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HEALTHCARE MONITORING SYSTEM AND TRANSFORMING MONITORED DATA INTO REAL-TIME CLINICAL FEEDBACK BASED ON IOT USING RASPBERRY PI

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***Abstract*—**In recent decade significant rise in chronic diseases and ageing population ratio in world, demand efficient Health monitoring system (HMS) for comfort of people. This approach is not only cost effective but also a feasible alternative to traditional healthcare. The aged peoples and patients having chronic diseases refrain visit to health institutions (hospitals and nursing homes etc.) as a result it reduces burden on health institutions. In this paper we proposed IoT-based ,intelligent HMS which continuously monitors patient's health parameters like blood pressure ,heart beat and ECG. Data from blood pressure sensor, heart rate sensor and ECG sensor automatically monitored by Arduino UNO and Pi-camera attached to raspberry pi for video. Arduino UNO sends sensor data to raspberry pi which fed data to server's database using Wi-Fi, finally server sent data to webpage, which updates every 2 minutes. Doctor access data anywhere using internet and give feedback accordingly using text. ***Keywords*—** Internet of things, healthcare, sensors network, Arduino UNO ,Raspberry pi, Realtime patient monitoring system.

I.INTRODUCTION

In recent Ageing population is significantly rising in recent years than ever before(1). According to report(2) the number of individuals age 50 or above will surge to 2 billion by 2050, another report published by World health Organization (WHO) revealed that in 2013 there was 7.2 million healthcare worker shortage and predicated to cross 12.9 million by 2035(3).These elderly population suffer from chronic diseases among the most that are commonly monitored and treated are blood pressure , diabetes and cardiac arrhythmia(4). These typical diseases combined with the naturally occurring diseases ;continuously decline in cognitive

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and physical abilities of elderly people, which reduces the chances of many aged people from living independently, in their own homes. For many years traditional exams were the standard way to measure blood pressure, heart beat and glucose level in a specialized healthcare center. Conventional health monitoring models are inconvenient and time-consuming for all involved [5]. These models will be inadequate to overcome challenges of healthcare services in increasing ageing society. Advancement in computing technologies, communication and intelligent technologies like sensors , make the dream of smart environment possible. Health monitoring system (HMS) is one such example. Due to its cutting edge features they attracts considerable attention in recent years. HMSs emerge as encouraging solution to the decline health situation of aging population. They have the capability to ensure e-health facility to overcome the need of the rapidly enhancing population. HMS system monitor and examines any health situation that the elder person may have, includes monitoring how their daily activity carries out. These systems not only make old citizen's life independent for a long time but also make medical care services more sustainable by providing e-health service at their door step. Avoiding frequent visit of aged people to hospital, will reduce healthcare cost and reducing pressure on overall health system.

II.LITERATURE SURVEY

Hasmah Mansor et al [8] aimed at LM35 temperature sensor for measuring body temperature and interface LM35 sensor with Arduino UNO board. Thereafter website is created using SQL database in which data is stored, collected by Arduino. Medical personnel can easily approach to webpage by just login. Through infrared receiver and transmitter of raspberry pi pulse rate of patients were monitored and thermistor was used to sense temperature of patient's body. Terminal Lx of d along with their feature and contribution in making the operation of health monitoring system possible. we have Raspberry pi 2, different sensors, pi camera, Arduino Nano (used as ADC), Power supply, LCD, Key board, Wi-Fi Dongle etc. The block diagram shown Fig.1, gives the outline of system operation.

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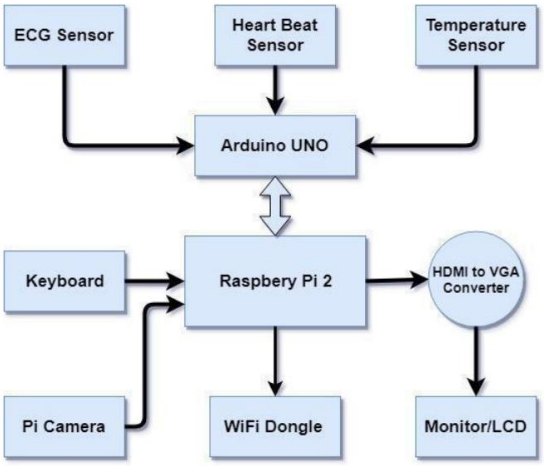

Fig. 1. Hardware Architecture

raspberry pi was used for display [9]. In [10] body temperature and pulse rate were also monitored using raspberry pi. In his research article he focused on integrating cloud computing and health sensor network data, for storage of data Amazon EC2 cloud service is used provided by Amazon Web Service. In [11] ATMEGA 32 was used for monitoring blood pressure, body temperature and pulse rate. For serial communication he used RS232 interface with GSM module, all the measured parameters were sent to doctors. Mathan Kumar et al[12] used android technology for remote patient monitoring system. Ppm and LM35 sensors were interfaced with PIC16F887A microcontroller data was collected by android mobile application through GSM module and Bluetooth. In the proposed system MLX90614 contactless sensor is used for temperature monitoring, A0813 is used for monitoring pulse rate while AD8232 helps in monitoring ECG of patients. Whole data is sensed and collected by Arduino board which then fed to Raspberry pi and transferred to server through WiFi dongle. The dynamic webpage is updating every two minutes after receiving data from server. Doctor can diagnose patients' condition by analyzing data shown on monitor screen.

III.PROPOSED SURVEY

The System architecture includes two main sections. • Hardware architecture • Software architecture A. Hardware Architecture Health monitoring system consisting of sensors along with peripheries for valuable operation. Here discussed prototype of hardware use:

1)Raspberry pi

Raspberry pi 2 model B is a uni-board microcomputer as shown in Fig. 2 having 40 GPIO pins, 4 USB ports, HDMI port to connect with LCD, Display connector (DSI), camera connector (CSI), 5V power supply port, SD card slot at the back side of the board for storing data and loading operating system, audio video jack and Ethernet port are the key feature. Though, it is very low cost yet powerful and effective tool for interfacing at the same time with different devices[13].Comparing with the previous model ,this model is fast

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and powerful on the based on ARMv7 32-bit processor.

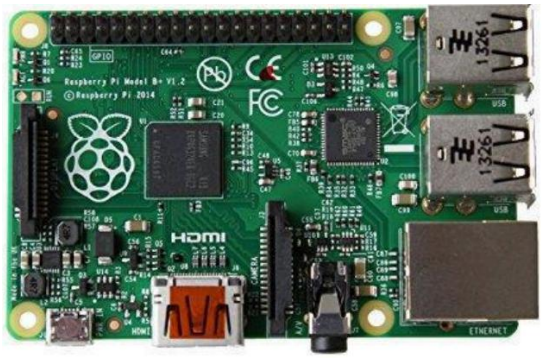

Fig. 2. Raspberry Pi

2) Raspberry Pi Camera Module

Pi camera module is compatible and specially design for raspberry pi as shown in Fig.3, comprising of Sony IMX219 eight-megapixel sensor contrasted with 5-megapixel Omni vision OV5647 sensor of the first Pi camera module is perfect and uniquely plan for raspberry pi. Pi camera is used for photographs along with high definition videos and which is then connected to raspberry pi using 15cm long ribbon cable through CSI(camera serial interface). Raspberry pi peripherals have cutting edge with the availability of open source libraries. Pi camera is proficient for 2592 x 1944-pixel images and able for 720p60, 1080p30 and 640x480p60/90 to support[14].

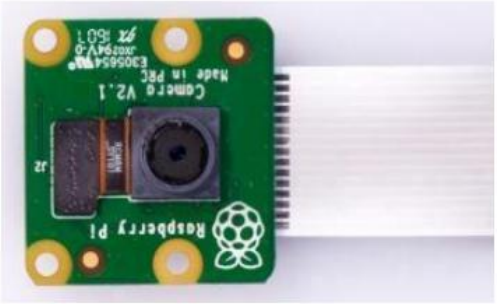

Fig.3. Raspberry Pi Camera Module

3) Arduino UNO

Uno board consists of 14 digital input and output pins ,in which 6 is used for generating PWM. It's based on the Atmega 328P and open source design with 16Mhz clock frequency as shown in Fig. 4. For data storage it can be interfaced conveniently with flash memory of 32kb, USB. Using as a serial device, ICSP header is available to interface it directly and stored data can be easily reset by just clicking the reset button[15].Remarkable feature of ADC (Analog to digital converter) increase its importance with specially assigned pins(A0 to A5) which is capable to read analog data. With 10-bit inbuilt ADC make it convenient for Arduino UNO distinguish 1024 analog values. It can scale analog voltage values from 0 to 5 volts into different 1024 integer values.

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Fig.4. *Arduino UNO*

4) Temperature sensor:

MLX90614 a Contactless infrared temperature sensor as name show ,it can measure temperature without making a physical contact as shown in Fig.5. MLX90614 can measure two different temperatures Ambient(environment) temperature and object temperature(desired). MLX90614 sensors have ranges from -70 to 380°C for object temperature and from -40 to 85°C for ambient temperature. Remarkable feature is ,it can sense temperature of moving bodies with less than 500ms , it will measure more efficiently if the distance is short between object and sensor.

5) PULSE SENSOR A0813

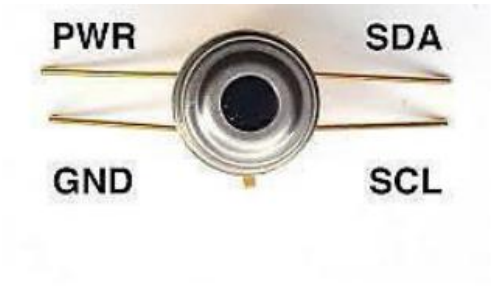

Fig.5. *MLX90614 Temperature Sensor*

A0813heartbeat sensor is working on Photo plethysmography (PPG) principle. Changes in blood volume in any organ of the body results in changing light intensity through the vascular organ/region. Thus, blood volume flow rate is computed from the rate of heart beat pulses, since light is captivated by the blood, the pulses of heart beat is proportional to the signal pulse. The timing related with these pulses is much more significant in the situation when monitoring the pulse rate.

Fig.6. A0813 Pulse Sensor

The heartbeat sensor comprising photodiode(light detecting resistor) and infrared LED for detecting finger's pulses. On one side photodiode is located while on the other side infrared LED is located. When tissue is illuminated by the light ,photodiode captures the reflected rays[6]. The detector gives electrical signals as output which basically shows the pulse rate monitored by the pulse sensor. The proposed pulse rate sensor illustrated in Fig.6 has distinguish features

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of +5VDC operating voltage with compact in size and illuminated LED for heartbeat indication.

6) ECG SENSOR MODULE (AD8232): ECG sensor AD8232 is a device used to measure and check the electrical activity of the heart, stands for electrocardiogram as shown in Fig.7. After measuring the heart activity, it is plotted or mapped according to heart functioning. Analog output of ECG is sensed and converter to digital by Arduino Nano to fed it to raspberry pi ,as raspberry pi cannot analyze analog signal. Measuring or plotting an ECG is a noisy one. AD8232 sensor module is especially designed for it to work as an operational amplifier (op amp) which is used to amplify and get a clear signal from PR and QT intervals. This module has also an LED which flashes every time with heart beat. AD8232 module has also a 3.5mm audio/video jack through which sensor cable can be connected. Sensor cable is a threeconductor cable having biomedical pads on each head of each conductor. Holes in AD8232 cannot use directly first we will solder a male to male header pins in it and then used it. ECG is based on two basics things PR interval and QR interval[16].

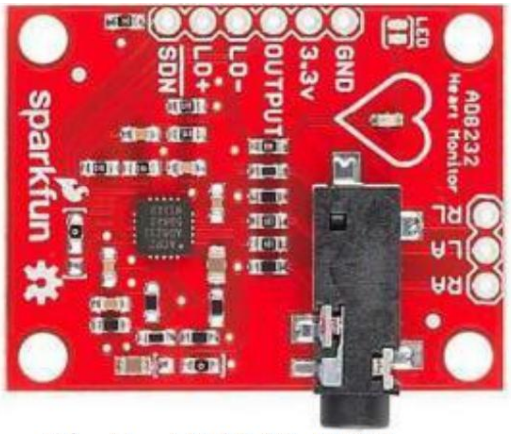

Fig.7. *AD8232 ECG sensor*

1)Sensor Cable : AD8232 ECG sensor module has audio jack to connect a sensor cable. Sensor cable as shown in Fig.8 has three conductors each having biomedical electrodes at the end. Sensor cable is 24 inches long dimension. One of the conductors is used for right arm, second for left arm and the third one is for right leg[16].

Fig.8. *Sensor Cable*

2)Biomedical pads: Biomedical pads are the disposable electrodes used to measure ECG, EMG and EEG of patient as shown in Fig.9. These pads as shown in figure 2.12 are circular in shape and easily stuck

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with human body. Biomedical pads have dimension of 24mm × 1mm[16].

Fig.9. *Biomedical Pads*

3)USB Wi-Fi Dongle To access the sensors data by medical staff anywhere in world we need to transfer data from raspberry pi using USB Wi-Fi dongle 802.11n as shown in Fig.10. This device using MIMO technique and with cutting edge of increase the speed and functioning of WLAN , enhancing its consistency and range of transmissions. WIFI adapter have speed of 150Mbps and operate on 2.4GHz and can be switched to 5Ghz[17]. Its light weight 20g ,18*9mm in dimension ,using wireless adapter with 13 channels

Fig.10. *USB Wi-Fi Dongle*

B. Software Architecture

It consists of MQTT protocol, Node-Red and Integrated Development Environment (IDE).

1)Integrated Development Environment

IDE plays a key role in Arduino hardware although it's independent on any specific platform. Different programming languages can be used to implement Arduino code or algorithms . IDE is an effective platform for researcher to develop sensors related project, Programmers and project development professionals . Arduino IDE is openly accessed ,introduced from Integrated Development Environment for widely used in wiring projects and Programming languages Processing. It can execute on MAC OS, Windows as well as Linux based OS. It was developed for beginner level in field of electronics. IDE include distinguishing feature like searching-replacing text, cutting-pasting, highlighting the syntax, , brace matching and automatic programs and indenting can be uploaded and compiled to the Arduino board by click procedure[15]. A toolbar for common functions and text console message area also added to IDE's features.

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Both C and C++ languages can be used for generating programming code in Arduino IDE and code written in IDE for Arduino called 'sketch'.

2) Node-RED

Node –RED is fundamental, easily used and open source tool used in IOT technology. It's a visual based programming tool that ensure IoT developers to merge API's , hardware and online services in an advanced and interested way. Run time of Node-RED consisting of node.js, which can be executed at the end of a network in Hardware e.g. in the cloud or Raspberry pi. Node-RED built-in library include nodes and flows allows the users to establish communications to all types of services and devices. Flows can be used by the IoT developers to a lightweight runtime.

3) MQTT protocol

Message Queuing Telemetry Transport (MQTT) is lightweight, low bandwidth protocol for communicating different equipment and applications together particularly for Machine to Machine(M2M) communication. MQTT base on publish/subscribe architecture in comparison to HTTP protocol flows request/response architecture. It's a client friendly by providing opportunity to communicate as a subscriber, owner or both. This protocol makes the Connection of user to MQTT broker which entirely regulate reception and transmission of messages.

IV.RESULTS

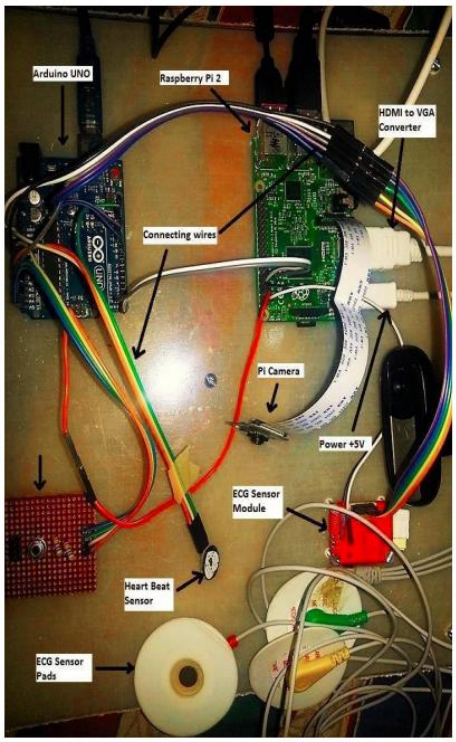

Fig.11. *Experimental Setup*

Experimental setup for our system as shown in Fig.11 consisting of sensors with its accessories like Biomedical pads and sensors cable ,Raspberry pi camera, Arduino UNO, Raspberry pi 2 and wi-fi dongle has been shown in figure. All the connections either between sensors and Arduino board or between raspberry pi and other devices

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(pi camera, wi-fi dongle ,HDMI and power supply) can be clearly seen .

The web page can be seen in Fig.12. After providing all the authentic information a doctor accessed the web page , where on left side he can watch the patient live video and on the right side he can communicate through text message bar provided on bottom right, to give real time feedback according to patient's health requirement. Sensor data being received at dynamic web page is shown in Table 1. All sensors data can be seen at different assigned columns with its respective report. Patient information and data timing is also mentioned in information and timing columns. The data is received at dynamic web page after every two minutes from server site. Hence all the patients' health record is stored; which can be used for diagnosing and better remote healthcare.

V.CONCLUSION

The proposed system highlights the shortcomings in our traditional healthcare system with the increasing aging population and overcome it by giving affordable, secured, fast and portable system by utilization technically sound devices(Arduino, raspberry pi ,sensors) and systems(IoT, Network topologies). Although this system is good tool for remote patientcare, but still future improvement can be made to make it more efficient. Adding a video conversation between patient and doctor can make the system more patient's friendly. GSM/GPRS module can be used to create message alert whenever patient sensor data is approaching to abnormality. Addition of more health-related sensor will make one's life more independent and convenient.

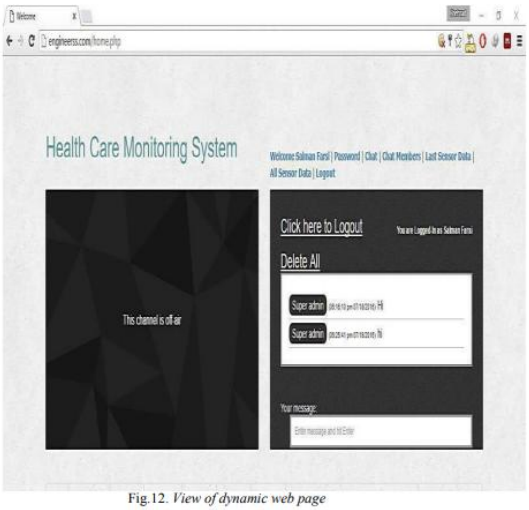

Fig.12. *View of dynamic web page*

TABLE 1. SENSORS DATA WITH PATIENT INFORMATION

Health care Monitoring Data								
Sl.No	Temperature (°C)	Pulse	Heart rate	ECG	Reserved	Other	Patient Information	Timing
1	30	OK	105	Normal	70	Present	Shahzad	July 19, 2016 12:01:00 PM
2	31	OK	84	Normal	70	Present	Shahzad	July 19, 2016 11:59:00 AM
3	31	OK	80	Normal	70	Present	Shahzad	July 19, 2016 11:57:00 AM
4	31	OK	87	Normal	70	Present	Shahzad	July 19, 2016 11:55:00 AM
5	31	OK	178	Normal	70	Present	Shahzad	July 19, 2016 11:53:00 AM
6	31	OK	61	Normal	70	Present	Shahzad	July 19, 2016 11:51:00 AM
7	31	OK	179	Normal	70	Present	Shahzad	July 19, 2016 11:49:00 AM

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