IoT-Based Portable Vital Sign Monitoring System for Rural Area

Vishal Verma, Deepali Gupta, and Sheifali Gupta

Abstract There is a heavy deficiency of medical equipment in rural areas. That is why there are needs of an electronic medical system for the rural area that is used to measure the vital sign parameter of a human. In this paper, the author proposes an electronic system that is capable to tell us about cardiovascular disease. The electrocardiograph (ECG), heart rate, and blood pressure (B.P) are the three important vital sign parameter of the human body. Cardiovascular diseases are related to human blood vessels. The human heart has four important parts like left atria, right atria, left ventricle, and right ventricle. The heart job is to pump blood into the human body. When our heart pumps blood in our blood vessels, the electrical signals are generated. This electrical signal tells us about the heart activity of the human body. Currently, the available ECG apparatus is bulky in size and it consumes a big amount of electricity. In rural areas, if a patient wants to check his heart activity, firstly, he goes to the pathology laboratory and performs ECG tests on the heart. After the test, he consults to the medical expert. So, the patient wastes his time and money both. So, we need an electronic system that itself is capable to tell us patient suffers from what type of heart disease.

Keywords IoT · AD8232 · Pulse sensor · Ubidot · Raspberry Pi · Sunroom blood pressure sensor

1 Introduction

Internet of things (IoT) means when we connect the physical world with the Internet then it became the Internet of things. The physical world tends for sensors, electronic gadgets, programming innovations, and system availability [1]. To make our health monitoring system long term and continuously monitoring, IoT plays an important

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D. Goyal et al. (eds.), *Proceedings of the Second International Conference on Information Management and Machine Intelligence*, Lecture Notes in Networks and Systems 166,
https://doi.org/10.1007/978-981-15-9689-6_14

role. Today some of the existing solutions use radio frequency identification (RFID) tag sensor to measure the vital sign of the patient. These RFID tags take power from small batteries and RF power source [2]. In an existing medical solution, a fixed bulky ECG system is used so that if any patient wants to diagnose heart disease firstly he came to the hospital [3]. The low power consumption health monitoring system is also existing and it contains a relay transmitter module that receives the ECG sensor, eye detection sensor, and accelerometer signals and then transfers to nearby module [4].

The proposed electronic system takes ECG, heart pulse, and blood pressure of the patient. Then, it converts ECG signal and heart rate into the graph. Now, artificial intelligence work starts the electronic healthcare system and compares ECG graph and heart pulse graph with existing dataset of different types of patients. The electronic system itself is capable to tell us about the approximate every type of heart disease.

2 Related Work

Xiao et al. [10], in this paper, the author describes a non-contactable radio frequency-based heartbeat monitoring system. This system is working on a 5 GHz frequency band spectrum. The patient distance must be under 2.5 m then approximate 80–90% accurate heartbeat results are observed with very low transmitted power app 20 MW.

Mansor et al. [11] develop a heartbeat monitoring electronic system that is called the smart home clinic. This electronic system is developed to order to connect remote access between the patient and doctor.

Park and Chou et al. [12] currently used wet ECG patches as they required a gel or chemical to establish electrical connectivity with the human body. This author presents a non-contactable ECG measure device. Capacitive ECG patches are used to measure the electrical activity of the human body. This ECG data are transferred wirelessly to the cloud. The doctor can retrieve their ECG data from anywhere in the world.

Koshti et al. [13] developed the electronic system that is used for telemedicine and this electronic system can measure the vital sign of the patient. 3-lead ECG module is used in this electronic system. This ECG data of the patient are sent to the cloud so that doctor can see the vital parameters of the patient. The doctor provides telemedicine to the patient.

Surya Deekshith Gupta et al. [14] make an inexpensive healthcare system for rural areas. This electronic system contains a Raspberry Pi microcontroller and an ECG module. This paper tells us how the Raspberry Pi is used for the healthcare system. After measuring the vital sign of the patient, it transfers to the Web cloud at which doctor can see their vital sign.

Hsu et al. [15] developed a healthcare system that records ECG, pulse rate, and blood pressure of the patient. After recording these parameters, they perform FFT power analysis on these parameters. Analysis of the spectrum of the patient heart activity analyzes low-frequency spectrum and high-frequency spectrum increases or decreases again and again.

3 Proposed Solution

In this paper, we proposed a healthcare kit for rural areas. This electronic system contains a pulse sensor, an ECG sensor (AD8232), and a blood pressure sensor module as shown in Fig. 1. All these sensors are interfaced with a Raspberry Pi microcontroller. Raspberry Pi microcontroller has an in-built Wi-Fi module, so that all vital sign parameters are easily transferred to the Internet cloud. The doctor can access all this parameter anywhere in the world. After analysis of the vital sign, the parameter doctor gives telemedicine to the patient so that patient easily recovers from the disease.

There are different types of the cloud platform available but we used Ubidots as an Internet cloud. All the patient data pulse rate, blood pressure, and ECG are transferred to it. Anyone can see their parameter from anywhere in the world.

As we know Raspberry Pi microcontroller has no in-built analog-to-digital (ADC) module. So Raspberry Pi microcontroller cannot read analog inputs, firstly we convert analog inputs into digital outputs. So we want to connect an external ADC so that

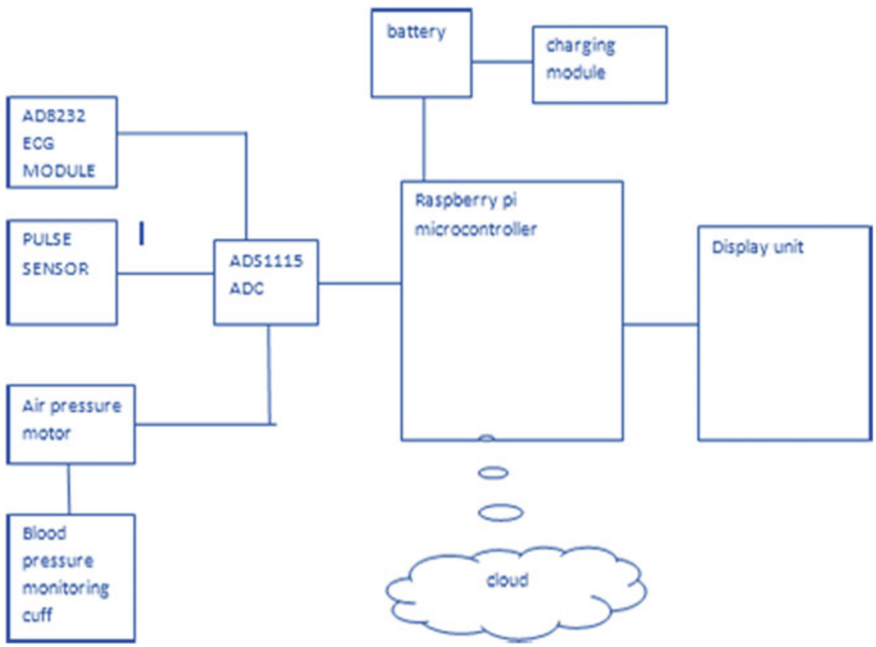

Fig. 1 Block diagram of proposed system

Raspberry Pi wants to read analog sensor outputs. AD1115 is 16-bit 4-channel ADC that makes analog sensor output compatible to the Raspberry Pi microcontrollers. The block diagram shows how we interface all the sensors to a single microcontroller. ECG (AD8232) is a sensor that measures the electrical activity of the heart. This sensor has five pins but out of five, we use only three pins (Vcc (3.3v), GND, output). Vcc and GND pins are used to provide power supply to the sensor module. The output pin is used to take the output from the ECG sensor. We use sunroom blood pressure and pulse sensor that is used to capture the pulse and ECG graph of the patient. These pulse rate and blood pressure data are serially transferred to the microcontroller and we can easily access these data.

4 Hardware Description

Raspberry Pi: Raspberry Pi microcontroller is a central processing unit (CPU) of our electronic system. The microcontroller has four USB ports, one Ethernet, one HDMI, and one audio jack as shown in Fig. 2. Raspberry Pi has 256 MB inbuilt RAM. It has approximately 40 GPIO pins that are used to connect external peripheral with it [5]. The advantage of using a Raspberry Pi microcontroller is we can apply artificial intelligence on an ECG signal with it.

Analog-to-Digital Converter (ADX1115): The microcontroller has two types of inputs and outputs. One is digital and the other is the analog as shown in Fig. 3. On the basis of this, some microcontroller has an inbuilt analog-to-digital converter. ADX1115 is 4-channel 16-bit analog-to-digital converter. It is working on the I2C communication protocol. The only limitation of the Raspberry Pi microcontroller is it cannot have an inbuilt analog-to-digital converter (ADC). So Raspberry Pi

Fig. 2 Raspberry Pi microcontroller

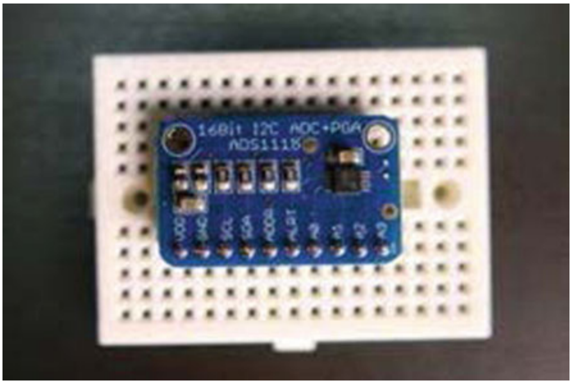

Fig. 3 ADX1115 analog-to-digital converter

microcontroller is read-only digital signal. Overcoming limitation of Raspberry Pi microcontroller, we use ADX1115 analog-to-digital converter with it [6].

Pulse sensor: PLSNSR1 is an optical pulse sensor that is used to measure the heart activity of the heart. When human heart contracts and expands, it pumps the blood in our body as shown in Fig. 4. The blood pressure changes according to heart expansion and contraction is occurring. The optical strength is changed when blood pressure changes and on that basis heartbeat is recorded by the optical pulse sensor. The electrical signal captured by the ECG electrode pass through this amplifier for better amplification [7].

AD8232 ECG sensor: Electrocardiograph (ECG) is a very important vital sign parameter for the detection of heart disease as shown in Fig. 5. The AD8232 is the three-lead single-channel ECG sensor which is used for heart disease detection. Our solution shows the live data graph of the ECG signals.

Fig. 4 Pulse sensor (PLSNSR1)

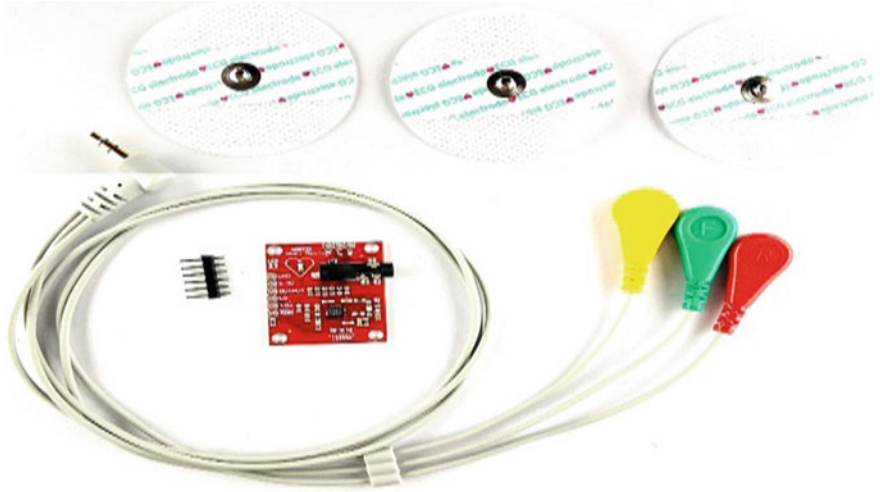

Fig. 5 AD8232 ECG sensor

Blood pressure sensor and pulse sensor: We used sunroom blood pressure and pulse sensor as shown in Fig. 6. That sensor is used to measure blood pressure and pulse rate of the patient. Sunroom sensor is given output in the form of serial data. We can easily interface serial communication with the sensor. We can easily interface the sunroom sensor with the Raspberry Pi and take sensor output on screen [8]. This sensor is firstly calculating the higher pulse this is systolic value and after it reading becomes constant. After reading the first higher pulse, it starts to measure the second higher pulse and the second-high pulse is the diastolic pulse of the patient.

Fig. 6 Sunroom blood pressure and pulse rate sensor

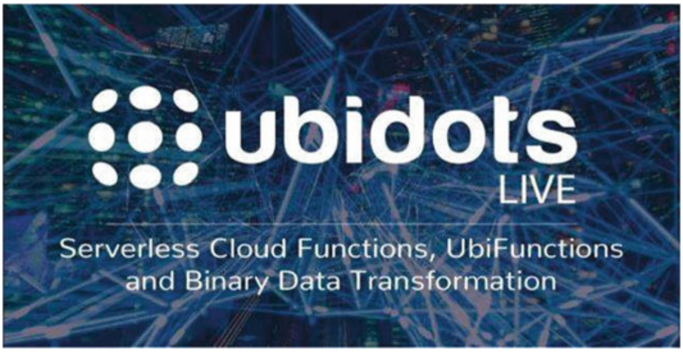

Fig. 7 Cloud for displaying data

5 Software Description

Ubidots Internet cloud: Ubidots as shown in Fig. 7 is Internet cloud platforms for professionals and beginners. It is established in 2012 and provides end-to-end Internet of things services to the users. Ubidots establish this IoT platform with a partnership with NETUX Pvt. Lmt. Ubidots IoT cloud platform is efficiently used for automation, surveillance, and healthcare applications. Approximately all microcontrollers with Wi-Fi modules are easily interfaced with Ubidots and we can easily transfer any sensor data or control any device with this IoT cloud platform [9].

Python: There are several programming languages like C, C++, Java, .Net, Python, etc. But the Python has many advantages over all other languages due to easiness and learning point of view. Python supports multiple paradigms object-oriented and functional programming.

Matplotlib: Doctors can process the ECG data if it is in the pictorial representation or in graphical representation. So matplotlib is the data visualization Python library that converts the AD8232 raw data into the graphical representation. Matplotlib is the Python library used for 2D graphical representation.

6 Working of Proposed Solution:

The proposed solution is used to get the all vital sign parameter of the patient. The architecture of the proposed solution is shown in Fig. 8. The pulse sensor (PLSNSR1) is used to get the heart rate of the patient. The ECG sensor is used to check the electrocardiograph of the people. In this proposed solution, three-lead single-channel ECG patches are used. The sunroom blood pressure sensor is used to check the blood pressure of the patient.

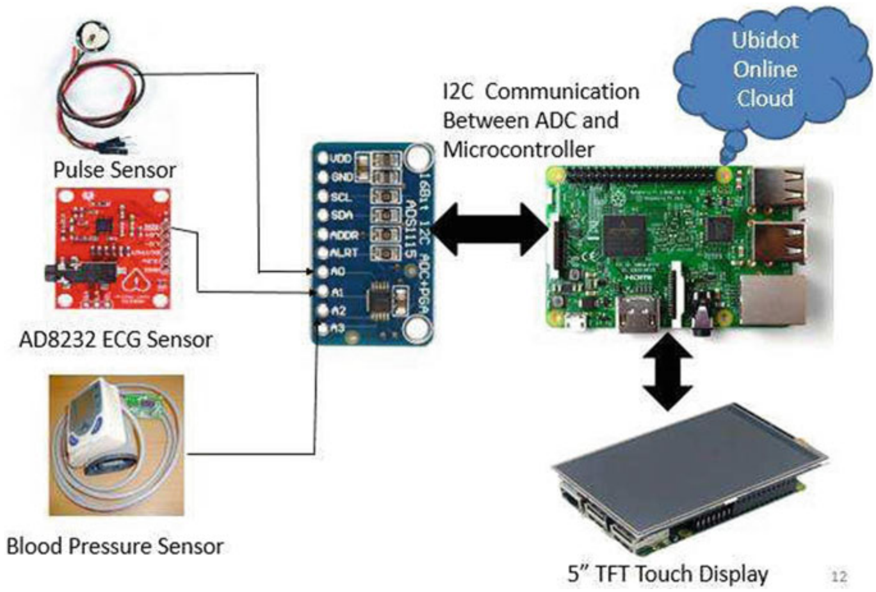

Fig. 8 Proposed solution architecture

All these sensors are the analog sensor that is interfaced with the Raspberry Pi microcontroller. The Raspberry Pi microcontroller does not have an inbuilt analog-to-digital converter. The ADS115 16-bit is used to convert the analog output into digital output. The ADS115 is the four-channel ADC so the four analog sensors are attached with this analog-to-digital converter.

Adafruit ADS115 library is used to get all the vital sign data from the sensors. In the coding part, firstly all sensor data are stored in the excel sheet. From the excel sheet, matplotlib Python package is used to get the live graph of the ECG sensor on the display. The doctors can see the live graph of the patient's vital sign on the display and take the appropriate action against it.

In the emergency, the doctor can see the patient vital sign parameter from anywhere in the world. Ubidot is an online cloud that plays a very important role. Then, the doctor can see the patient vital sign parameters as well as in the online Web cloud. The Ubidot is used for online cloud storage. Figure 8 shows the architecture diagram of the proposed solution (Fig. 9).

7 Conclusion

In this paper, we developed a healthcare kit for rural areas. This health monitoring system is capable of measuring almost all the vital sign parameters of the patient like blood pressure, heartbeat, and ECG. All the vital sign parameter is stored on

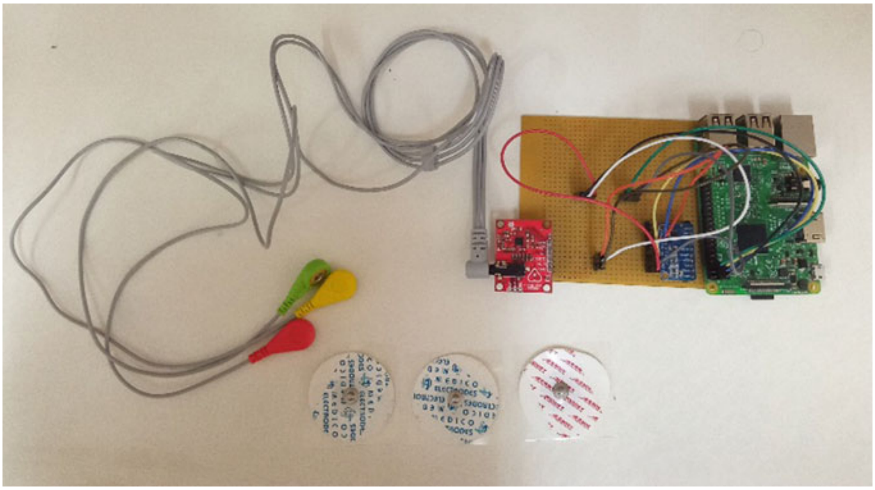

Fig. 9 ECG sensor interfacing with Raspberry Pi

the Web cloud. These vital signs are seen by the doctor for anywhere in the world. Furthermore, in the future, we apply an artificial intelligence o this system so that system itself capable to tell us about the heart disease of the patient.

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