COVID-19 Symptoms Monitoring Mechanism using Internet of Things and Wireless Sensor Networks

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Summary
Internet of Things (IoT) technology is rapidly developing and it makes the connectivity of various smart objects possible for many applications, such as industry, military, education and health. Recently, Coronavirus spreads rapidly over the world, and there are no specific treatments for it at this time. Therefore, preventing infection and monitoring its symptoms such as fever and shortness of breath, is very important. Since Coronavirus is a very fast spreading disease, and the social distancing is very important to prevent the infection, the need to a mechanism which is smart enough for monitoring the symptoms of the isolated people without direct communication with them is necessary. This paper presents a design and simulation of COVID-19 Symptoms Monitoring Mechanism (CSMM) based on IoT and wireless sensor network to monitor people during their quarantine; especially the eldest who suffer from chronic diseases and immune deficiency, hence they are more likely to develop serious illness. The mechanism depends on remote monitoring of the patient health data. The monitoring process can be done by the doctor or medical provider. This system can be easily used to detect an urgent or abnormal case, for instance, when there is a highly fever or difficulty breathing. As a result, the system can issue an alarm to the doctor or medical provider by sending urgent SMS including the time and patient condition in order to intervene and save the patient life without any delay.

Key Words:
Internet of Things, Sensors, Monitoring System, Covid-19, Arduino Uno, Healthcare System.

1. Introduction

At the end of 2019, a new coronavirus disease named Coronavirus Disease 2019 (COVID-19) appeared in China [1]. The disease spreads quickly among people and in March 2020, the World Health Organization (WHO) declared it a pandemic due to the large number of cases around the world, which are 21,991,954 cases by August 19, 2020 [2].

The common symptoms of COVID-19 include fever, dry cough, sore throat and shortness of breath. Most people have mild symptoms, but those who have medical conditions or their age is over 60 years, have a high risk which may lead to death [3].

The statistics from WHO show that COVID-19 spreads very quickly among people in close contact when a person who is infected with the virus talks, sneezes or coughs. Therefore, people with medical conditions or those over 60 years old should be self-isolated and contact their medical provider for critical cases [4].

Most of the time, due to the large number of COVID-19 cases, it is necessary to monitor the people who contacted with infected cases, especially the eldest. On the other hand, inattentiveness of relatives may cause abnormality go unnoticed, and this will result in contact person's health issues. Thus, developing smart monitoring mechanism that can monitor COVID-19 symptoms and some vital signs of a contact person such as fever and oxygen level in the blood, from distance position is very important to save the health of a contact person, and also save the doctor from the direct contact with any person which may be infected with a COVID-19 [4].

The healthcare monitoring system combines both of Wireless Sensor Networks (WSNs) and Internet of Things (IoT). The WSN consists of many sensors that sense different phenomena such as the temperature and humidity. On the other hand, by using IoT, person's parameters can be measured in the real time. Sensors collect person's fever and the oxygen in blood, and then transfer data to the medical provider which takes an action by depending on the values of that data [5,6,7,16].

As the eldest are more vulnerable to be infected with the COVID-19, the need of a continuous monitoring especially for those who contacted other infected people. Monitoring the eldest by the traditional ways has many difficulties, such as contacting with them many times daily which shall increase the possibility of COVID-19 infection to the medical team (nurses, doctors). Moreover, COVID-19 increases rapidly, and the number of confirmed cases, as well as the number of the contacted persons, is very high and increases instantly. Other reason is the difficulties of monitoring the eldest by their relatives especially in the emergency cases [3].

A monitoring mechanism is very important in the case of monitoring the eldest who contacted a confirmed case of COVID-19 to enhance the quality of their life and protect the doctors from a possible infection.

This paper deals with the design of a COVID-19 symptoms monitoring mechanism for isolated-cases of the eldest who contacted with confirm cases of COVID-19 disease. Those people will stay in quarantine for 14 days. During this period, wearable devices will be used to monitor the vital signs of the quarantined people by using different mode of

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communications. Section II reviews the earlier monitoring systems using IoT. Section III describes the hardware and software component of the proposed system. The next section discusses the data communication in the system.

2. Literature Review

IoT is used in various fields such as manufacturing, agriculture, healthcare and remote real-time monitoring for various parameters. Many studies were conducted for healthcare monitoring using IoT. Recently, and after the COVID-19 pandemic, it is necessary to remotely monitoring the eldest who contacted with COVID-19 cases to check there vital signs during the 14-days of quarantine and make sure that no COVID-19 symptoms appear.

This section describes some of the previously proposed healthcare systems for other cases rather than the COVID-19 cases because still no studies for the new COVID-19 infectious.

The study proposed in [8] emphases on monitoring and evaluating health settings of obese adults using IoT. The study focused also on the medical data storage. The device used in this study allows the storage of medical records for many patients at the same time by using Arduino board. The medical data sent to the IoT using a Wi-Fi module. In this study, the doctor can monitor the changes of symptoms for any case remotely.

Lakkis and Elshakankiri [9] have proposed a system which focuses on the emergency services such as patient emergency, ambulance and vehicles services. The proposed system used sensors for detecting and transmitting health information. This information is only used for health monitoring and emergency reaction. In addition, the proposed system did not mention any specific disease.

Neyja et al. [10] proposed a monitoring system for cardio vascular disease. Heart rate data must be sent to the hospital via an electrocardiogram sensor. An algorithm is proposed in this system is triggered in the case of unusual conditions, which requires an immediate response from the medical provider.

The authors in [11] proposed a system for monitoring multiple diseases. They used Cisco packet tracer tool for implementing the system. Firstly, the system collects the data using sensors and then processes it by using a microcontroller. Secondly, many decisions will be taken regarding diagnosis, medicine administration and emergency response. The proposed system deals with three diseases, but still COVID-19 is not yet considered.

The previously proposed systems considered various diseases and cases, but the monitoring the eldest who contacted COVID-19 cases is still not yet considered. Next section explains the components which are required in the proposed system.

3. System Components

Internet of Things (IoT) technology increases the possibility of connecting smart devices through the Internet in various applications. In COVID-19 Symptoms Monitoring Mechanism which is proposed in this paper, sensors are used to monitor the vital signs of the quarantined person during his isolation period, which shall increase health quality and decrease the possibility of COVID-19 infection.

In this proposed mechanism, the temperature, which is a very important vital sign and considered as a common symptom for COVID-19 cases, is sensed by using the appropriate sensor. The sensed data is read by using Arduino Uno board, which takes the input signals and send the corresponding digital reading via Wi-Fi module to the cloud (server), which gives a live monitoring to the receiver side (doctor). Hence, this process enables continuous monitoring of the quarantined person's parameters by the medical provider.

Arduino is an easy-to-use hardware and software which consists of a microcontroller or circuit board, and an Integrated Development Environment (IDE) is used to upload the programming code to the board by using a simplified version of C++ [12].

There are different types of Arduino boards in respect to the number of inputs and outputs, clock speed, operating voltage and other factors. In this paper, the Arduino Uno board is selected because it is the most common type. Fig. 1 describes the Arduino Uno board and its components [12].

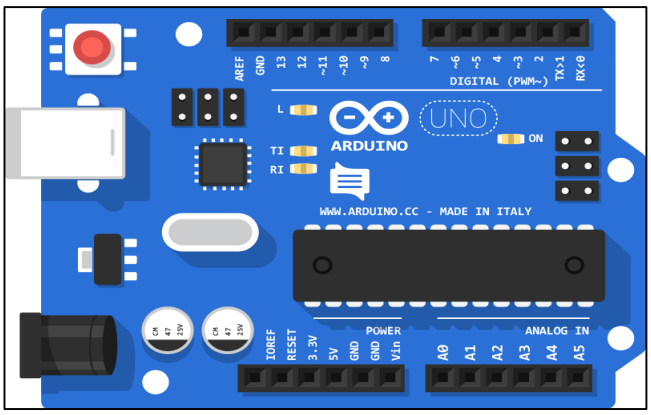

Fig. 1 Arduino Uno Board

As shown in Fig. 1, Arduino Uno board can be connected to the PC by using USB cable. Moreover, there are six analog pins (A0-A5) to read the signals from the sensors (e.g. the temperature sensor) and convert them to digital data. Moreover, Arduino board has a microcontroller chip which is the most important part of it [12].

As previously discussed, the temperature of the quarantined person is a very important sign, and to monitor this sign, LM35 temperature sensor is used in the proposed

mechanism. LM35 sensor has an analog output voltage related to the temperature, which is provided in Celsius. The description of the LM35 sensor is shown in Fig. 2 [13].

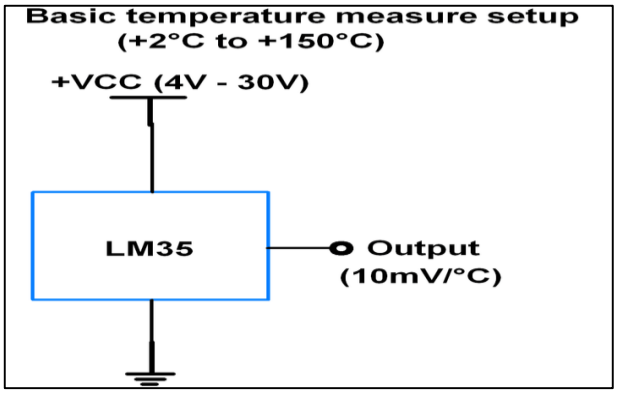

Fig. 2 LM35 Temperature Sensor

As shown in Fig. 2, LM35 has three pins: VCC which is a supply voltage, Out which gives analog output voltage that is related to the temperature, and GND which is ground. The LM35 sensor is connected to the Arduino Uno, and the analog voltage output is given to the analog pin A1 of Arduino Uno, then it is converted to the corresponding digital form which is processed to give the reading of the temperature. Fig. 3 displays the interfacing of LM35 with Arduino Uno board [13].

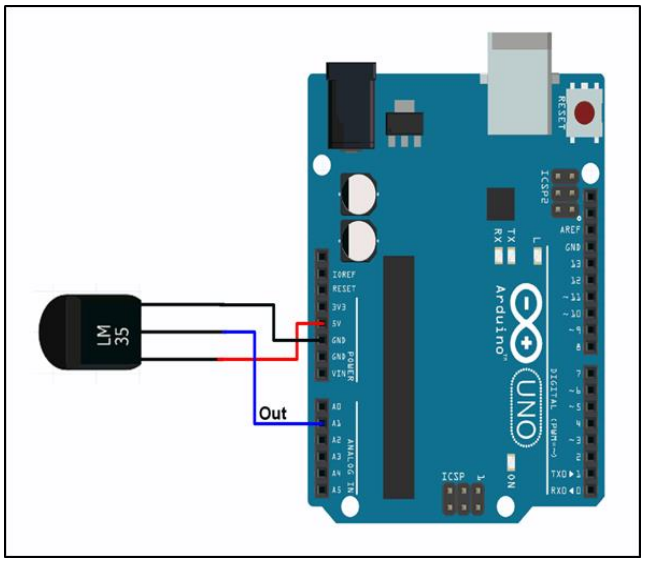

Fig. 3 Interfacing LM35 Sensor with Arduino Uno

Fig. 3 shows how the LM35 sensor is connected to the Arduino Uno board. The output pin of LM35 is connected to the analog pin A1 in the Arduino Uno which converts the analog signal to a digital value that can be read by the microprocessor. The VCC of LM35 sensor is connected to the 5V pin on the Arduino, and the GND of LM35 is connected to the GND pin of the Arduino. The next section explains the proposed COVID-19 symptoms monitoring mechanism in details [14].

Another component of the proposed mechanism is ESP8266 Wi-Fi module, which provides internet connectivity to upload the sensed data to the internet and making IoT application as easy as possible. Moreover, it can be programmed by using Arduino IDE. The following section provides the details of the proposed mechanism [15].

4. The Proposed Monitoring Mechanism

The proposed mechanism in this paper considers the persons who are quarantined for 14 days, which is the COVID-19 incubation period. During this period, the quarantined persons, especially the eldest, must be monitored, and the COVID-19 symptoms should be considered. The temperature is a common symptom, hence, it must be monitored by the medical provider.

The eldest have high risk of COVID-19, and it is difficult for them to go to the hospital or be monitored directly at home by their relatives. Therefore, the proposed monitoring mechanism can help them to be monitored during their quarantine period by a doctor. The monitoring process in the proposed mechanism is done remotely by applying the IoT technology, where the LM35 temperature sensor is connected to a quarantined person and monitors his/her temperature by using Arduino Uno.

Arduino Uno receives analog signals from the sensor and converts them to the corresponding digital form. After that, the microcontroller processes the digital data and sends the readings to the cloud which acts as a server. Then the receiver side (doctor) can get the readings instantly.

In the proposed system, sensor's data is saved, analyzed and visualized in the cloud by using ThingSpeak, which is an IoT platform that provides instant visualizations of the data posted by the sensors. Fig. 4 illustrates the block diagram of the proposed mechanism.

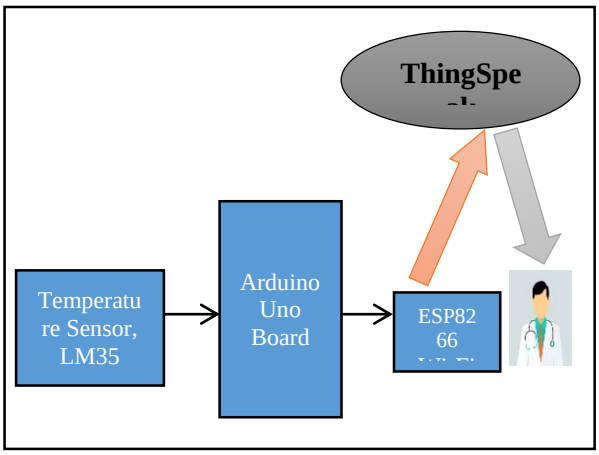

Fig. 4 Block Diagram of the Proposed System

As shown in Fig. 4, LM35 temperature sensor senses the temperature of the quarantined person. Then, the Arduino Uno processes the signals and gives the corresponding digital reading of the temperature in Celsius. After that, ESP8266 Wi-Fi module connects to the available Wi-Fi and sends the data to the IoT server, which is ThingSpeak in the proposed mechanism. Finally, the doctor can monitor the data instantly from anywhere in the world by logging into ThingSpeak channel related to the proposed mechanism.
By creating an account in ThingSpeak, you will be able to create a specific channel for reading and writing data, and visualizing it as a chart for more decisions. Fig. 5 shows the created channel for this application.

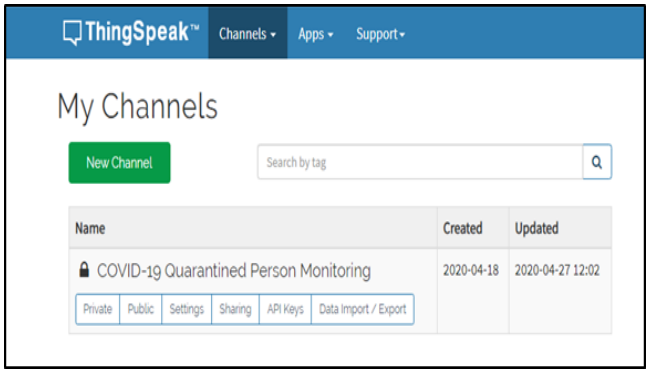

Fig. 5 COVID-19 Quarantined Person Monitoring Channel

Fig. 5 shows the COVID-19 Quarantined Person Monitoring channel. API keys are generated automatically for writing the data to a channel or reading the data from a channel via API requests.
The graphical output at the specified channel at the cloud (ThingSpeak) can be easily monitored instantly at anywhere in the world by the doctor, and if the readings of the quarantined person are high, then the doctor will take the correct action to deal with that person and take him/her to the hospital. Fig. 6 shows some readings of a person's temperature which are output on the cloud.

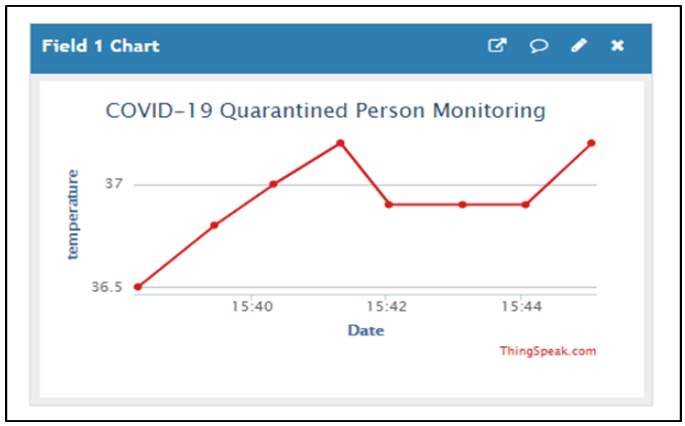

Fig. 6 Output Temperature's Reading at the C

Fig. 6 shows some readings of the quarantined person's temperature shown at the ThingSpeak. The doctor can now log into the cloud and see the graphical output to check the status of the quarantined person during the quarantine period, i.e. 14 days. This process can help the doctors in monitoring the large number of the quarantined persons directly in their houses, and it will also reduce the large number of hospital's entries.

5. Conclusions

The COVID-19 is an infectious disease was initiated in China and spread rapidly around the world. The main important issue in this new infection is the quick spread, and accordingly the increasing number of the infected cases. The quarantine process is also a very important issue to deal with the large number of the persons who contact the infected persons. The proposed mechanism gives a live monitoring of the quarantined persons, especially the eldest, during their quarantine period. The proposed mechanism helps the doctors to deal with this large number of quarantined persons remotely. The ThingSpeak IoT platform provides a graphical output of the sensed data which makes the analysis as easy as possible.

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