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Wireless Wearable Smart Healthcare Monitoring using Android

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Abstract—The healthcare monitoring system is very useful for the old age people, cardiac vascular endues and many others for observing vital parameters like blood pressure, heart rate, pulse rate, body temperature etc. The proposed work utilizes 8bit X-Mega2560 microcontroller with an application created for overseers and hospital to constantly watch the patient's parameters from their home, hospitals etc. The proposed system senses the vital parameters of the patients and sends an alert message to respective caretakers, through Wi-Fi which utilizes COAP conventions. These models are integrated to a simple arduino uno microcontroller to exhibit different functionalities. The system will reduce the cost, empowering the patients who are not able to consult the doctors for diagnosis and also minimize the patient's transportations. This system will bridge the gap between patient and doctor in real time.

Index Terms**—**Wi-Fi, COAP (Constrained application protocol), Monitoring, Arduino UNO microcontroller, vital parameters, LCD.

I. INTRODUCTION

Now a day's health is very important because everyone needs it at several points in their life time. There are many issues on health related cases throughout the year. It is very much essential to continuously monitor the one's health. Well-being is the most vital consideration for every single living being irrespective of their age and standards. The medical problems occur due to lack of knowledge regarding cleanliness, not knowing the maladies, self-medication, drug addiction, alcohol consumption etc. Due to these problems people suffer more and frequently visit hospital to check their health. The proposed system helps the patient continuously monitor their health condition at home and send the information regarding to doctor using android application. The most noteworthy feature of this system is that, the health condition of a patient can be made known to all concerned. The rest of the paper is organized as follows. In section II, a literature survey has been presented. Motivation of a proposed system is discussed in section III. The problem statement is given in section IV and objectives of proposed work are stated in section V. Section VI discusses the implementation of proposed work. The results are discussed in section VII, and the conclusion is given in section VIII.

II. RELATED WORK

Monitoring of the health condition of a patient under critical illness and conveying the monitored information to the care takers and concerned doctors is a major concern of this work. This section reviews the various technologies available for wireless communication, their merits and demerits. This section also reviews the different sensors to measure the vital sign parameters like blood pressure, heart rate and body temperature.

In [1], it implements the tele-monitoring system for continuous monitoring of chronic conditions such as CHF (chronic heart- failure) and alert physicians for any Signs and symptoms occurrence. This is not a battery powered system which is the main drawback.

In [2], a healthcare monitoring system is implemented through GSM based networks. On violation of vital parameters, automatically send the message to caretakers or doctor.

Paper [3] details design and implementations based on GSM enabled embedded system for monitoring the bio-medical parameters like blood pressure and body temperature. The system uses GSM for communicating the abnormalities in the simulated bio-medical parameters.

Paper [4] explains about how to monitor the patient's health condition by introducing the WBAN system and cloud based computing.

Paper [5] describes to improve the efficiency of medical gadget. Based on IOT technology monitoring the patient's sign parameters which uses the different protocol and RFID to identify physiological conditions, UHRFID is used and must be implement to every patient to make this system local access only.

In [6], proposes a novel algorithm for BEC node and monitors the patient's health via WBAN server.

Authors in [7], planned a mobile health application for fare observance and assessment, which is able to keep a track of daily personal health record of a user for blubber interference. The appliance can send alerts and messages regarding the user's diet program taking into consideration his physical activity.

In [8], the embedded microcontroller is connected to set of medical sensors and communication modules which check the patient health condition status. If the results are abnormal, embedded unit uses the patient's phone to transmit the patient's status to medical center. In this situation doctor will send medical advice to patient to save his\her life.

Paper [9] focuses on the measurement and monitoring various parameters of patient's body like heart rate, temperature, and blood pressure using web server and android application. Using an android app doctor can monitor the patient's condition, and patient's data will be stored on the web server. And doctor can access the patient's information whenever needed.

Paper [10] presents an IOT remote healthcare monitoring system that provides the patient's vital sign parameters (heart rate, ECG, blood pressure, oxygen saturation in blood level, etc.) through web browser. Implementation is based on CoAP protocol on Mozilla Firefox web browser and the manipulation of resources by CoAP methods.

Paper [11] gives the proper and efficient medical services to patients by connecting and collecting the required data information through health status monitors which would include patient's blood pressure, ECG and heart rate and sends an alert message to concerned doctor with his current status and full medical information.

In [12], using a specific sensor, the data will be captured and compared with a configurable threshold via microcontroller which is defined by a specialized doctor. In case of emergency a short message service (SMS) will be sent to the Doctor's mobile number along with the measured values through GSM module. Furthermore, the GPS provides the position information of the monitored person who is under surveillance all the time. This paper also demonstrates the feasibility of realizing a complete end to end smart health system responding to the real health system.

Paper [13] demonstrates the feasibility of using flexible, and user-friendly equipment to inform others when user needs an emergency response. And also presents a combination of mobile communication with data transmission through Wi-Fi.

In [14], improving ambulance transportation availability services when requests are made without having to call or wait for long time. This paper analyzed, designed and implemented a prototype to demonstration the operation of the system to show its effectiveness with respect to the current system.

Paper [15], presented the health monitoring using smart phone accessories. The major benefit to using this system is that the users do not have to carry an extra device while maintaining their health and safety. Additionally, to improved the accuracy of the ECG measurement.

Following are the drawbacks of the existing systems which the authors have learned through literature survey.

- Safety and security measures have not considered.
- Many of the authors use the GSM and GPS network to monitoring the patient's health.

III. Motivation

When a patient is in critical illness, timely monitoring of vital sign parameters and providing with the required treatment is very important. In many cases the patient may be alone, caretakers and concerned doctors are faraway for him. Under this condition the patient may reach a critical state or even die. In order to help such kind of people to draw the attention of concerned and provide with them the necessary treatment, the author's thought of developing a fully automated wearable and smart healthcare monitoring system.

IV. Problem Statement

Medical facilities in rural areas are of major concerned due to lack of transportations, infrastructure facilities and non-availability of medical faculties. Hence to overcome these difficulties a smart real-time embedded based medical healthcare system has to be designed which continuously monitors the patient's health, alerts concerned persons over App for health degradations so that medication is possible to provide in stipulated time.

V. Objectives

The objective of a proposed work is to build up a healthcare monitoring system that provides assistance in case of emergency for the patients, old age people, cardiovascular suffer etc. for monitoring vital parameters. The system continuously acquires the patient data, process and sends information wirelessly to caretakers and concerned doctor, using CoAP protocol without any human interference. The main objectives of the proposed system are as follows.

- To monitor the patient's condition in real-time and provide an effective and needful medical service alert at the earliest.
- To design emergency medical assistance system (EMAS), and provide gateway using CoAP for secured communication.
- To monitor the patient's health status through an android app.
- To create an RTOS based embedded design for the proposed system.

VI. Implementation

The main aim of a proposed system is to cover end to end smart healthcare application system. It consists of LCD, microcontroller and sensors, etc. as shown in fig.1. The system block diagram is divided into two units first unit is controlling and communication which is done using X-Mega2560, 16 MIPS processing speed, 8bit controller, 10bit ADC, 3UART, SPI and GPIO.

The various components required for implementation of a proposed system are described in following sub-section.

A. Arduino Microcontroller

In this proposed system we have used arduino X-Mega 2560 microcontroller board, which is based on X-Mega 2560 microcontroller. All models are controlled by microcontroller.

B. Wi-Fi

ESP8266 node MCU Wi-Fi communicate at 100Kbps speed using 2.4GHz frequency, user can get access to the status information about vital parameters by using specific android app install in the smart phone.

C. LCD

A LCD is a tool used for visual display of the output and it follows the properties of light modulation for its display. A LCD is required in this project to display various messages to user and thus making the device convenient. The various types of messages include a bed wet detected or alert due to increase in temperature or heart rate.

D. LM35

LM35 is an analog sensor is mainly used to measure temperature variation in patient’s body, LM35 sensor is a RTD type which gives the output as according to variation in temperature resistance. Output voltage of the sensor will vary from 0.1 to 5V. LM35 sensor is connected to ADC channel of microcontroller for the best conversion of voltage into temperature.

E. Pulse Oximetry

Fingertip sensor based BPM estimation with the help of infrared transmitter and a photo transistor arranged side by side by using optical type TCRT1000 sensor. This sensor divided into four stages first stage consist of TCRT with two transistor forming as a voltage divider and current limiting for photo diode, 10kΩ resistor is connected to V_{cc} and collector, emitter is connected to ground. When IR light reflects back to photo transistor they act as a barrier breaks, causing the electron to move from P to N. when transistor turn on, output at V Sensor changes its waveform in periodic attributed formation for physical variation of reflected IR.

F. Blood Pressure

Systolic and diastolic pressures can be measured by auto inflate BP unit. This consists of cuff, air pump and solenoid d pressure valve and 50Kba pressure sensor. When system is activated it starts pumping air into cuff through air pump. Which must not be more than 161mmHg of systolic and 91mmHg of diastolic pressure. When systolic pulse is obtained at 121mmHg and diastolic pulse obtained at 81 mmHg pump will be stopped after that air will be deflected.

G. Bed Wet Detection

Bed wet detection detects the saline contain in water. This sensor is made up of two electrodes, one is a copper wire another one is nick chrome wire with an j-fit transistor, nick chrome connected to base of transistor, copper is connected to V_{cc} through a 10kΩ resistor, collector of these transistor is directly connected to V_{cc}, emitter is connected to ground via 10kΩ resistor a output is taken for analog to digital conversion.

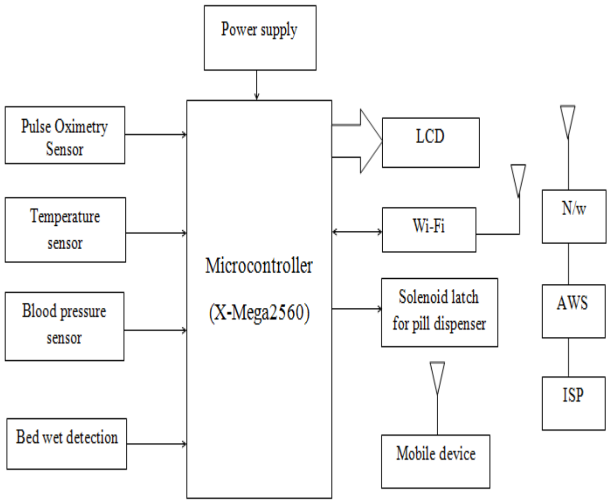

Fig.1. Block diagram of a Proposed System.

H. Pill Dispenser

A 12V latch type solenoid is used to stimulate the operation of pill dispenser. Solenoid is an analog electromagnetic type device. Microcontroller cannot drive the solenoid directly because microcontroller is a digital device, solenoid needs 12V at 120mA current to drive. Hence to overcome these problems a L293D H-bridge is used to drive the microcontroller, when user press dispenser button, microcontroller sends a high signal to driver and derive drives the solenoid latch.

The flowchart of a proposed system is shown in Fig 2.

VII. Results and Discussion

The proposed system requires low-bandwidth and it can be battery-powered. Fig. 3 shows the complete module setup. Here we develop the prototype of monitoring the various vital parameters with the help of microcontroller and an alert message through android app. This prototype streams the live sense data onto vital parameters of the patient.

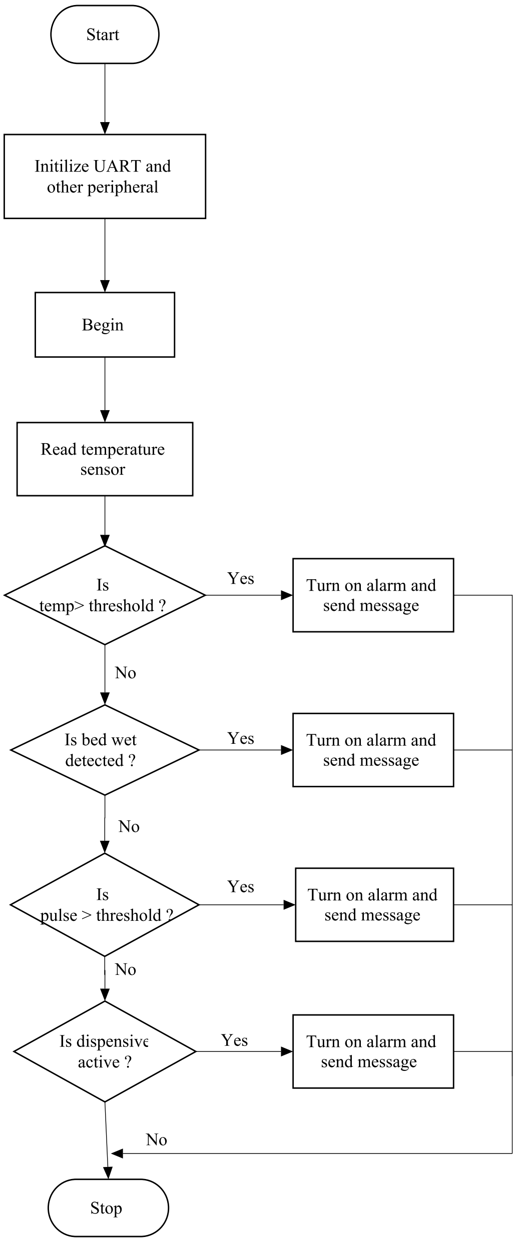

Fig.2. Flo wchart of a Proposed System.

Fig.3. Complete Module Setup.

LCD displays the operating condition of a device and also indicates its status. The following snapshots are taken from system LCD and can be used in result analysis.

Bed wet detection: For the detection of bed wet two probes are inserted into pad. The probes measure the conductivity. In the presence of wetness the conductivity will be more than when it is dry. In case of bed wet detection the information is displayed on LCD and an alert message is also sent as shown in Fig. 4.

Fig.4. Bed Wet Detection is displayed on LCD with Respect to App to Monitor.

Temperature detection: Temperature detection is done by using a temperature sensor (LM35). Which is placed in between armpit to detect the body temperature and the measured data is displayed on LCD and a message is sent as shown in Fig.5. If the temperature crosses its threshold value then an alert message is sent to mobile app.

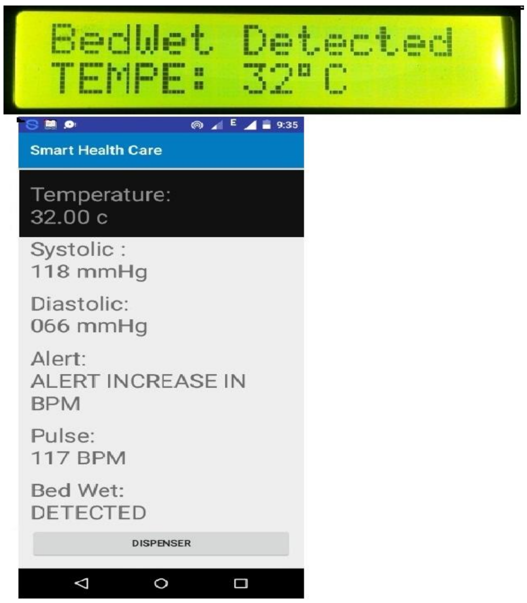

Fig.5. Temperature Reading on LCD and App.

Blood pressure: For the measure of blood pressure a blood pressure unit is used, which is inserted into the hand, blood pressure of both systolic and diastolic pressures is measured by the BP unit that are displayed in LCD and also sent a message to mobile app as shown in fig.6. If any variation in the blood pressure is found then an alert message is sent to an android app.

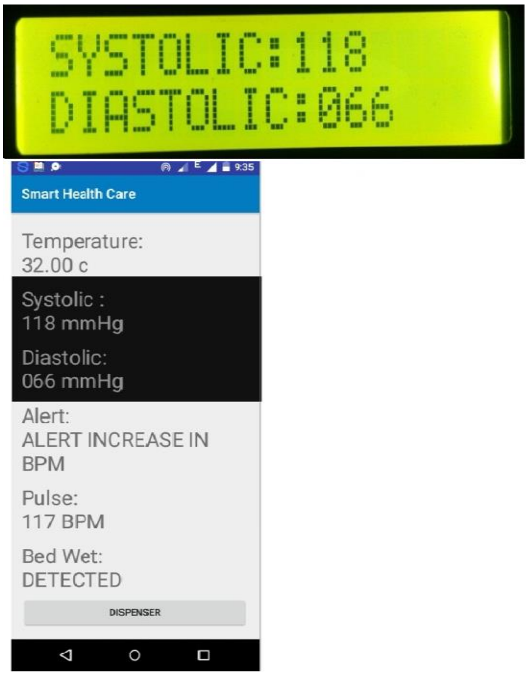

Fig.6. Blood Pressures Reading on LCD and App.

Pulse rate detection: Monitoring the pulse rate is done by using the sensor which is fixed to the index finger. An alert message is displayed on LCD as shown in fig.7. Fig. 8 shows the monitored of all vital parameters are displayed on LCD with respect to app. Table 1 shows the comparison between proposed system and exiting system.

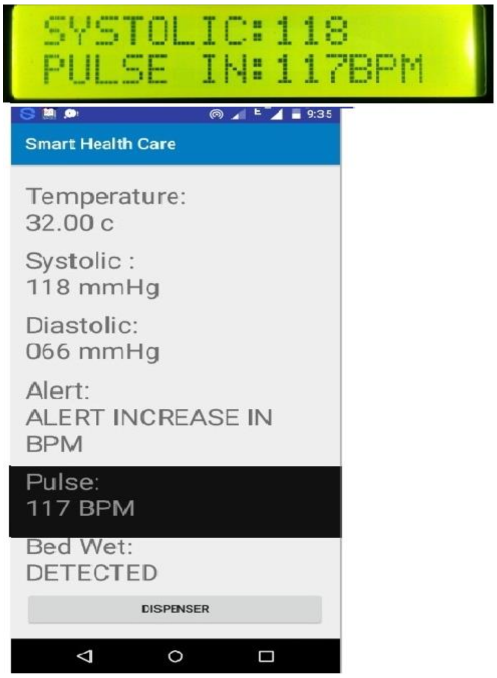

Fig.7. Indication of Bed Wet Detection and Increased in Pulse Rate On LCD and App.

Fig.8. Measurement and Display of all Vital Parameters on LCD and App.

Table 1 shows the comparison between proposed system and exiting system. Tables 2, 3, 4 and 5 will present the vital sign measurement like heart rate, body temperature and blood pressure of various patients.

Table 1. Comparison between Proposed System and Exiting System

Parameters	Existing design	Proposed design
Communications and cost	Reliable in communication and cost [12]	Real time and minimal band width
Security	less secured [4]	Highly secured due to QOS_2
Could computing	Support only desktop [7]	Support AWS using CoAP
GPS, GSM	Based location identification, SMS sending [5]	Due to specific ID, no need GPS
Monitoring	Quiz real time (SMS only) [5]	Real time
Display type	Text [8]	GUI
Transmission requirement	Only when network connection exits [1]	All time due to Wi-Fi
Data size	Few bytes [6]	Up-to 1Kb
Sensor monitoring	Continuous [3]	Continuous

Table 2. Heart Rate Measurement

SI. NO	Patient name	Patient age	Heart rate (BPM)		[1] % Error
			As per the physician	As per the system	
1	XXXX1	23	91	90	+1.1
2	XXXX2	26	89	87	+2.2
3	XXXX3	32	90	88	+2.2
4	XXXX4	35	77	76	+1.3
5	XXXX5	37	97	96	+1.0
6	XXXX6	38	87	88	-1.1
7	XXXX7	42	90	91	-1.1
8	XXXX8	43	90	89	+1.1
9	XXXX9	49	77	75	+2.6
10	XXX10	54	92	95	-3.3
11	XXX11	56	101	100	+1.0
12	XXX12	62	91	93	-2.2
13	XXX13	65	90	91	-1.1
14	XXX14	70	71	73	-2.8
15	XXX15	76	77	75	-2.6
16	XXX16	80	107	110	-2.8

$$^{1}\ \%\ \text{Error} = \frac{X - Y}{X} \times 100 \quad (1)$$

Where:

X = Heart rate recorded by physician
Y = Heart rate recorded by the system

Table 2 lists the readings of heart rate measurement of patients belong into a wide range of age groups note that the error is ±3.3% which is in tolerable limits.

Table 3. Body Temperature Measurement

SI. NO	Patient name	Patient age	Body temperature (^{0} c)		[2] % Error
			As per the physician	As per the system	
1	XXXX1	23	35.2	36	+2.8
2	XXXX2	26	38.5	38	+1.3
3	XXXX3	32	38.6	38	+1.6
4	XXXX4	35	36.5	37	-1.4
5	XXXX5	37	36.3	37	-1.9
6	XXXX6	38	37.5	38	-1.3
7	XXXX7	42	37.5	36	-1.4
8	XXXX8	43	37.5	37	+1.3
9	XXXX9	49	35.2	36	+2.3
10	XXX10	54	35.5	36	-1.4
11	XXX11	56	36.3	37	-1.9
12	XXX12	62	35.6	36	-1.1
13	XXX13	65	36.5	36	+1.4
14	XXX14	70	38	39	-2.6
15	XXX15	76	37.5	38	-0.01
16	XXX16	80	37	38	-2.7

$$^{2}\ \%\ \text{Error} = \frac{A - B}{A} \times 100 \quad (2)$$

Where:

A = Body temperature recorded by physician
B = Body temperature recorded by the system

From table 3, it clear that the measured body temperature of patients under various age groups using the proposed system deviates with a percentage error of ±2.8% with respect to conventional approach. This error is in tolerable limits.

Table 4. Systolic of Blood Pressure Measurement

SI. NO	Patient name	Patient age	Blood pressure for systolic (mmHg)		[3] % Error
			As per the physician	As per the system	
1	XXXX1	23	120	123	-2.5
2	XXXX2	26	158	156	+1.3
3	XXXX3	32	118	120	-1.7
4	XXXX4	35	119	119	0.0
5	XXXX5	37	130	127	+2.3
6	XXXX6	38	128	130	-1.6
7	XXXX7	42	139	140	-0.7
8	XXXX8	43	125	124	+0.8
9	XXXX9	49	113	115	-1.8
10	XXX10	54	118	120	-1.7
11	XXX11	56	140	138	+1.4
12	XXX12	62	130	129	+0.8
13	XXX13	65	128	130	-1.6
14	XXX14	70	138	140	-1.4
15	XXX15	76	140	138	+1.4
16	XXX16	80	156	156	0.0

Table 5. Diastolic of Blood Pressure Measurement

SI.NO	Patient name	Patient age	Blood pressure for diastolic (mmHg)		[3] % Error
			As per the physician	As per the system	
1	XXXX1	23	83	84	-1.2
2	XXXX2	26	96	97	-1.0
3	XXXX3	32	86	87	-1.1
4	XXXX4	35	88	90	-2.5
5	XXXX5	37	90	93	-3.3
6	XXXX6	38	82	84	-2.4
7	XXXX7	42	95	92	+3.1
8	XXXX8	43	85	85	0.0
9	XXXX9	49	77	76	+1.3
10	XXX10	54	87	89	-2.3
11	XXX11	56	100	97	+3.0
12	XXX12	62	90	89	+1.1
13	XXX13	65	89	92	-3.4
14	XXX14	70	95	98	-3.2
15	XXX15	76	100	101	-1.0
16	XXX16	80	101	102	-0.9

The table 4 and 5 shows the measurement of both systolic and diastolic blood pressure. Observe from above table that the errors in the measurement of systolic and diastolic blood pressures respectively are ±2.5% and ±3.3% which are in the tolerable limits.

$$^{3}\% \text{ Error} = \frac{P - Q}{P} \times 100 \tag{3}$$

Where:

P = Systolic and diastolic blood pressures as recorded by physician

Q = Systolic and diastolic blood pressures as recorded by the system

VIII. Conculsion and Future Work

The proposed system provides low power consumption, low complexity and highly portable for healthcare monitoring of patient's and it can reduce the need of utilization of expensive facilities. The doctor can easily access the patient's information at any time and in anywhere with the help of android application. This innovation enhances the life style of the people.

In future, we can develop a long range remote data base of all the patients of any hospital and these health parameters can be monitored continuously, and also the information is uploaded to the hospital server. These servers keep the information of patients in the data base, and doctors can have the access of patient's history, when any further consultancy happens with the doctor.

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