IOT BASED E-HEALTH MONITORING SYSTEM USING ARDUINO UNO

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Abstract: The medical world today faces basic two problems when it comes to patient monitoring, firstly the need of healthcare providers present bedside the patient and secondly the patient is restricted to bed and wired to large machines. In order to achieve better quality patient care, the above cited problems have to be solved. This paper presents an IoT based E-Health Monitoring System using Arduino Uno which monitors certain health parameters of the patient and broadcasts the monitored data on a particular IP address(Wi-Fi). A prototype of the proposed system has been built to demonstrate its performance.

Keywords: Health Monitoring, Arduino, IoT, Wi-Fi module, Sensors, front-end GUI

I. INTRODUCTION

The medical world today faces basic two problems when it comes to patient monitoring, firstly the need of healthcare providers present bedside the patient and secondly the patient is restricted to bed and wired to large machines [1]. In order to achieve better quality patient care, the above cited problems have to be solved.

Advanced Internet of Things(IoT) technology, offering anywhere and anytime connectivity, play a key role in the development of a modern healthcare systems [5]. Various online systems for monitoring and collecting patient data exists nowadays. This kind of solutions are very useful especially when a treatment includes monitoring of some vital parameters for long period of time. The Internet of Things (IoT) is the network of physical devices like chair, doors, pen, books etc, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these objects to connect with each other and exchange data between them [2][3][4].

The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, [6] creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention [7][8][9][10].

There are a number of researchers focusing their activities in the field of E-Health monitoring. Ostmark et al. [11] proposed sensor system that acts as a Bluetooth device providing a TCP/IP interface for configuration and maintenance and allows user interaction through standard www-browser technology. Their concept is based on mobile wireless EIS (Embedded Internet System) sensor platform. Hung and Zhang [12] described the implementation and experiences with a WAP-based telemedicine system for monitoring. Authorized users can access to patients' general data and can monitor blood pressure and electrocardiogram on WAP devices in store-and-forward mode. Sorwar and Hasan [13] proposed an integrated tele-monitoring framework for supporting patient monitoring process. They used Smart TV technology for interaction between patient and health care providers. Arcelus et al. [14] used a sensor technology integrated in a home-based system that monitors patients' health. They also proposed a framework for data processing. Chan et al. [15] focused their work on multi-sensor home monitoring system developed to help elderly people, by observing mobility changes indicative of abnormal events. The proposed system is only one part of their final goal - to build an abnormal event diagnosis system to help elderly people living alone. Similar system that provides an end-to-end solution is described by Agarwal and Lau [16]. Authors described a remote health monitoring service that collects blood pressure readings from a patient through a mobile phone and make them available to the doctors through a web interface. Yong et al. [17] developed a health monitoring system based on smart phones. 3G or Wi-Fi network is used for transferring data to a remote healthcare server, that can monitor multiple users in real-time. Sapal et al. [18] and Silva et al. [19] review some new technologies for making remote monitoring and health care process more flexible and convenient. Additionally, authors present a comprehensive review of the state of the art on m-Health applications.

This paper presents an IoT based E-Health monitoring system which is proposed in order to improve quality of patient care. The system can be used for monitoring patient's health parameters such as: blood pressure, heart rate and body temperature. Because of the nature of these health parameters, their values must be monitored and controlled on a regular basis. The system monitors patient's body temperature, pulse rate and blood pressure (both systolic and diastolic) and send the monitored data to the smart phones or PCs connected to the system through a Wi-Fi module. The doctors and patient's caretakers can connect their smart phones or PCs to the system and keep track of patient's health. The system can collect required vital data and make them visible to doctors. Doctors can act upon them (suggest or modify the therapy for example). The proposed system also includes a frontend GUI developed using Vb.net which displays the graphical representation of the monitored data. The doctors can refer those waveforms to know how the patient is doing and take necessary actions. The proposed system can be used for healthcare of elderly people living alone in their homes, patients in rural areas, as well as chronically ill patients that have high level of medical need.

The paper is organized as follows. The section 2 presents the methodology of the proposed IoT health monitoring, section 3 presents the working principle of the proposed system. A preliminary set of result of a prototype of this architecture is presented in section 4. The paper is concluded in section 5.

II. METHODOLOGY

The proposed system design has the micro controller Arduino uno, sensors like LM-35 temperature sensor and BP/pulse test kit, the regulated power supply, a Wi-Fi module ESP 8266-01 for transmitting the monitored data and a 16x2 LCD display. The system also has a front-end GUI that displays the monitored data in the form of graphical representations.

A. Block diagram

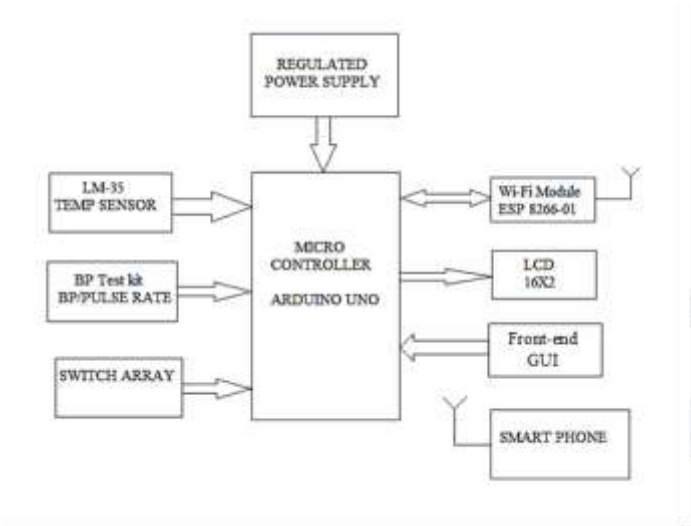

Fig.1 Block diagram of IoT based E-Health monitoring system

B. Hardware

Fig.2.a

Fig 2.b

Fig.2.c

Fig. 2.d

Fig. 2.e

Fig. 2.f

Fig. 2.g

Fig 2 Hardware components of the proposed system

1. Arduino

The above figure 2.a shows the Arduino Uno board.

- It belongs to the family of microcontrollers ATMEGA328P.
- It has 14 digital input/output pins out of which 6 pins can be used as PWM outputs, 6 analog inputs, power pins such as Vin, 5v, 3.3v and GND, transmitter (TX) pin no.1 and receiver (RX) pin no.0, pin no. 13 for LED, AREF pin for providing reference voltage for analog pins, a 16 MHz crystal oscillator, a power jack, an ICSP header, a USB connection, and a reset button
- It has 32k FLASH memory, 2kb of SRAM, 1kb of EEPROM.

- It can be powered by connecting it to pc through USB cable or by a battery or by an 12v ac-to-dc adapter. It only needs 5v-12v to operate.

2. Regulated Power Supply

The above figure 2.b shows a regulated power supply board.

- It has a voltage regulator, a power jack, a LED light, 10k SIP resistor array, a pull up resistor and also a capacitor.
- The input voltage taken by this regulated power is basically around 7-20V AC or DC. And it gives a constant output voltage of 5V and 3.3 V.
- The capacitor used in this circuit acts as a filter.
- The LED used is to ensure proper working of the circuit.

3. LM-35

The above figure 2.c shows a sensor LM-35.

- It is used to sense the temperature.
- LM-35 has three pins Vin, Analog Output and Gnd.
- Operating voltage range 5v-30v
- LM35 sensor measure temperature more accurately than a using a thermistor since it is an industrial temperature sensor.

4. Wi-Fi module ESP8266-01

The above figure 2.d shows the Wi-Fi module ESP8266-01.

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability produced by Shanghai-based Chinese manufacturer, Espressif Systems [24].

It has 8 pins:

- VCC, Voltage (+ 3.3 V)
- GND, Ground
- RX, Receive data
- TX, Transmit data
- CH_PD, Chip Power Down
- RST, Reset
- GPIO 0, General Purpose Input-Output No. 0
- GPIO 2, General Purpose Input-Output No. 2

5. LCD screen and driver

The above figure 2.e and 2.f shows a 16x2 LCD screen and its driver.

- The 16x2 LCD screen means that the display has 16 columns and 2 rows. Which also means that it can display 16 characters in one line and it has two such lines.
- As shown in the first picture above the display module has few wires. Those wires are connected to the LCD driver.
- The LCD driver has 12 pin header which can be used to interface the LCD to the microcontroller.
- The first two pins of the driver are RS (register select) and E (enable) as marked in the above picture.
- The D4, D5, D6 and D7 pins as marked in the above picture are the 8-bit data pins. It also has 5v and ground pin.
- The LCD driver also has a variable potentiometer for the contrast adjustments.

6. BP Test Kit

The above picture 2.g shows a BP test kit. It is made to wrap around the upper arm or wrist then press the start button it displays the systolic and diastolic blood pressure readings and also the pulse rate. It has three pins 5v, Ground and a Tx pin using which the device can be connected to a microcontroller.

Readings are taken by wrapping the pressure cuff around the upper arm and pressing the "START" button. An air pump inflates the cuff which compresses the upper arm until blood flow is cut off. Then the cuff's air pressure is slowly released.
When the air pressure gets low enough, blood flow resumes but is pulsed with each heartbeat. That sound is detected by a microphone and the pressure threshold of that pulsing is called the "systolic" pressure. As the cuff air pressure continues to get lower, blood flow eventually stops pulsing and becomes continuous. The pulsing sound goes away and that second threshold is called the "diastolic" pressure.

C. Software

The front-end gui of the proposed system

The front-end GUI of the system has four separate tables is shown in figure 3 below. The First table is to display systolic Bp, second for diastolic BP, third one for pulse rate and the last one for displaying the temperature. The Gui is developed using C sharp(.net).

It has start button and small text box. When is system is ready for operation the start button on the front-end GUI has to be clicked. The system monitors the data and first it displays the result on the LCD screen of the system as shown in figure 4. Then it gets displayed on the text box of GUI as shown in the above fig 3. and graphical representation of the monitored data gets displayed in the corresponding tables along with the date and time of check-up. This is shown in figure 5 in the next section. The x axis of the graph shows the count and the y axis shows the monitored data.

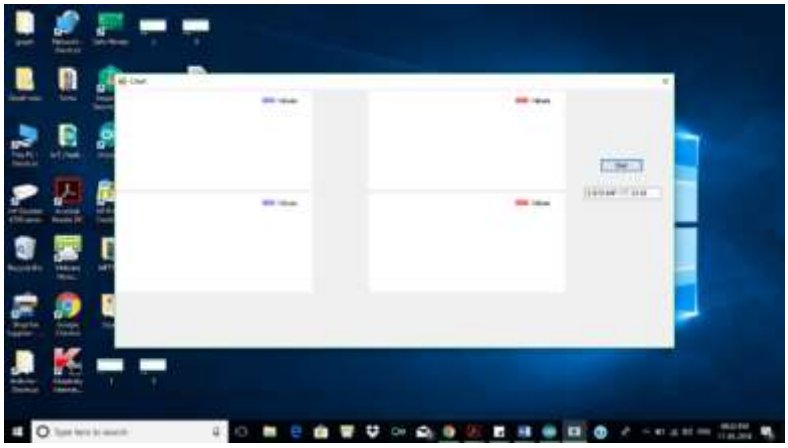

Fig. 3 Front-end GUI of the proposed system

III. WORKING

The proposed system works on the concept of IoT. As in the Internet of Things concept how the things are made to interact or communicate with its environment and the user from anywhere in the world so as in this proposed system the doctor or the patient's care takers can monitor the patient's condition from any locations.

The proposed system monitors four health parameters. They are pulse rate, body temperature, systolic and diastolic blood pressure. The components used to monitor these parameters are LM-35 and BP test kit. The LM-35 is a temperature sensor. BP test kit monitors the pulse rate and systolic and diastolic blood pressure. Both LM-35 and BP test kit are connected to the microcontroller Arduino Uno board. The LM-35 has three pins: 5v, ground and analog output. The output pin of LM-35 is connected to the analog pin A0 of the Arduino. The BP test kit also has three pins: 5v, ground and a Tx pin. The Tx pin is connected to the Rx pin (pin no.0) of the Arduino Uno. The outputs of LM-35 and BP test kit are the inputs to the Arduino. The proposed system also has a Wi-Fi module ESP 8266-01. It's Rx pin is connected to pin no. 10 and Tx pin is connected to pin no. 11 of the Arduino. Its Vcc pin is given to 3.3v and gnd pin to ground. The hospital healthcare services and patient's care takers can connect their PCs or smart phones to the proposed system through the Wi-Fi module and can keep track of the patient's health. The system also has a front-end gui which makes the results visible to the doctors or care takers in the form of graphical representations so that they can take needful actions.

We know that the normal body temperature of a healthy person is 37°C, the normal pulse rate is 60-100bpm (beats per minute) and the normal systolic BP is less than 120 mmHg and normal diastolic BP is less than 80mmHg. For the proposed system the Arduino is programmed such a way that the normal range of these four parameters are set as the threshold values. Whenever the output of the LM-35 or the BP test kit is more or less than the threshold value the Arduino sends the alert to the devices (smart phones or PCs) connected to the system through Wi-Fi module. It also gets displayed on the LCD screen on the system. If the system is serially connected to the PC through USB then the results can be viewed in the serial monitor of the Arduino software as well. This is the overall working of the proposed system.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

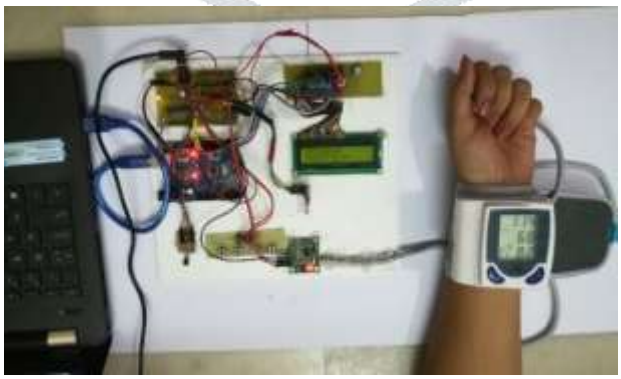

Fig. 4 Hardware setup of the proposed system

As a proof of concept, a prototype of IoT based E-health monitoring system using Arduino Uno has been implemented as show in the figure 4 to evaluate the proposed system. The system has been designed to collect data from LM-35 and BP pulse kit and to display the data in the user's smart phone or PC

The figure 4 shows the proposed system displaying the monitored data on the LCD screen. In the above experiment the data monitored by the BP test kit and the LM-35 is being displayed on the LCD screen. When I wrapped the BP test kit around my wrist I got the following values. The LCD showed that my systolic BP is S:114mmHg, diastolic BP D:68mmHg, pulse rate P:82bpm and the room temperature T:32.71℃. The data is also displayed on the PC which connected to the system serially.

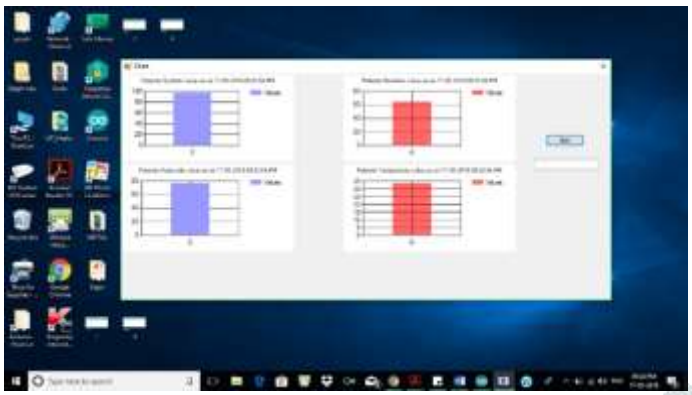

Fig. a

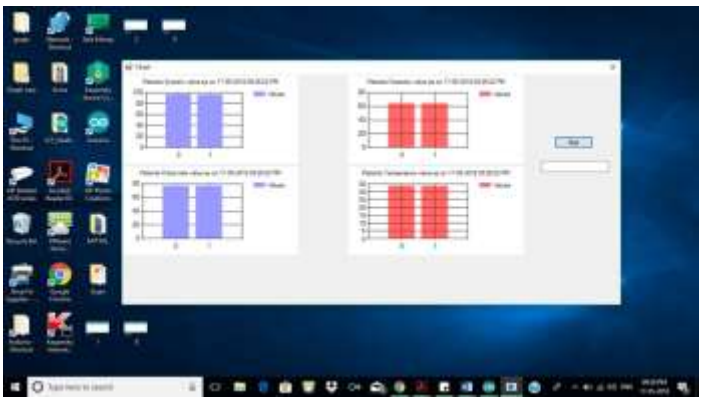

Fig. b

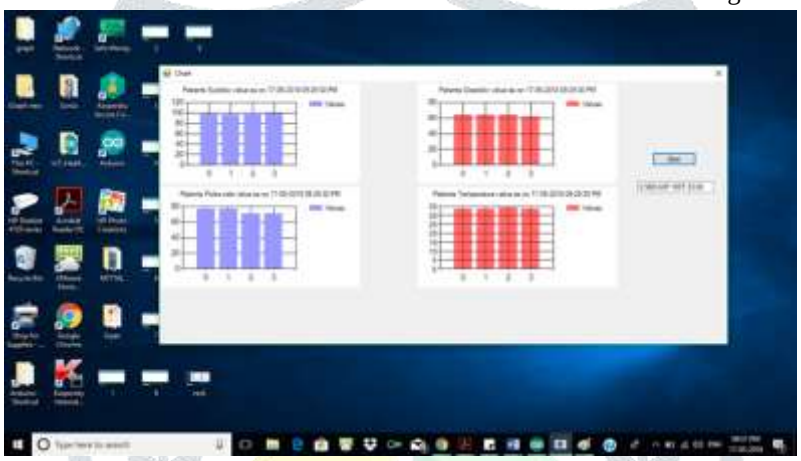

Fig. c

Fig.5a, b, c Graphical representation of the monitored data

Once the monitored data is displayed on the gui it gets stored there. When the system is operated again to check the health parameters of the patient after some time from the first check, the results of current check-up gets displayed on the gui along with the previously checked value with current check-up time and date. The above figures in fig.5 shows two monitored values.

V. CONCLUSION

This paper presents an IoT based E-Health monitoring system using Arduino Uno. I have outlined the main components of the proposed system and explained their implementation details. A prototype of the proposed system is built to illustrate the different performance aspects of the proposed system. The preliminary performance evaluation results have demonstrated the efficiency of the proposed system despite being a low-cost one. This makes the proposed system a good candidate for implementing a wide set of E-Health monitoring system.

VI. REFERENCES

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