International Journal of Modern Electronics and Communication Engineering (IJMECE) ISSN: 2321-2152
Volume No. - 6, Issue No. – 1, January, 2018

System for Remote Patient Healthcare Monitoring

Tarig Mustafa Elhadi Lazim
Dept. Computer Engineering,
Faculty of Engineering and Technology
Wad Medani, Sudan
Email: lazim.tarig@gmail.com

Abdalla A. Osman
Dept. Communication Engineering, Electronic Engineering,
Faculty of Engineering and Technology
Wad Medani, Sudan
Email: akode63@yahoo.com

Abdulrahman H. A. Widaa
School of Communication & Information Engineering,
University of Electronic Science & Technology of China
Chengdu, P. R. China
Email: a.rahman-Hassan@uofg.edu.sd

Abstract: One field became of focal importance recently; incorporates body sensor networks (BSNs) for monitoring patient's bio-activities. In present situation when patient's monitored-vital signs showed abnormal behaviour health provider must be informed immediately. But, unfortunately, for some reasons the information delivery may be slower than needed when time in this case is very important, and crucial. In addition to that, most of recent BSNs are based on using an expensive networks infrastructures, and it won't work properly without availability of stable internet connections. In this paper, a system is designed for monitoring patients' body temperature, heart rate, and blood pressure, as well as issuing an instant warning via SMS/GSM in emergence. The modelled system ran very well and achieved an accurate reading, and an excellent time response with an overall average time for SMS deliver and doctor feedback of 16 ±2 seconds.

Keywords: Healthcare monitoring; BSNs; LCD; GSM modem; biomedical sensors; Arduino.

I. INTRODUCTION

Since the past few decades, diseases are showing a rapid growth. In turn, doctors need to pay more attention for patient's bio-conditions. In hospitals ,or in homes' portable healthcare units, when patient's monitored-vital signs show an abnormal behavior or readings, healthcare provider must be informed immediately. But unfortunately, while time in these cases is crucial and important; for some reasons the information delivery process may be slower than needed.

A special-purpose sensor networks developed for monitoring human body and internal-body environment are known as body sensor network (BSN). BSNs occupy on-body sensors, each sensor has tiny-processor, transmitter, and an energy source. All nodes send their compressed data to a local processing node. The processing node in turn relay sensed data over wide area networks (WANs) to monitoring servers. Sensors used in BSN also are referred to as biosensors which are sensor dedicated for bio-measurements. More attention had being focused on body networks to deliver better users services with a main goal in mind of improving patient's quality of lifestyle. From usage-category point of view BSNs are used to monitor temporary/lifetime diseases, elderly monitoring, and activity tracing. [1] [2] [3] [4].

Most of suggested monitoring systems reviewed incorporated sensor nodes deployed on/in body on specific locations, a coordinator (central) node collected data from other sensors within the network, the coordinator (central) node may then relayed sensed data to remote medical server, the connection to these servers' encountered several methods like cable connection, GPRS/UMTS, or an IP-based routing. Biomedical sensors was implemented on wearable fabric for monitoring and extracting noisy ECG signal monitoring as in [5]. Also Y. Chi and G. Cauwenberghs presented a BSN model where EEG and ECG were monitored using dry non-contact capacitive electrodes [6]. Another system, suggested by R. Paradiso, addressed the problem of monitoring patients in real-time manner [7]. AWSN-based epileptic seizure detection for patients in normal living environment was introduced by G. T. Borujen and his colleagues. [8]. A hospital patient monitoring system of biological signs was developed by M. Aminian and H. Naji [1]. Another study introduced by E. Smithayer and D. Kotz focused on obtaining correct blood pressure readings by assuring correct arm position [9]. Women health state related to intra-body temperature was investigated in [10].

These studies used several methods for connection with remote servers like UMTS, IP-based, or even traditional cable connection. PDAs are not available to everyone, also Internet connections are not always accessible and medical-based servers are unreachable. In developed countries these methods and facilities are either not obtainable or unreachable, besides that, taking into account implementation and operation costs.

In this paper, we present an alternative reliable and cost effective design of BSN model which monitors patient's body temperature, heart rate, and blood pressure, continuously. A remote healthcare monitoring system is also developed to deliver patients' abnormal conditions and to reduce alert delivery-latency in situations when time is of crucial value. In emergence or when abnormal readings are captured, the system must send an instant warning SMS/GSM to the responsible officer / doctor.

II. METHODOLOGY

The methodology implemented for this work was to use sensors to measure body temperature, heart rate, and blood pressure. The system used GSM networks to alert, instantly, doctor with abnormal sensor readings. The microcontroller pulled sensor values (temperature, hear rate, and two pressure sensors) and displayed them on a 20x4 LCD screen, measured values was compared to predefined threshold values and when abnormal reading were detected a short message was sent via GSM modem to responsible doctor phone number with abnormal values and to the in-duty healthcare provider contact screen. The doctor acknowledged the reception of SMS and gave immediate feedback for actions to be taken by the healthcare provider. The short message delivery time will be measured.

A. *System requirements:*

The system combined both hardware and software components. The system for monitoring patient's health state incorporated several hardware comptometers which are: Arduino UNO, LM35, MPX4115, pulse sensor, LM044L LCD, and a GSM modem.

B. *Schematic layout:*

The sensors outputs for temperature, systolic blood pressure, diastolic blood pressure, and heart rate were connected to Arduino UNO pins A0, A1, A2, and 7, respectively. The LCD data and control pins (D4-D7), E, and RS, were attached to 8-11, 12, and 13, respectively. Table 1 listed pins connections and the schematic layout of the circuit is shown in Fig. 1.

C. *Equations*:

The LM35 had a linear analog voltage output of 10mV/1°C. This value was mapped to 1 to 210 (0 to 1023) (or 4.9 mV/1°C) at the microcontroller ADC input. To display this value on LCD, it had to be converted back to analog value. The ADC and DAC conversation equation is shown in Eq. (1).

$$\frac{ADC\ resolution}{System\ voltage} = \frac{ACD\ value}{Measured\ voltage} \qquad (1)$$

This MXP5114 operated between 15~115KPa or as 0~4.8 VDC (41 mV/KPA). Human blood pressure is usually represented as mmHg, though, sensor KPa output need to be converted and displayed as mmHg. Equation (2) showed the conversion invoked for converting pressure from KPa to mmHg. MPX4115 output, as DC voltage, was mapped at microcontroller ADC input to a value between 0 and 1023.

$$\frac{X_{mmHg}}{Y_{KPa}} = \frac{760.0_{mmHg}}{101.3_{KPa}} \qquad (2)$$

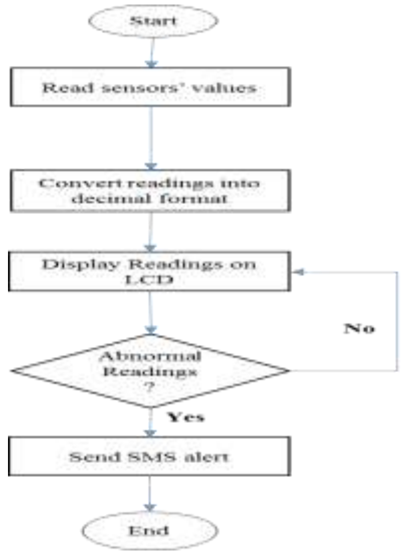

Figure 1. System's flowchart.

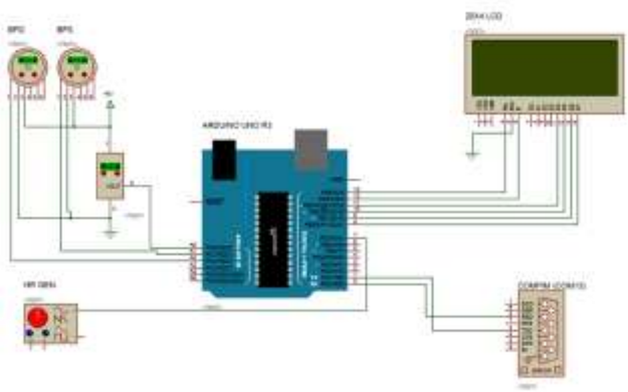

Figure 2. Schematic layout

Table 1. Peripherals connection to Arduino UNO description.

Microcontroller		Peripheral	
Pin #	Pin name	Pin #	Pin name
A0	PC0/ADC0	2	V_{OUT}
A1	PC1/ADC1	1	V_{OUT}
A2	PC2/ADC2	1	V_{OUT}
7	PD7/AIN1	+	N/A
0	PD0/RXD	2	RXD
1	PD1/TXD	3	TXD
8	PB0/ICP1/CLKO	14	D7
9	PB1/OC1A	13	D6
10	PB2/SS/OC1B	12	D5
11	PB3/MOSI/OC2	11	D4

	A		
12	PB4/MISO	6	E
13	PB5/SCK	4	RS

III. Modeling and Simulation

The simulated proposed system, in general, pulls sensor readings, process and display them, when critical values are captured, an SMS will be send to doctor/officer in charge. The modeled simulation-based system incorporates four key stages, namely: set-up, process/display, SMS/GSM, and doctor feedback. In the first stage, the system was initialized, the simulations of the required parameters were configured, and microcontroller code was de-bugged. In the second stage, four sensor values body temperature, heart rate, and two blood pressure sensors were pulled by a micro-controller and the measured readings were displayed on a simple liquid crystal display (LCD) screen. The SMS/GSM was get involved only when the measured values reaches or gone beyond threshold-defined values (temperature $\geqslant 37^{\circ}$ C, heart rate $\geqslant$ 120 bpm, and systolic/diastolic $\geqslant$ 120/80 mmHg), the SMS sends the current sensors values among call-back number over GSM network to the doctor predefined-phone number. Finally, the doctor acknowledges the reception of the warning SMS and calls call-back number for immediate instructions.

The modeled monitoring system was simulated with two well-known simulation softwares. The first emulator used Proteus PCB design and simulation for circuit design, and the other software is Arduino integrated development environment (IDE) which was used for writing and compiling microcontroller's code.

Figure 3. Running simulation (normal readings).

Figure 4. LCD output with normal readings.

Fig. 3, and Fig.4 show the circuit in the running stage. Each sensor value could be adjusted directly from the corresponding sensor. The LCD represented each sensor value, line one shows temperature reading, line 2 shows heart beating rate, and in line three the blood pressure is shown. No data is transferred to serial interface, as all processed values are under the threshold-values. The abnormal readings are simulated by increasing one of the sensors value, when the threshold is met the process of interfacing USB modem as invoked.

Figure 5. Running simulation (abnormal readings).

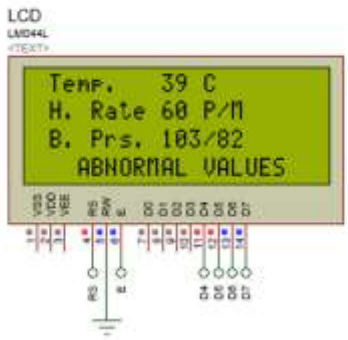

Figure 6. LCD and MCU output commands with abnormal readings.

Figures 5, and 6 are showing the system's response (outputs) when an abnormal values are captured by the processing unit. The LCD, in line four, shows a warning message. The serial interface/ GSM interface is taken into action, the AT commands are involved in order to send warning SMS relayed via GSM network to reception cell phone number. The virtual terminal shows data sent over GSM modem, both control commands (Start with AT line) and message body.

IV. Results

A microcontroller-based monitoring system that issues a notification alert for abnormal conditions via SMS/GSM to in-duty doctor and/or officer was developed successfully. Several bio-sensors values kept monitored for raised values by microcontroller, and when capturing an abnormal readings, the system will send an SMS to doctor or to nursing staff with current readings with call-back number for instructions.

The overall average time of 16 ±2 seconds for SMS deliver and doctor feed-back was obtained. This time may encounter different unexpected network delays. Figure 7 shows an SMS received by doctor when an abnormal readings happened to the patient.

Figure 7. SMS of abnormal condition received by the doctor.

IV. Conclusions

Most remote healthcare monitoring systems employed various information exchange schemes, these systems took advantage of modern networks architecture like medical servers and IP-based monitoring. Such systems may encounter difficulties in developed counties which suffers from poor infrastructure. Furthermore a probability of delay is expected in IP-based systems, also the cost of these systems would be expensive due to using of high cost physical infrastructures.

Here in this research, a reliable, simple and available solution for remote medical monitoring based on GSM networks was employed. The system granted instant delivery of emergence SMS warning to healthcare provider. The SMS was successfully delivered over GSM net-works within an excellent time window.

REFFERENCES

[1] M. Aminian and H. Naji, "A Hospital Healthcare Monitoring System Using Wireless Sensor Networks," Journal of Health & Medical Informatics, vol. 4, no. 2, pp. 1-6, 2013.

[2] O. Aziz, B. Lo, A. Darzi and G.-Z. Yang, Body Sensor Networks, G. Yang, Ed., London: Springer, 2006, pp. 1-4.

[3] A. Darwish and A. Hassanien, "Wearable and Implantable Wireless Sensor Network Solutions for Healthcare Monitoring," Sensors, vol. 11, pp. 5561-5594, 2011.

[4] D. Chaudhary and L. Waghmare, "Design Challenges of Wireless Sensor Networks and Impact on Healthcare Applications," Int. J. of Latest Research in Science and Technology, vol. 3, no. 2, pp. 110-114, 2014.

[5] R. Paradiso, "Wearable Health Care System for Vital Signs Monitoring," in 4th Int. IEEE EMBS Special Topic Conference on Information Technology Applications in Biomedicine, 2003., Prato, 2016.

[6] Y. Chi and G. Cauwenberghs, "Wireless Non-contact EEG/ECG Electrodes for Body Sensor Networks," in Int. Conf. on Body Sensor Networks, Singapore, 2010.

[7] P. Halapeti and S. Patil, "Healthcare Monitoring System Using Wireless Sensor Networks," International Journal of Advanced Reasearch in Computer Science & Technology (IJARCST 2014), vol. 2, no. 2(3), pp. 443-446, 2014.

[8] G. T. Borujeny, M. Yazdi, A. Heshavarz-Haddad and A. R. Borujeny, "Detection of Epilepric Seizure Using Wireless Sensor Networks," Journal of Medical Signals & Sensors, vol. 3, no. 2, pp. 63-68, 2013.

[9] E. Smithayer and D. Kotz, "Sensor-based system for verifying blood-pressure measurement position," Dartmouth College, Dartmouth, USA, 2012.

[10] J. Calderia, J. Mountinho, B. Vaidya, P. Lorenz and J. Rodrigues, "Intra-Body Temperature Monitoring using a Biofeedback Solution," IEEE 2nd Int. Conference on eHealth, Telemedicine, and Social Medicine, pp. 119-124, 2010.