends this information to the mobile nodes. The node will display the information when the patient's sensor value is less than the threshold value such as heartbeat, blood pressure and body temperature. Hua et al., 2014 [4] examined the fall-detection mechanism with the help of SPO_2 Sensor, Heart Beat Sensor, Ambient Temperature Sensor, Triple Axis Accelerometer and GPS Sensor. When the normal value exceeds a value of more or less than 15%, the status is viewed as dangerous. These dangerous values will be detected by using micro controller and from the controller the information will be sent to the display unit at the same time it will be updated in the cloud server. Maria et al., 2014 [6] analyzed wireless monitoring system for pulse-oximetry sensors. Many pulse oximetry sensors were placed on several heart patients' body without using a wired or infrastructure network. These sensed signals will be transmitted to the internet through WLAN and GPRS. Information exchange between the patients and doctor will be more efficient, quick and secure by using Wi-Fi and GPRS. By using a wireless handheld device the doctors can access patient's history, medicine and lab reports etc. Alumona et al., 2014 [7] examined wearable sensor technology. Electrocardiography sensor, blood pressure sensor, breathing sensor, electromyogram sensor and electroenphalogram sensors were used to monitor biological functions of the patients. These wireless sensor nodes will form medical super sensor. This server will collect the information from WBAN and give priority to the sensed parameters. Lai et al., 2010 [8] examined adaptive body posture analysis for elderly-falling detection. Collaborative accelerometer sensors, body posture analysis, adaptive adjustment model and fall detection. In collaborative detection, persons standing, sitting and lying down positions angle values are kept as a threshold value and if the detected acceleration value does not coincide with the threshold the fall has occurred.

Lai et al., 2011 [9] investigated the detection of cognitive injured body region using multiple triaxial accelerometers. The body acceleration depends according to the gravity towards the earth surface. While sitting, standing and lying the gravitational direction will vary and the acceleration will differ. This system uses several sensor modules to improve accuracy fast Fourier transform is used and it is a combination of fall sensing methods and cognitive adjustment technology. Constantinescu et al., 2012 [10] studied dynamic integration of multimedia medical data. This system is constructed by self-managing and automated network for medical data and it can be accessed by any handheld devices. Service oriented architecture is used to add web service software application to the existing tool. This will create a complex medical application and mount them on the cloud network. Basu et al., 2012 [11] studied fusion architecture for cloud network**.** Fusion architecture consists of infrastructure service and healthcare applications. The infrastructure layer contains information about stored data of patients, communication between the healthcare providers. Data management block is used for data encryption, data retention and data analyses and it will also provide data authentication. Thomas et al., 2010 [12] analyzed fall detection using wrist watch. Fault detection algorithm was built in wrist watch. It will be easy to handle. The wrist watch will alert the relatives or call center through wireless link. Chen et al., 2012 [13] examined fall detection mechanism. This system uses tri-axial accelerometers, barometer and zigbee protocol. This method has higher accuracy by using patient's daily activity details. The system has sensitivity and specificity of 95.71% and 97.78%.

METHODOLOGY

Wireless sensor networks contain thousands of highly integrated sensor nodes. These nodes are capable of sensing of physical quantities. In the proposed method, in order to make the existing system more efficient and reliable in addition to heart rate, pulse rate we are going to measure the oxygen saturation, temperature and blood pressure of the patients by using SPO_2 sensor, temperature sensor and pressure sensor. For the heart patients, the proposed system design between data transmission and data reception can be demonstrated by using below architectural design structure which is shown in Figure 1. A pressure sensor measures pressure, typically of gases or liquids. Pressure is an expression of the force required to stop a fluid from expanding, and is usually stated in terms of force per unit area. A pressure sensor usually acts as a transducer it generates a signal as a function of the pressure imposed. By using this sensor the patient's blood pressure can be sensed. The threshold value of the pressure sensor, the upper limit is 120 and the lower limit will be 80.

Thermistor is a form of resistor whose conflict varies with temperature. The temperature retort is also different. RTDs are valuable over larger temperature ranges; at the same time thermistors has a higher accuracy within a restricted temperature range −90 °C to 130 °C. The threshold value for the temperature sensor is 37^0C. A pulse oximetry sensor is an all-encompassing sensor which provides nonstop evaluation of arterial hemoglobin oxygen dispersion. The pulse oximetry consists of two LEDS. One LED will emit red light and another will emit infrared light. The photo detector is used to absorb the two beams of lights and from the received signal the heart rate can be estimated. The threshold value of pulse oximetry sensor will be 95%. This sensed data will be given to the PIC micro controller. The controller will be already having the predefined threshold values and it has inbuilt comparator by using the sensed current data will be compared with the threshold values. If the updated sensor value is less or greater than the threshold value the alert will be given to the caretakers of the individual patients smart phone and from the smart phone the data will be transmitted to the cloud network. By using cloud network any physician anywhere in the world

can access the data and they can provide solutions to the patients.

IMPLEMENTATION AND RESULT DISCUSSION

Transmitter Section

The transmitter section consist of step down transformer, rectifier, filter, regulator circuit, PIC controller board, SPO_2 sensor , pressure sensor, LCD display, Zigbee transmitter. Initially 230V is given as input and it is converted to 9V by using a step down transformer. Then this 9V is given to the rectifier and filter circuit to remove the harmonics and noise. The regulator circuit is used to regulate the voltage to 5V, 12V. This regulated voltage is given as the supply to the PIC controller board. At the same SPO_2 sensor senses the insensible heart patients oxygen saturation rate and it is amplified by using amplifier and given to the NOT gate to generate high low pulse. The pressure sensor is used to measure the patient's pressure range. These values will be given to port A, B of microcontroller and it will be displayed in the LCD and Zigbee is used to transmit the data and it was shown in Figure 2A.

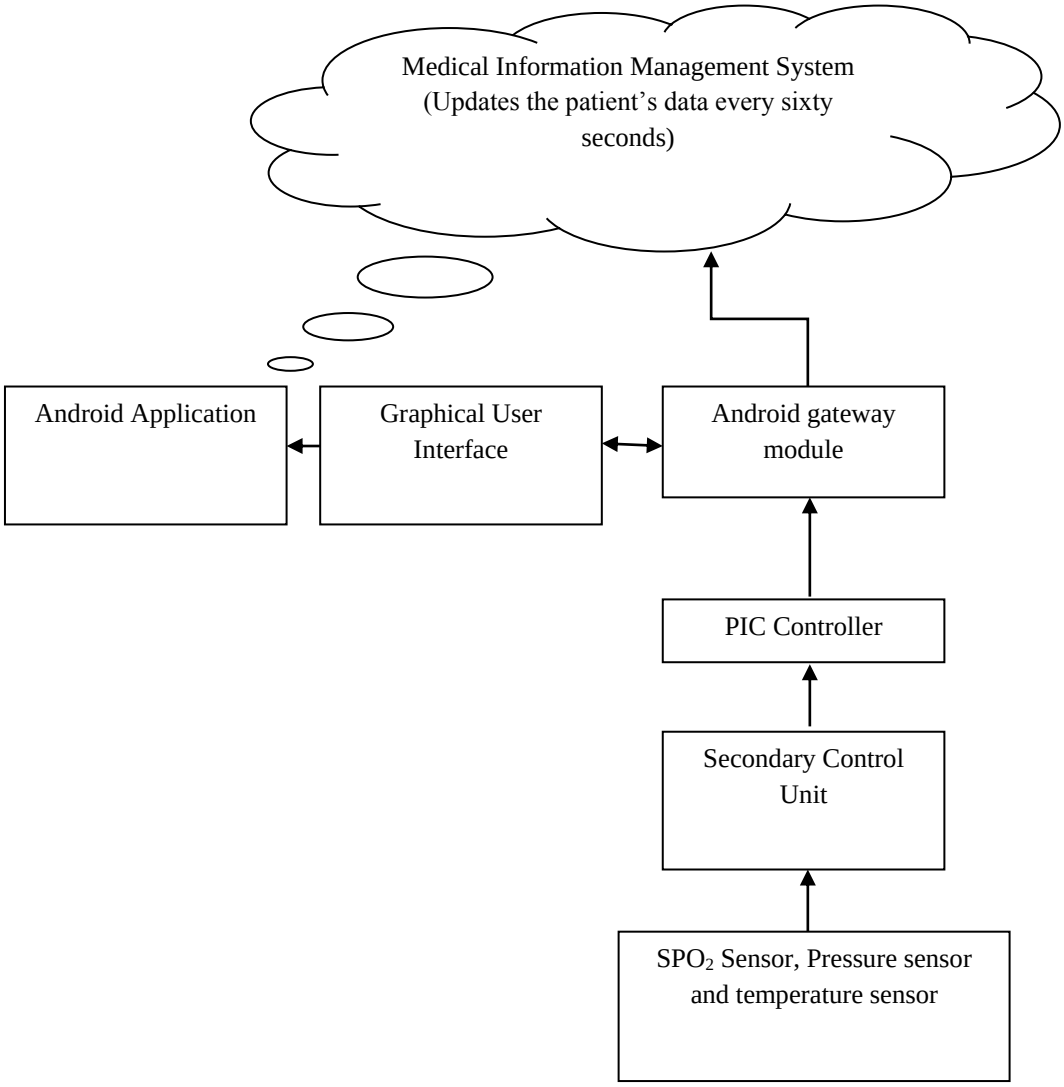
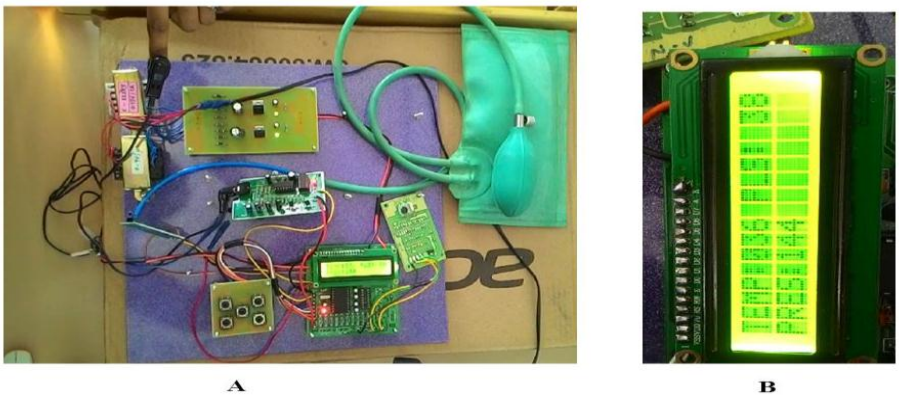


Figure 1. Block Diagram of wireless health monitoring system



A B

Figure 2 (A) transmitter section of heart patient monitoring system and **(B)** Displaying Patients Detail in LCD

For example, displaying the data of the patients such as oxygen saturation rate is 38, pressure is 144 and the temperature is 36ºC. In normal condition pressure should be less than 120 and saturation should be 60- 100 so abnormalities exist from this result the patient is possible to get heart stroke or heart problem and it is illustrated in Figure 2B.

Receiver Section

The receiver section consist of step down transformer, rectifier, filter, regulator circuit same as transmitter section to provide power supply to receiver. In addition to this Zigbee receiver is used. The coverage of the Zigbee receiver is 10-20 meters. The transmitted data will be received by the Zigbee receiver. The transmitter /receiver Zigbee consist of protocol to convert the data (signal) to frequency and vice versa and it is shown in Figure 3A. This received signal will be updated in the online server by using JAVA which can be viewed by physicians anywhere in the world. At the same time the updated information can be sent to the caretakers of the patients by using an android application and it is demonstrated in Figure 3B.

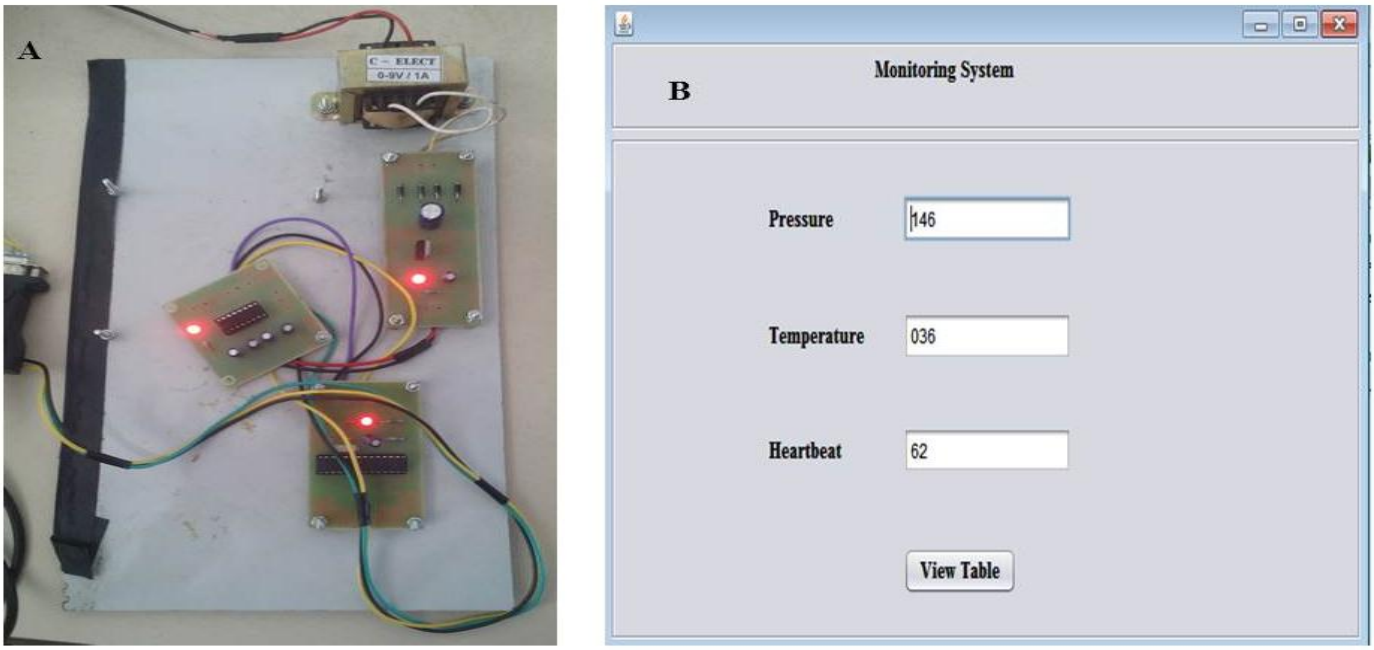


Figure 3 (A) Receiver section and **(B)** Displaying the data of patients in particular time on the online server in wireless heart monitoring system

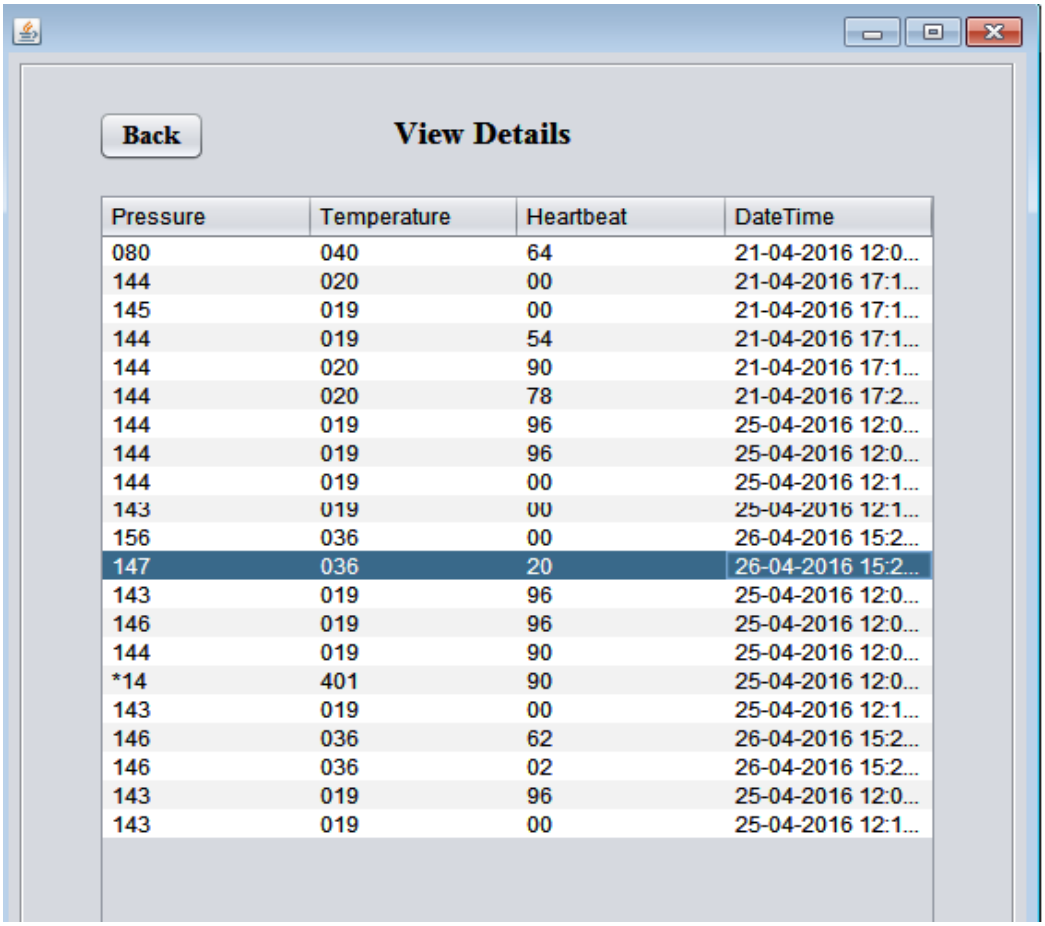


Figure 4. Stored Data of the Patients in the Server

Figure 4 describes about the data stored in the online for single patient but in different period of time. The table consists of pressure value, temperature value and oxygen saturation rate value of same patient but in different period of time in different dates. The SPO_2 sensor will sense the pulse for every 6 seconds and it will be multiplied by 10 to calculate the value for every 60 seconds. The pressure will be continuously monitored.

The android application is created to alert the caretakers of the patients. We focus on the Mobile-Phone-based Remote Patient's Vital Signs Monitoring and Intelligent Alerts System and an intelligent data record system with validation and transmission of health tips to the patients as well as to the guardians. Once if the patient data is less than the normal values it will be updated in the online server and to the android app. For example, in this the patient has pressure 147, temperature 36 and heart rate 20 and it is shown in Figure 5. So abnormalities have been found. Finally the system indicates that first aid recover measures should be done by the caretakers. Similar research has been reported by Sawand et al., 2014 proposed Multidisciplinary methods to achieve efficient and reliable eHealth monitoring structures, technological integration among wireless body area network, IOT and cloud.

Figure 5. Displaying the patient details in Mobile Application

Cloud computing have significant contribution in eHealth monitoring which enhances the excellence of medical system,

basically patient monitoring system plays a vital role in e health care facilities which comprise medical data gathering, accumulation, data transmission and analysis and here entire monitoring lifecycle and essential services component have been discussed as well as the challenging issues in designing the patient monitoring system along with possible solution.

CONCLUSION

Critical infrastructure monitoring has distinctive characteristics, based on the type of monitoring to be achieved. Depending on the position of the sensors and the type of monitoring system, communication technology will be used, taking patients information with different time period. Based on the perspective of communications, a wireless communication protocol will be used. The proposed method achieves the monitoring of temperature, oxygen saturation rate and blood pressure of heart patients using temperature sensor, SPO2 sensor and pressure sensor. Cardiac patients can be monitored by large No. of sensing parameters (coverage of the system, area size, and number of patients, data type, and speed of the transmission)) computing to achieve better analysis on heart patients. The online server has used to store and retrieve the details of multiple patients. In addition to this an android application has been created to provide alert message to the smart phones of the caretakers. By using the cloud network (online server) large amount of data of different patient's records can be stored and retrieved for future purpose. The physicians anyone, anywhere in the world can access the data through the cloud network. In future artificial hands can be implemented for insensible heart patients to provide first aid solutions to themselves by using robotics concept.

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