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A novel approach to IoT based health status monitoring of COVID-19 patient.

Dipayan Mazumder
Electrical & Electronic Engineering
Premier University
Chittagong, Bangladesh.
dip.eee.puc@gmail.com

***Abstract*— COVID-19 is a SARS-CoV-2 virus infection that almost always damages a person's respiratory system. Moderate symptoms often include fever, low saturation, and soreness, which frequently lead to severe conditions. An individual with mild breathing difficulties will perhaps not know when to go to a hospital or need oxygen. This is why people must get accurate information about their current condition. Many patients with COVID-19, even if they feel well, have a low concentration of oxygen in their blood. Low oxygen saturation levels can be an early warning sign that emergency medical assistance is required. The four key indicators that medical and healthcare providers regularly track include body temperature, heartbeat, respiration, and blood pressure. As the number of patients is increasing rapidly, it has been difficult to provide treatment in hospitals due to the limited number of seats, especially in a third-world country like Bangladesh. So, COVID-19 patient treatment should not only be centralized in treatment centers and outpatient facilities, but it is also equally important to develop remote monitoring strategies to monitor and advise the patients remotely. The proposed device involves multiple sensors for the tracking of vital signs and the results of the sensor will be transmitted in the cloud, which will be made available to health professionals for comprehensive analysis. The paper proposes a solution for health status monitoring of patients using the Internet of Things (IoT) that could prove beneficial while battling the deadly virus.**

***Keywords*— IoT, Covid-19, Heartbeat, Respiration rate, Blood pressure, Temperature.**

I. INTRODUCTION

A recently detected corona virus, has resulted in a global respiratory disease pandemic, called COVID-19. It originated at the beginning of December 2019 near Wuhan City of China. On 31 December2019, the China Health Authority reported the World Health Organization (WHO) of some pneumonia cases of an unidentified etiological disease [1]. A total of 113 million cases were recorded around the world as at 27 February 2021, with 2.5 million deaths. In the early stages of the pandemic, rate of death or fatality in the whole world was measured at approximately 2%, and survival rate was 41.8%. [2]. As the total number of cases each day changes, the numbers differ often. When the pandemic broke out, lockdowns were imposed in almost all areas worldwide, closing down events involving human interaction and communication, including colleges, universities, malls, temples, banks, major airport and metro stations [2]. As a result it took more than 2 months for cases to go down from 20 to 40 million. As the world is now adopting a 'New Normal' policy, post lockdown scenario is different. It took just 1 month for cases to go from 80 million to 100 million [3]. Compared to pre-lockdown stages, the use of internet services has risen from 40% to 100%. Amazon, an international tech company, announced a 70% increase in earnings in the first nine months of 2020. At a time of crisis technologies should still look forward to responding effectively and improving their ability to face new challenges. Remote monitoring technology has immense potential to do so regardless of COVID-19.

This paper organizes the key contents in the following way; Literature reviews have been represented in Section II. Section III describes the measurement technique of blood pressure, body temperature, respiration, oxygen saturation and heartbeat. Section IV focuses on the implementation of the system and gives a brief outline of the results. The conclusion given in Section V ends this paper.

II. LITERATURE REVIEW

Numerous solutions are available on the market to detect key indicators such as body temperature, pulse, ECG, as indicated in several literatures. However, a new approach to incorporating and developing a dedicated monitoring system for Covid-19 patients is now essential.

Lee et al. introduced a remote monitoring system of patients based on smartphone [4]. A mobile application (app) is configured in this framework. Patients will have a virtual meeting with a doctor using a computer or smartphone to receive the medical treatment. This device operates with AES-style encryption of Skype to protect video files of patient. The device does not allow real-time mode. Any abnormalities and detected vital signs should be manually uploaded to the database.

Mustapha et al. suggested a remote patient management system using Edge Cloud & Web Real-Time Contact (WebRTC) [5]. Not only can Edge Cloud be used as storage, it can also be used as a medium of communication. There are two different moods in the framework: push mode and pull mode. In remote push-mode control, the device sends a warning to the user if suspicious health data is observed.

Although remote control via pull-mode is for the user to check the data previously obtained. WebRTC supports various means of connectivity between the system & cloud server. The video and data obtained would be processed by the system's analytical engine. This machine focuses primarily on transferring and optimizing video data rather than critical signal data.

By using a Raspberry Pi an e-health system based on IoT was implemented by Pap et al. [6]. Node.js server-side program was used to provide the user with a web interface to analyze a particular chart and document the details in the chart. E-health is equipped with several sensors, such as pulse, blood pressure, breathing, and temperature sensors. This interface allows the user to select between a live session or a recording mode. The data can only be kept briefly in live session mode but indefinitely preserved for the recording session.

Harish.H.M et al [7] initially developed the Zig-Bee based wearable device for monitoring physiological parameters. Physiological factors such as the user's heartbeat and body temperature can be tracked using such method. This system is focused on an individual, who is mentally unstable and the receiver unit connected to the machine will create graph to track human physiological parameters.

III. Methodology

Blood Pressure Monitoring:

Blood pressure may be described as a measure of the force that our hearts use to transport blood across the body. An automated blood pressure (BP) meter (Model: KD 202F) is used throughout the work. The device supports microcontroller interface via USB for health management purposes. The KD 202F is wired to the microcontroller when using E-Health Module. The Arduino microcontroller is interfaced with the ESP8266, which transmits information from these sensors to the cloud. Fig.1 provides the operating protocol for the proposed scheme.

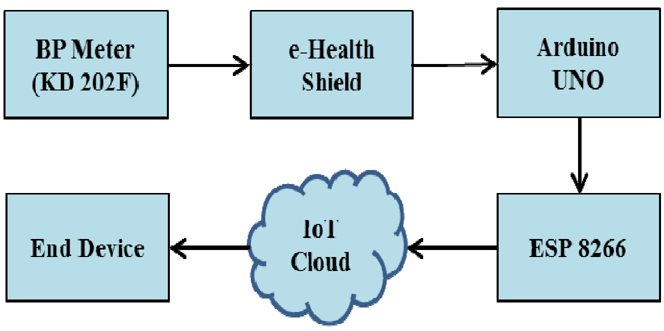

Fig.1: Blood Pressure (BP) monitoring block diagram

Non-invasive airflow (breathing) sensor:

According to the new clinical study, the respiratory pattern of COVID-19 varies from the respiratory behavior of flu and common cold [8]. People afflicted with COVID-19 start breathing more rapidly. Abnormal breathing rate and variations in breathing rate are a large predictor of significant physiological dysfunction and, in several situations, breathing rate is one of the first symptoms of this disorder. The breathing rate as an indicator of patient status is also necessary to follow. Air flow sensor is capable of providing advance indication of hypoxemia. The airflow sensor is used for determining the breathing rate of a patient to monitor whether he/she needs respiratory assistance or not. This system comes with an adjustable string that fits behind the ears and a series of 2 prongs that are positioned in the nostrils as seen in Fig.:2. Breathing is calculated with these prongs. Standard healthy adults have a breathing rate of 15–30 breaths per minute [9].

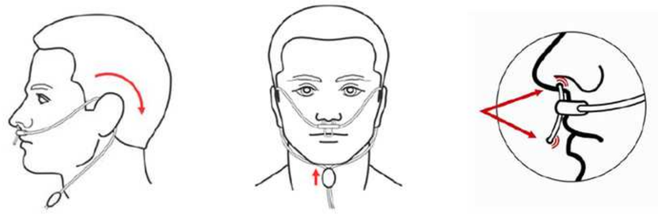

Fig.2: Airflow sensor placement [10]

The AirFlow e-health sensor is compatible with the Arduino microcontroller and the e-health shield. The Arduino microcontroller is interfaced with the ESP8266, which transmit data from these sensors to the cloud. The working procedure of the proposed solution is given in Fig.3.

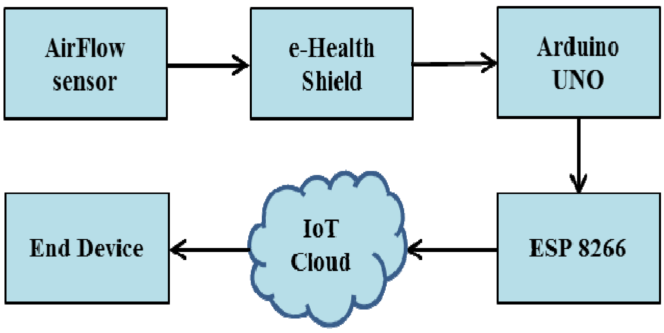

Fig.3: Block diagram of respiration monitoring

Heart rate, oxygen saturation and body temperature:

An LM35 IC is mounted and strapped to test body temperature on the patient's armpit. This sensor is attached to Arduino Uno and it needs programming to ensure the sensors operate properly. The ESP 8266, which transmits all the information gathered from the sensor, is attached to the Arduino microcontroller. An optical sensor (MAX30102) is used for the reading of PPG signals and the calculation of heart rate, SpO2 and blood oxygen saturation from the finger. The board is interfaced with the Arduino microcontroller & ESP8266. For several decades pulse oximetry (percentage of blood SpO2 concentration) has been utilised as a primary health measure . The oxygen level (oxygen saturation) is calculated in the blood. It is a direct and pain free assessment of how well oxygen is sent from the heart to other areas of the body including legs and arms. It can be used to check whether adequate oxygen is available in the blood and to check a person's health for any conditions affect blood oxygen.

BPM is the "beats per minute" which is around 65-75 when relaxing for an average person. SpO2 is the amount of oxygen saturation, and for an average human it is more than 95% [11]. The working procedure of the proposed system is given in Fig.4.

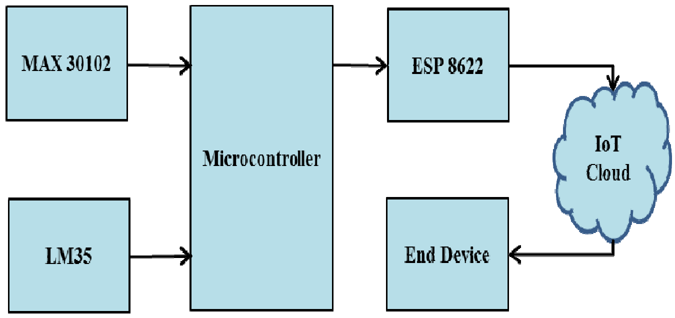

Fig.4: Block diagram of Temperature, Heart Rate and SpO2 Monitoring

Proposed Monitoring System Description:
This study demonstrates a Patient's health status monitoring system model with various parameters such as body temperature, heartbeat (BPM), oxygen levels and blood pressure. These data can be tracked via ThingSpeak anywhere around the world. It is an open data framework for the Internet of Things (IoT) that allows data to be gathered in a channel and data to be collected from other networks using the API. In order to send data to ThingSpeakTM using Arduino®, Arduino is required to have internet access.

As ThingSpeak allows up to 8 data fields, all sensor information would be available at the same time. When the data is on ThingSpeak, it can be accessed by using MATLAB Visualizations software as well as on the internet. Fig.5 displays End to End connectivity for constant monitoring using the ESP8266 Wi-Fi microchip and the Arduino microcontroller. Data from LM35 IC is used to measure body temperature, and MAX30102 provides information on heart rate and blood oxygen saturation. These outcomes would then be transferred to the cloud. This information will be used to determine the patient's current condition. In addition, it is also possible to warn family and physicians about the patient's condition.

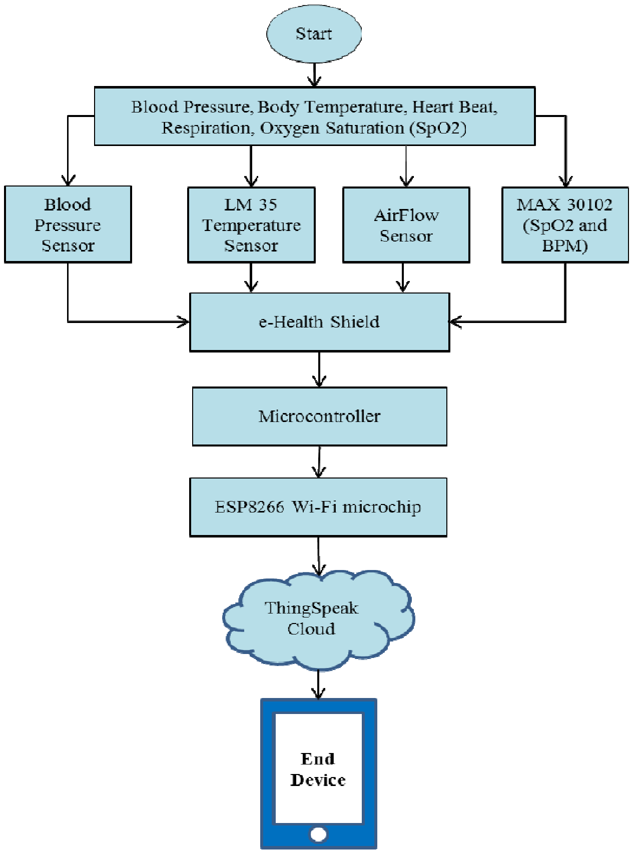

Fig. 5: End to End communication for continuous monitoring

IV. Implementation and Result

Every three seconds, the temperature is shown on the LCD, and every fifteen seconds, the pulse rate and blood oxygen saturation are shown. The values will then be transmitted to the ThingSpeak cloud, based on the preference of the user. For ease of visualization, a collection of values from the sensors sent to the ThingSpeak channel is presented in a graphical format.

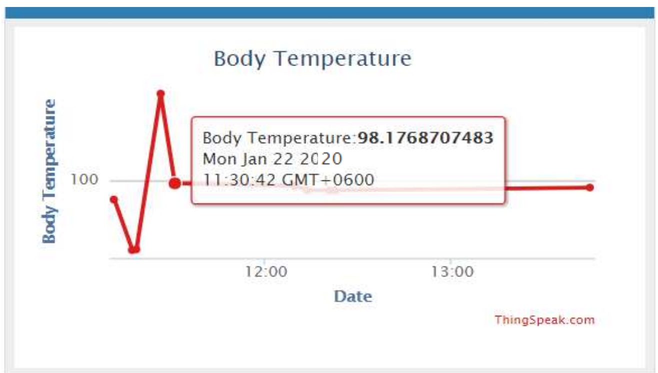

Fig.6: Body temperature data from ThingSpeak

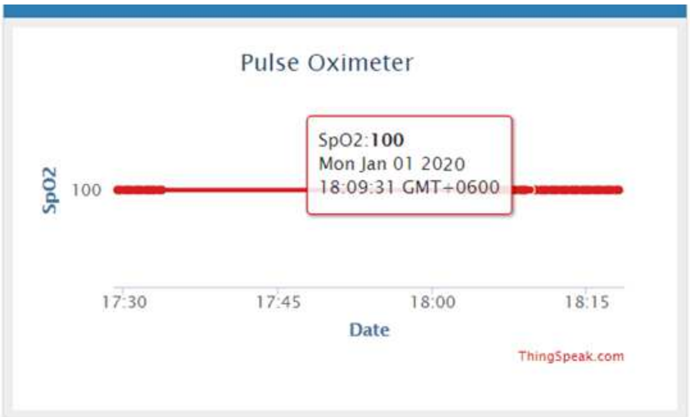

Fig.7: Oxygen saturation data from ThingSpeak

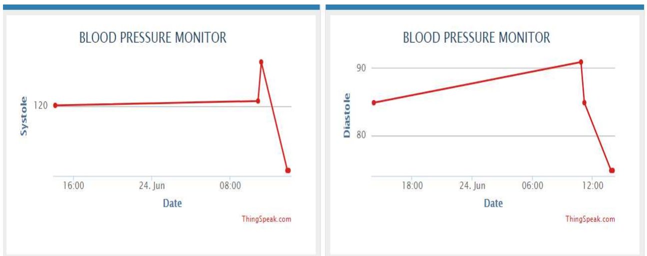

Fig.8: Blood pressure monitoring from ThingSpeak

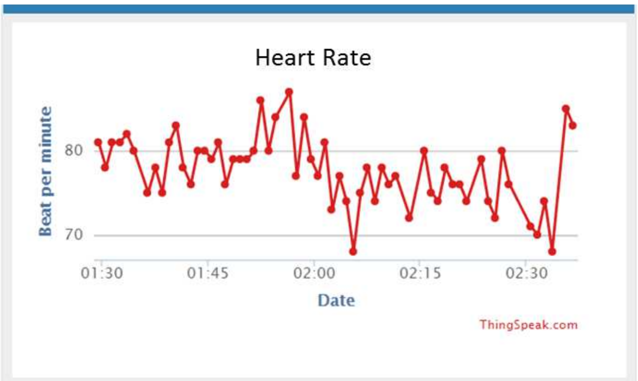

Fig.9: Heartbeat (BPM) monitoring from ThingSpeak

The graphs in Fig.6 display the difference in body temperature (in Fahrenheit) over time. The measurements were transmitted at a thirty-minute interval, which can be modified using the selection unit. Similarly, the graphs in Figs. 7 and 8 display the change in blood oxygen saturation (in percentage) and blood pressure over time. The deviation in heart rate is illustrated in Figure 9. (in beats per minute). The accuracy of the health parameter values can be seen here. As a result, we can confidently conclude that the proposed system's data transmission unit is extremely reliable that can be used by anyone for health status monitoring.

V. Conclusion

The proposed approach is an IoT-based embedded system for remote patient monitoring which is low power, low cost, compact, and reliable. The processing unit in the system is an Arduino UNO, which is a viable solution because it is low-power, low-cost, and has a decent processing power and speed. The device enables healthcare staffs and physicians to monitor Covid-19 patients, senior citizens, and people in remote communities, thus enhancing their quality of life.

More e-health sensors can be connected to this system to capture different health parameters. To improve the efficiency of the proposed device, further research on extracting the noise signal is deemed necessary.

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