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IoT Based Health Monitoring System for Physiological Investigation

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Abstract
The health monitoring system is emerged in the recent times since it is most desirable for checking physiological conditions. Internet of Things (IoT) based health care is one of the growing research which helps to monitor the physiological conditions in a repeated span of time. This technology is much obliged especially during epidemic conditions. Hence, present study focuses on development of distembot system which is used to measure temperature, pulse rate and respiratory rate of a person for a repeated span of time. It is identified that wrist position provides the accurate measurements of human body conditions. Hence in this paper, wrist watch is developed as distembot system. Initially, distembot system is designed and fabricated using Fused Deposition Modelling (FDM) technology. Then, temperature sensor and pulse sensor amped heart rate sensor are employed in the system to measure temperature, pulse rate and respiratory rate of a person. The distembot system is interfaced with respective sensors using ESP32 module. Network Time Protocol (NTP) is adopted to synchronize the clock over a network and OLED is interfaced with the system to display the measurements. The digital values of various measurements are extracted from the device using Wi-Fi module. The results suggested that proposed system is performing effectively to monitor the human health conditions in a repeated span of time.
Keywords: Distembot; IoT; Health monitoring; wrist sensor

1. Introduction

Mobile health monitoring is one of the non-invasive measurement technique which helps to detect human anomalies at regular intervals in real time [1]. Wearable sensors integrated with patient's environment have gained renewed interest in past few decades for long term monitoring process [2,3]. There are several studies have been carried out by researchers in the field of health monitoring system. Muhammad *et al* [4] have developed wearable system that used for detection and warning of heart attack to avoid traffic collision. They employed SVM algorithm with extended time-frequency features rather than linear classification algorithm to avoid noisy ECG signals. They identified that it is feasible to the user if the system is developed as wearable smart watch. Valchinov *et al* [5] designed a wearable wireless sensor for ECG monitoring aimed to recover cardiac disease patients. The proposed system can be sufficient for continuous monitoring for more than 48 hours. Darshan *et al* [6] reviewed Internet of Things (IoT) in health care to facilitate the patients such as chronic disorder, cardiac disease, hyperactive disorder, etc. They also mentioned the challenges involved of IoT in the health care system.

Banka *et al* [7] built a system to grasp the information such as temperature, heart rate and blood pressure of human body through raspberry pi microcontroller system. They suggested that integration of Artificial Intelligence (AI) with the wearable system may lead to facilitate the patients and doctors. Noh *et al* [8] implemented fuzzy rule based method for wearable ECG recording to avoid the noise in ubiquitous ECG recording. They employed 3 axis accelerometer with ECG system and found that significant improvement has been experienced during fast movement activity state. Valsalan *et al* [9] developed the system to monitor the patient's heartbeat, temperature and other basic parameters of the environment. They adopted the fuzzy inference system to predict the output responses which will further correlate with the experimental results. Motoi *et al* [10]

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fabricated a prototype for early diagnosis and treatment of cardiovascular and other diseases. From the experiments, they experienced that fabricated system capable to monitor ECG, respiration, excretion weight, cardiac beat and blood pressure effectively with reasonable accuracy. Some studies dealt with detection of myocardial infarction which is important parameter in heart disease [11, 12]. They adopted time domain method and linear classifier to achieve minimum time for receiving standard treatment. Rahman *et al* [13] conducted non-invasive breath test to monitor the ketone level for diabetic patients with the help of ESP 8266 Wi-Fi Module. The results suggested that acceptable correlation have been made between breath acetone level and blood ketone level. Valsalan *et al* [14] presented the method to perform respiratory test for TB patients. The volatile organic compounds present in exhaled breath is considered as test data which is used for diagnosis through IoT. They concluded that the sensor should capable of having high mechanical resistance and low energy consumption for high temperature conditions. Motoi *et al* [15] dealt with measurement of electrocardiograms for chronic cardiopulmonary patients. They considered that taking a bath is the risk factor for respective patients due to thermal effect and pressure of water on the body. Hence they developed the system to detect ECG signals through tap water which is placed outside the bathtub wall. Richard *et al* [16] designed ECG amplifier to obtain the heart rate data for portable applications. Digital signal processing technique is opted for reducing noise levels. Tamura *et al* [17] constructed the temperature domain profile for measuring distribution of temperature in bed during sleep. They concluded that the developed system is reliable and capable of delivering high accuracy and high reproducibility of body movement.

The present study focuses on design and development of Distembot system to monitor the temperature, pulse rate and respiratory rate of a person for a repeated span of time. Beforehand, the wrist watch system is designed and fabricated using FDM technology.

2. Materials and methodology

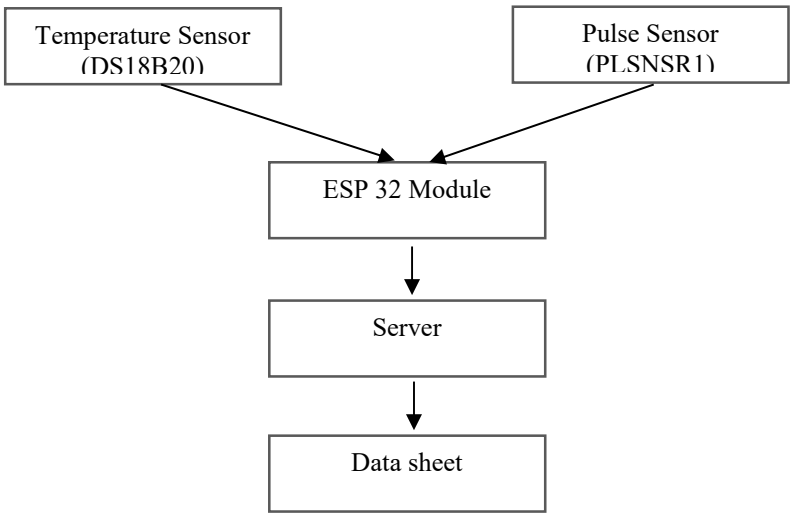

Fig. 1. Methodology

The following sensors are used in this work to obtain human health conditions such as temperature, pulse rate and respiratory rate.

- ESP32 Module
- Pulse sensor
- Temperature sensor
- OLED display

The methodology adopted for the present study is shown in Fig. 1. Initially the sensors such as DS18B20 and PLSNSR1 are interfaced with ESP 32 module. It is connected with the server which will repeatedly monitor the health conditions and the data can be transferred to data sheet.

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3. Design and fabrication of proposed system

The case for Distembot system is designed using SOLIDWORKS as shown in Fig. 2. Then it is fabricated using FDM technology which is one of the commercial 3D printing technology in the industry and it is shown in Fig. 3. Poly Lactic Acid (PLA) material is used as working material for fabricating the proposed system.

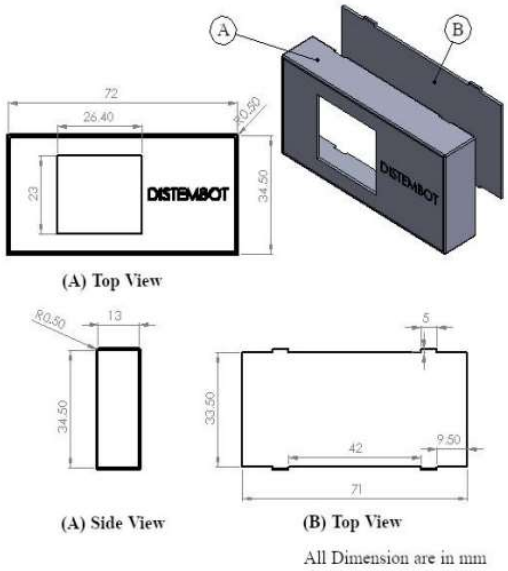

Fig. 2. Design of Distembot system

Fig. 3. Developed Distembot system

4. Electronics circuit

4. 1. Collection of data from sensors

The output pins of sensors such as DS18B20 and PLSNSR1 are connected to the analog pin of ESP 32 module. The V_{in} and GND pins of the temperature sensor (DS18B20) and pulse sensor (PLSNSR1) are connected to the supply voltage out pins of the ESP32 module. The respective reading from the sensors are stored into the ESP32 module. The respiration rate is calculated by the below mentioned formula,

$$\text{Respiration rate} = \frac{\text{Pulse per minute}}{5} \quad (1)$$

4. 2. Collection of date and time

Network Time Protocol (NTP) is used to obtain the current date and time. NTP is used for synchronizing the clocks over a network. The ESP32 acts as the client and it is connected to the server. The client transmits a request packet to a network time protocol server. Then, the NTP server sends back the time stamp packet ie., current date and time. Hence the date and time have been derived over the network which can be seen from Fig. 4.

Fig. 4. Display of date and time

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4. 3. Display of measurements

The date and time obtained from the NTP server is displayed in the OLED display for user's reference. Also, the readings which have been obtained from the temperature sensor, pulse sensor and calibrated respiration rate are displayed in the OLED display as shown in Fig. 5.

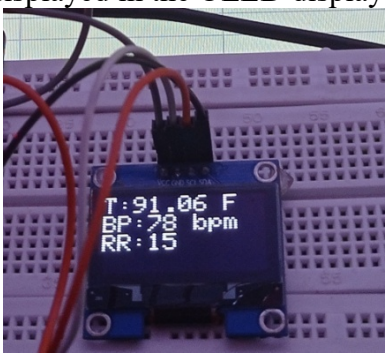

Fig. 5. Display of received measurements

4. 4. Printing data in the google sheet

The readings such as temperature, pulse rate and respiration rate can be sent to the google sheets for future reference. The ESP32 module is connected to a network through Wi-Fi module. The received data from the sensors is published at regular time intervals as shown in Fig. 6.

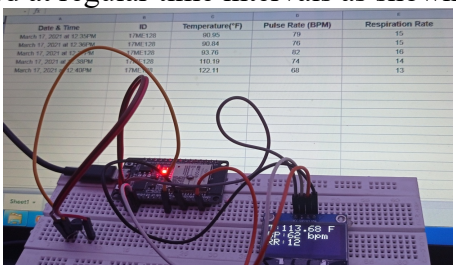

Fig. 6. Extraction of measurements in google sheet.

5. Results and discussion

The collective information from the sensors such as temperature, pulse rate and respiration rate are attained using the Distembot device and it provides the direct reading of the patients. Hence, there is no need of attender for measuring the parameters often. The data which is received from the device got stored in the data sheet and it is used for monitoring the health conditions of patient under emergency situation. And it also used to minimize the spread of the contagious deadly virus as separate devices are worn by individual patients. This device is portable unlike other devices. However, maintenance of these devices for long time is difficult.

5. 1. Temperature sensor

The temperature of human body is monitored continuously over the period of time as shown in Fig. 7. It can be seen that the temperature predicted with an accuracy of 0.01°C with respect to time. The measurements are plotted for the sampling length of 48 mins time interval.

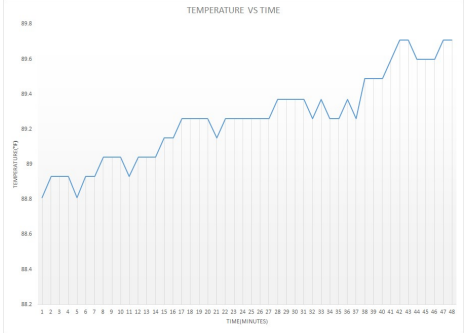

Fig. 7. Variation of temperature over period of time

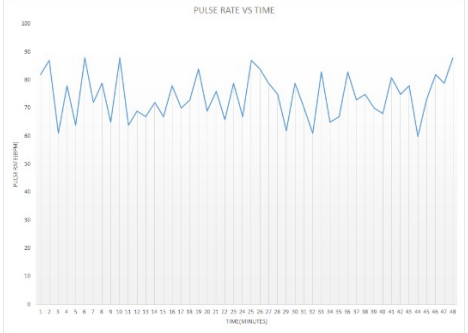

Fig. 8. Variation of pulse rate over period of time

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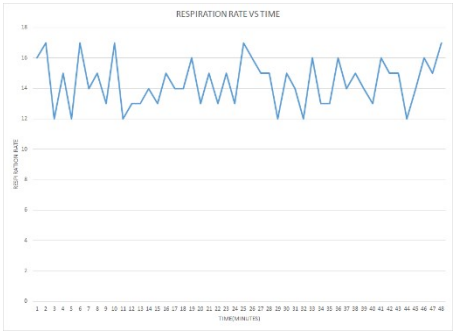

Fig. 9. Respiration rate of a person over a period.

Pulse rate act as the important factor of the patients who has severe health issues. Several devices are commercially available in the market for the measurement of this pulse rate. However, those devices are not feasible for portable applications. Distembot facilitates the patient in the view of portability as it can be wearing in arms or at wrist. Fig. 8 shows the variation of pulse rate with respect to time. It is inferred that the pulse rate is typically varied from 60 to 90 over the period of time.

In general, the average respiration rate of person is 12 to 16 per minute. The Distembot is used to monitor the respiration rate continuously as shown in Fig. 9. From the figure, it is identified that the measurements are lies within the range for the period of time. It is concluded that the proposed system is effectively used to monitor the temperature, pulse rate and respiration rate of human body.

6. Conclusion

The present work focused on the design and development of IoT based healthcare monitoring system which is called as Distembot. The main ideology of distembot is to make a smart watch in which measuring features like temperature, pulse rate, respiratory rate of a person, has been measured in a repeated span of time. The purpose of proposed system is to use it in hospitals/industries where it is highly desirable. It is portable device which continuously monitor the human health conditions. The conclusions are made as follows:

- Wrist position is efficiently functioned as it can provide accurate measurements of human body conditions.
- The temperature sensor (DS18B20) is used for measuring body temperature rather than using thermistor and thermometer to reduce complexity of the system.
- The temperature of human body is predicted with an accuracy of 0.01°C with respect to time.
- The pulse rate is typically varied from 60 to 90 over the period of time. The measurements of respiration rate are lies within the range for the period of time.
- Hence, the proposed system is effectively used to monitor the temperature, pulse rate and respiration rate of human body.

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