Design of Smart Heart Rate Monitoring and Stress Detection System with Cloud Data Storage and Privacy

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ABSTRACT

The COVID-19 pandemic affected the entire world in various ways. It influenced the global order, lives, livelihoods, travel, workspace, digital systems and most importantly the health systems. One unarguably the most unusual and striking effect of the pandemic has been on the mental health of people worldwide as lives underwent drastic changes in the pandemic. As the pandemic continues, the demand for mental health treatment is only increasing with focus on more personalized and customized healthcare as each individual has his/her own sets of issues, fears and insecurities and 'one size-fits-all' approach cannot be practiced in such cases. This paper presents a comprehensive solution in the form of a novel stress monitoring system that detects stress levels and guides the person to relax by pursuing a hobby like watching a meditative video or distract for some time and play some soothing game. It also alerts his personal psychiatrist or doctor who can then check up on him and prescribe him appropriate treatment and medication in case of high stress levels.

Keywords: COVID-19, cloud, heart rate, intelligent systems, mental health, pulse sensor, smart devices, stress

1 Introduction

After the world was struck by COVID-19 pandemic, the lives and livelihoods of people underwent several and severe changes. The world witnessed isolation, bereavement, rampant job losses, interpersonal transgressions in family, domestic abuse, over-work at odd hours due to 'work from homes', future insecurities, fear etc. The effects of pandemic took a drastic toll on mental health of the people and disrupted or halted critical mental health services in 93% of the countries. [1] Furthermore, the GDP spending that was small in developed countries and dismal in developing countries further exacerbated this divide. Telemedicine and teletherapy could bridge the gap only up to a certain extent with less than 50% coverage in low income countries. The demand for mental health services is only growing with emphasis on more personalized and tailored healthcare as each client has his/her own sets of problems, concerns and insecurities and 'one size-fits-all' approach cannot be practiced in such cases with the continuation of the pandemic.

To overcome this challenge, this paper presents an affordable novel stress monitoring device that detects stress levels based on pulse sensor and temperature sensor inputs. To overcome minor bouts of anxiety and stress, some solutions such as meditation videos and playing online games intended for relaxation have been prescribed. On higher levels of stress detection, it sends an alert to the personal physician/therapist of the person who can then prescribe appropriate therapy, treatment or medication. Such a device can be translated as a wearable device and can be easily made available en masse. Furthermore, contacting the personal doctor/therapist, thus, offers for a more personalized and customized care as opposed to "general toll free therapy sessions".

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2 Literature Review

There are reports cited to understand in depth the severity of mental health and its consequence during the pandemic. Earlier works have been done in the field of diagnosis of heart diseases using Electrocardiograph (ECG) and Pulse sensor. The paper in [3] employs a wireless heart rate monitoring system so that a patient is mobile in the hospital. In [4], a remote smart health clinic has been developed by using a portable heart monitoring system. In [5], an alert system to continuously monitor patient has been developed. In [6], another method to monitor heartbeat using Light Dependant Resistance and Light Emitting Diode has been studied. Furthermore, in [7] an alarm system is developed when an abnormal ECG is detected. The paper in [8] uses an RFID tag to transmit heart signals when an ECG is connected at its source. Thus, most of the earlier work done focuses mainly on detection of heartbeat and pulse rate and its abnormalities.

The present paper is a first of a kind that uses a combination of pulse and temperature sensor data along with cloud storage of his vitals to measure and record stress levels in an individual and to contact personal therapist/physician for diagnosis and treatment of his illness in severe cases. It is a novel approach towards management of stress levels that have been on a rise since COVID-19 pandemic.

3 Methodology

The following section describes the methodology and functioning of the system in detail. It illustrates diagrammatically as to how the idea was conceived, followed by the schematic built up of the system. It goes on to describe the methodology and functioning of the various components employed in the system with their specifications. Finally, it demonstrates the system hardware that has been built keeping the aforementioned guidelines in mind.

3.1 Block Illustration

The Figure 1 depicts the block illustration of the system.

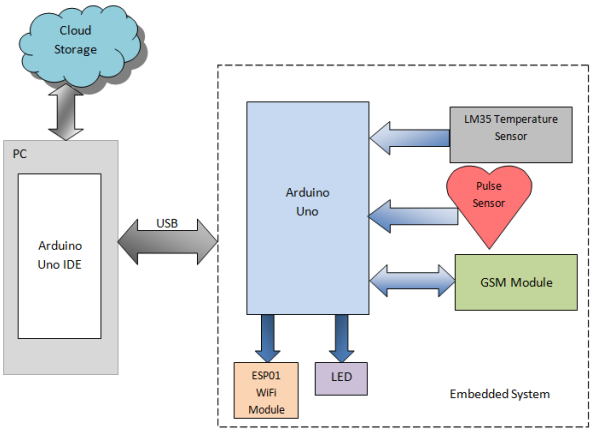

Figure 1: *Block Illustration of the technique*

3.2 Methodology and Functioning

1. Sensor Data as Input

Firstly, the temperature and pulse of an individual is measured via LM35 temperature sensor and Pulse sensor respectively. The sensors, both LM35 temperature sensor and the Pulse Sensor are connected to the Arduino Uno.

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2. Processing of Data of vitals and Cloud Storage

The data recorded from the sensors are processed via the ESP01 WiFi Module connected with Arduino Uno and are stored in the Cloud at periodic intervals. The LED indicates the detection of pulse and temperature.

3. Data Analysis and Computation of Sensor Data

Sensor data is computed at periodic intervals as set by the patient and represented in graphical form to analyse the stress levels in the past, say 30 minutes or 1 hour. The average result if higher implies high stress levels.

4. Detection of High Pulse OR High Temperature

Once a high pulse or a high temperature is detected in the lifestyle due to a stressful situation at home or workplace, an email alert is sent to the patient via cloud. The email alert carries a message to take a break and also carries a link to watch a meditative video, soothing music or play a calming game.

5. Stored Cloud data is shared with doctor/therapist

The data stored in the cloud can be accessed only by the patient and his authorized doctor/therapist who can review it himself periodically. Thus, this ensures protection of data privacy.

6. Alert sent to Doctor/Therapist for Review

Furthermore, a periodical email or SMS alert is sent as a reminder to the Doctor to review the patient's records and diagnose him appropriately.

3.3 Schematic Diagram

Figure 2 depicts the schematic diagram of the system.

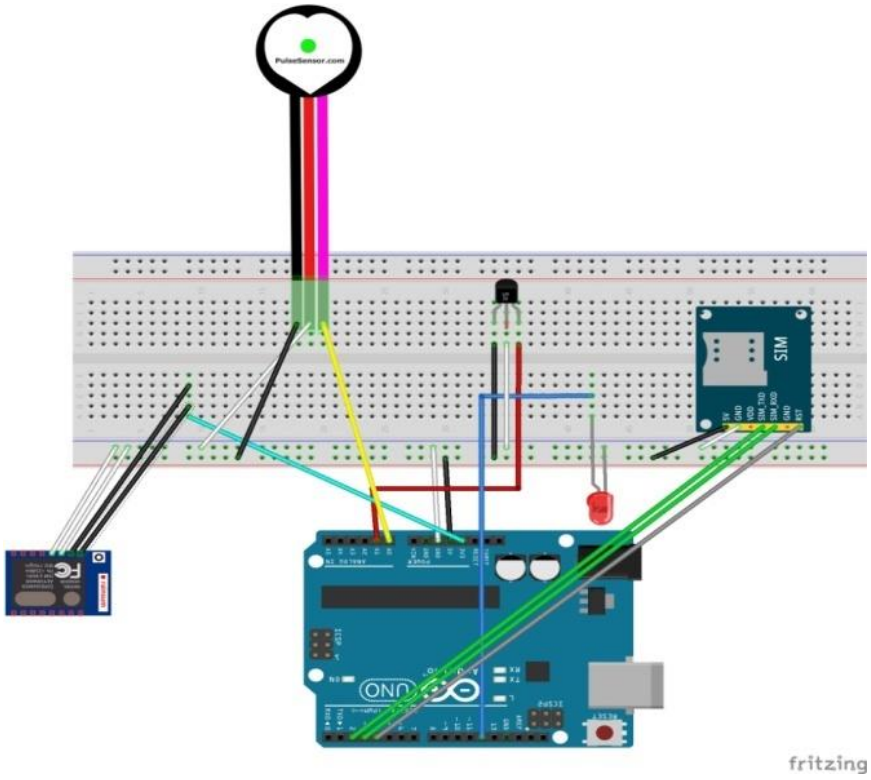

Figure 2: *Schematic Diagram*

3.4 System Hardware and Connections

Figure 3 depicts the system hardware and its respective connections in the system.

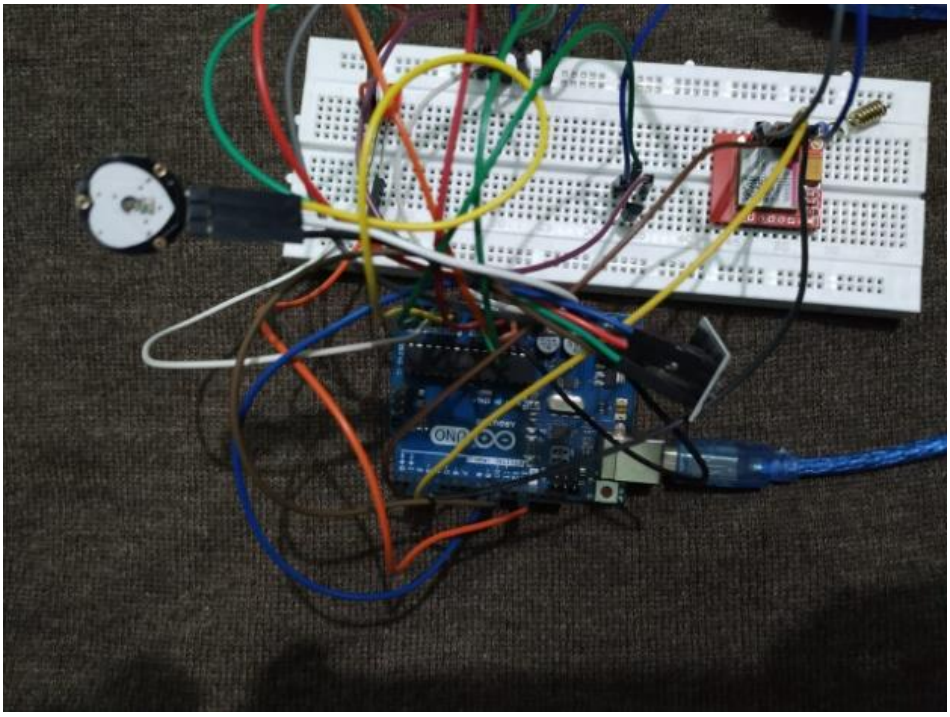

Figure 3: *System Hardware and Connections*

4 Experimental Results and Analysis

This section presents an extensive analysis of observations and the results obtained in the working of the system and its distinguished features.

4.1 Experimental Results

New TimeControl

Recurring TimeControls

Name	Recurrence	Last Ran	Run At
Stress monitor View Edit	Every 30 minutes	2020-12-10 6:19 pm	2020-12-10 6:49 pm

Figure 4: *Periodic Upload of Vitals Data on Cloud*

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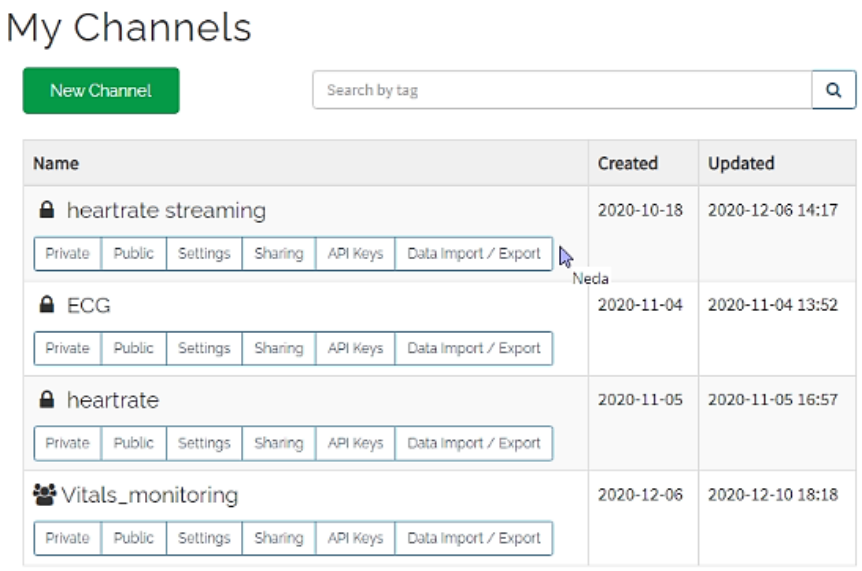

Figure 5: *Channels for different Vital Data Streaming*

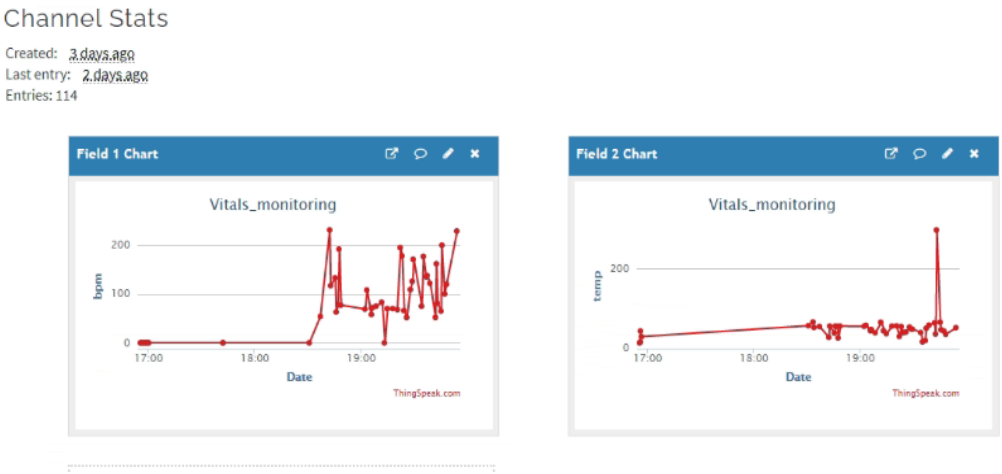

Figure 6: *Channel Statistics for different Vital Data Streaming*

a) Pulse Monitoring

b) Temperature Monitoring

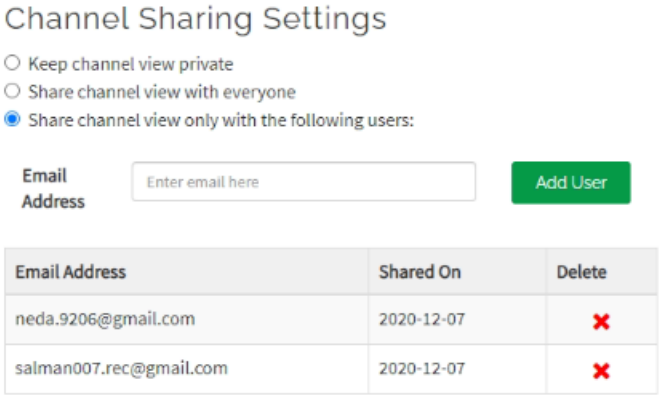

Figure 7: *Data Privacy Settings to limit*

4.2 Analysis of the System

1. Though the pulse sensor generates readings within milliseconds, but considering the overall implementation the pulse sensor and LM35 temperature sensor data are pushed on to the cloud within every 3-4 seconds.
2. The system works with accuracy and data generated are stored on the cloud appropriately.
3. Periodical SMS alerts were received on the registered phone number to test the functioning of sending SMS to doctor and the results were satisfactory as shown in the figures.
4. MATLAB analysis was performed on the uploaded cloud data and based on that the health status of concerned person was determined and mail alerts are sent as shown in the figures 8 and 9.

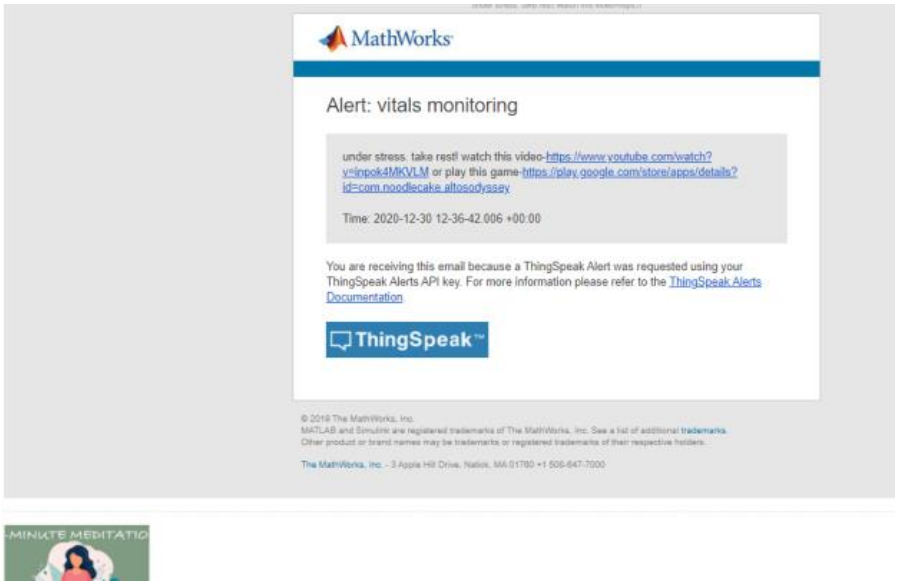

Figure 8(a): *Email Alerts*

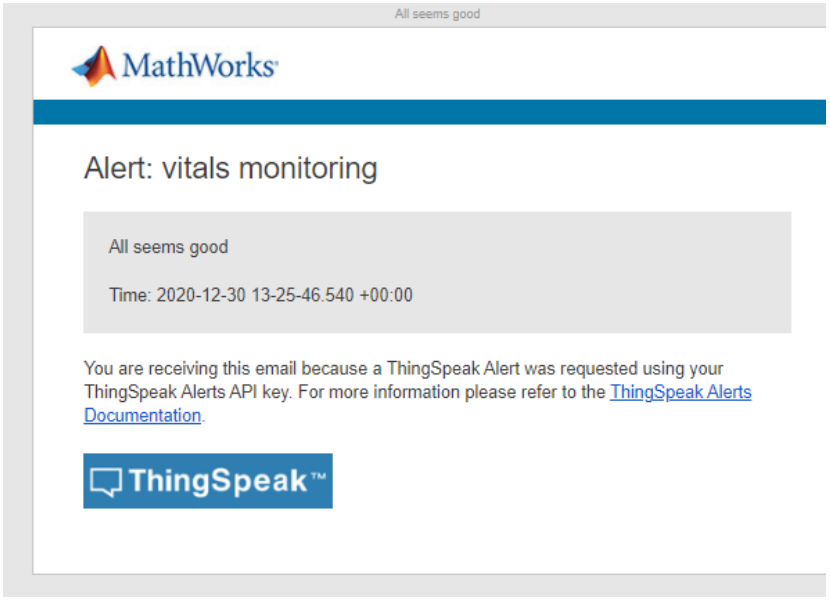

Figure 8(b): *Email Alerts*

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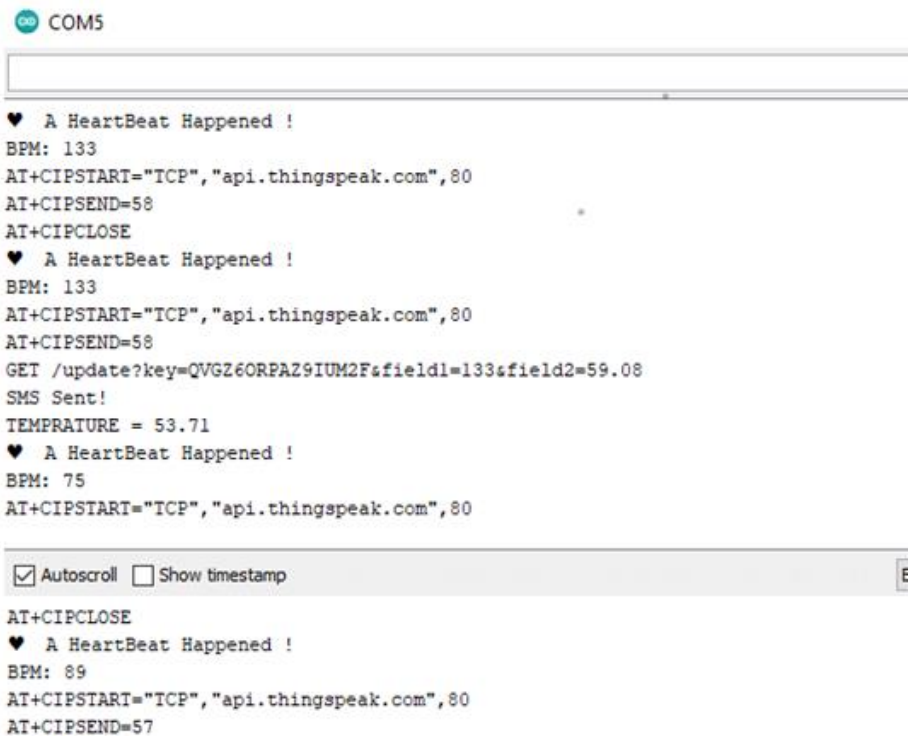

Figures 9: *System Output*

4.3 Distinguished Features of the System

1. A wireless system for monitoring patient can aid the doctor to remotely monitor the patient especially in the time of COVID pandemic thus upholding social distancing protocols.
2. The system implements efficient memory utilisation by using cloud storage instead of external memory devices.
3. Special emphasis has also been on Data security and Data privacy to prevent possible ostracism of mental health patients by the society as the data is securely accessed only by his therapist or doctor.
4. This system offers inexpensive alternative to Smart Watches and other expensive Heart Rate Monitors.
5. The system can be integrated in a band with Arduino Nano driving the functionality.

5 Conclusions

The implementation of above paper is a classic example of how technology can aid in improving our health and in our lives without replacing the human and intelligent aspect associated with it. Also, the data and further graphical representations obtained can help the doctor/therapist to prescribe a more technical and nuanced diagnosis as his 24 hour update can be reviewed before recommending medication. Furthermore, utmost caution has been taken to preserve the data privacy of the patient where the sharing of data can be controlled by the patient and limit its access. An efficient, viable and affordable implementation of the system presented can be in the form of a wrist band with the said sensors attached to give a continuous update of data especially with ever increasing stress in our daily lives. Furthermore, since only cloud memory is being utilized, there is no memory redundancy or wastage. A further implementation of this system can be to include more number

of sensors for improvement of data by including more vitals like the ECG with the help of ECG sensor. This would generate a much wider database and would further aid in honing the results and further diagnosis. However, there might be a possibility that its portability of the system could be limited in that case.
Finally, as the mental health cases rise in this fast pacing world, there could be collaboration between the fitness industry and hospitals and mental health institutions to come up with a joint venture to develop such devices on a large scale to be easily availed by all those affected.

6 Competing Interests

There are no potential conflicts of interest with regard to this research.

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