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Smart Wearable System for COVID-19 Patients.

Rekha G[1], Prof. D.R. Nagamani[2]

M.Tech Student, Department of Computer Science and Engineering, Bangalore Institute of Technology, Bangalore, Karnataka, India.

Assistant Professor, Department of Computer Science and Engineering, Bangalore Institute of Technology, Bangalore, Karnataka, India.

Abstract: During the COVID-19 pandemic, it is particularly challenging to monitor and treat people who are infected with the virus. The indications of COVID-19 are going to be measured with the help of this wearable monitoring device. To provide the effective approaches for helping the covid-19 patients by the proposed model, the model consists of sensors such as temperature, oxygen ($Sp0_2$), heart rate, GPS for location access, emergency switch provided and camera is attached to view only a covid patient wore it. The Raspberry pi is employed to collect the information from the sensors, the sensor data is displayed on the LCD screen, if the threshold is exceed the information is passed to the nearby hospitals with location of the patient. If the patient is in emergency situation, the switch is provided to inform to the doctors. Another feature is provided, camera is provided to detect the face of the patient using Viola jones which provides the information about the patient is wearing or not. The system is developed using the Python coding and imposed on the raspberry pi to obtain the input from patient. In real time patient's temperature location can be tracked. If the patient leaves the home the notification is sent to the concerned person.

Keywords: COVID-19, wearable sensor, real time tracking, face recognition, location tracking.

I. INTRODUCTION

The continuing coronavirus outbreak has caught the medical establishments of the globe by surprise. The bulk of the first efforts being made by the government are focused on restricting the spread of the coronavirus and identifying possible zones of infection. Healthcare workers are the most at risk for contracting coronavirus infections [1], since they cannot avoid coming into contact with patients who may be infected with the virus. Patients infected with COVID-19 are difficult to detect and manage, even with the most cutting-edge technology [2]. There are just a few of IoT-based temperature monitoring devices [3–5], and although they do exist, their major function is to scan patients rather than keep track of them. Aarogya Setu is a software programme that is utilised for the tracking and monitoring of patients [6]. The Aarogya Setu app is a contact tracking app that notifies you if you've had contact with a COVID19 positive patient while you're out and about [7]. The software leverages the GPS and Bluetooth capabilities of your smartphone to do this. However, this raises concerns about the confidentiality of the data. In order to get the data, the Aarogya Setu app requires the use of another device. It is not a gadget that can function on its own. Even now, there is no prompt device available that can be used to keep track of people infected with COVID19. The implementation of our suggested work would take place inside a single device and would not intrude upon the privacy of individuals. The fundamental purpose of this study is to make an effort to design an device that can track the position of COVID19 as well as its symptoms. Wearing a smart band on either your left or right wrist allows for the tracking and monitoring of the symptoms of a COVID-19 infection. The COVID-19 epidemic has spread around the globe in a manner that has had a significant influence on the current situation. The only feasible method to lessen the impact of it is to take preventative measures and put a stop to the disease's further spread. The best technique to limit and manage the illness is to monitor the Potentially Infected Patient (PIP) in quarantine by enforcing the designated location throughout the duration. This is the most effective method. It is only feasible with the assistance of technologies that are based on the embedded system, such as collecting, monitoring, managing, and analysing the symptoms of an illness in a way that is performed remotely [10]. Wearable technology is able to monitor and forecast the occurrence of COVID-19 by using sensor devices such as heart rate, temperature, oxygen saturation, and other respiratory systems [2]. This is because vaccines are slow to appear and are already in the process of being developed and distributed in the market. Wearable technology has been playing an increasingly important part in the diagnosis of the current covid-19 outbreak in the healthcare industry. The deep learning approach can filter through a massive quantity of data from sensor data in order to analyse it. The method of providing medical treatment has undergone a complete transformation as a result of the convergence of Internet of Things and deep learning technologies [8]. These technologies have allowed for the fundamental problems that have been plaguing medical care to be resolved in an efficient and dependable way [9].

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A. *Contributions*

- Individual and automatic reading of sensor values for health condition.
- Intimation to the doctor if any changes.
- GPS used for tracking the patient.
- Continuously monitoring patient location & health conditions.
- Pi Camera has been used to detected wheatear the same patient is wearing the band or not.

II. RELATED WORK

SARS-COV-2 is a highly contagious coronavirus, and medical and non-medical teams throughout the globe are working hard to find ways to prevent, reduce, and halt its spread [9]. The use of wearable technology has increased dramatically during the last two decades, notably in the medical field [10]. Together, advances in wearable sensor technology and medical-grade wearable devices provide a once-in-a-generation chance to shift from a retrospective, dogmatic perspective of prediction to a prospective, data-driven strategy for identifying the earliest stages of disease development. To begin, wearables are convenient and unobtrusive since they can keep tabs on users all the time with little effort on their end. In addition to offering a non-invasive examination of patients, they are simple to apply and effective even in inpatient or distant settings. Finally, wearables may provide a platform for real-time feedback to patients and clinicians by presenting objective measures of physiological indicators that may correspond with practical wireless network systems. In addition, wearables are paving the way for improved outcomes in the epidemic. To diagnose COVID-19, for instance, Reference [11] created a paper-based electrochemical biosensor that can detect targeted antibodies with a sensitivity of 100% and a specificity of 90%, respectively. There is potential for wearables to play a larger role in infection monitoring beyond their current use as an early warning system for the spread of COVID-19. The literature has presented wearable devices that not only record physiological parameters, but also centre on contact tracking for the purpose of disease prevention. Few validation studies have been conducted, which creates obstacles for healthcare workers regarding the clinical utility of wearables; false-positive results create risks, so more work and effort are needed for the correct interpretation of the data; patients are always concerned, to name a few. Despite the enormous potential of wearables in healthcare, there are a number of challenges that must be overcome. A wide variety of fitness trackers, smartwatches, and smart helmets equipped with sensor technologies to detect COVID-19 symptoms are now on the market. However, these devices only reflect a single or a small number of interconnected symptoms. Existing technology needs to fulfil additional requirements, such as cloud-based solutions for remote patient monitoring.

The COVID-19 virus may be detectable with the use of wearable sensors [16]. Heart rate, respiration rate, physical activity, body temperature, oxygen saturation, cough symptoms, and stress are just some of the metrics that may be measured with the use of a variety of sensors. Metrics in wearable devices for detecting and tracking the COVID-19 virus are reported in Table 1. Sensors upload physiology data to the cloud, where it is processed and analysed to forecast the spread of the COVID-19 virus [17]. The research shows that the Internet of Things (IoT) and Deep Learning can assist monitor and notify on people's health [18]. In the Internet of Things, data is gathered and processed according to predetermined thresholds by means of edge, fog, and cloud computing. Decision making, treatment assistance, and risk monitoring are all areas where deep learning has shown to be useful and trustworthy. Meeting the real-time demands may be aided by multimodal illness detection, monitoring, and therapy. In this study, we propose a lightweight, wearable monitoring device for tracking the health of covid-19 PIP [19]. In the event of an emergency or a breach of self-quarantine restrictions, this wearable technology is intended to remotely monitor the patient in a simple and efficient way [20]. Temperature, heart rate, oxygen saturation, and the number of times you cough may all be recorded by the wearable gadget and sent to a doctor to aid in a diagnosis. In addition, a cloud-based API system is implemented to store the information, which allows alerts to be sent and access to the patient's infraction data to be granted to the appropriate authorities [21]. This portable technology can pinpoint the precise GPS position of the patient, allowing emergency personnel to quickly arrive on the scene. It is possible to meet the need for optional isolation of possibly contaminated persons in a ubiquitous environment.

III. PROPOSED ALGORITHM

The embedded system has played an important role in making the remote health monitoring of the patient as simple, convenient and accessible for measuring and recording the parameters of the patients which helps in consulting the doctor. The components involved in the embedded system is that sensors, actuators, microcontrollers and the output device. The proposed embedded system based health monitoring system can measure physiological parameters and health symptoms of COVID-19 affected patient and able to transmit their real time data such as temperature, location, oxygen level, location of the patient and heartbeat. The system will be monitoring the level of these data and decides the level of the infection. Furthermore, the work also provides the geographical data of possible infected patient in quarantine or self-

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isolated place. The stored database system is used for alerting the medical authorities about the patient health symptoms and designated location. Basically, the proposed system consists of three layers as wearable device. The individual functioning and connected to each other for wireless monitoring of covid-19 infected patients. One of the significant facts of the proposed work is it can create great impact in alerting medical authorities from the geographical data of potential infected people to predict and analyze the situation.

The proposed architecture is as shown in the below figure,

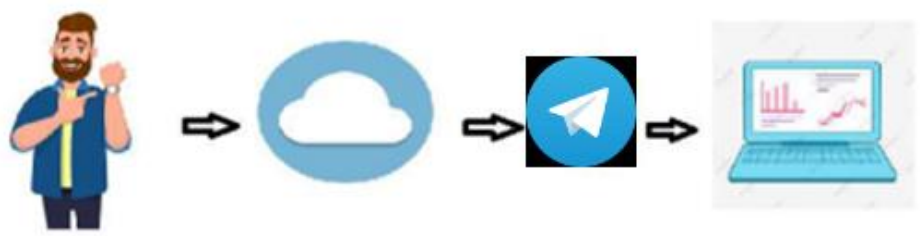

Figure 1: System architecture [13]

The block diagram of the propose model is as shown in the below figure, which consists of the microcontroller raspberry pi, temperature sensor (LM35), heartbeat sensor, oxygen level found through SPO_2, GPS to locate the location of the patients and the camera to verify that the covid-19 patient only wearing it through face recognition system using viola-jones algorithm.

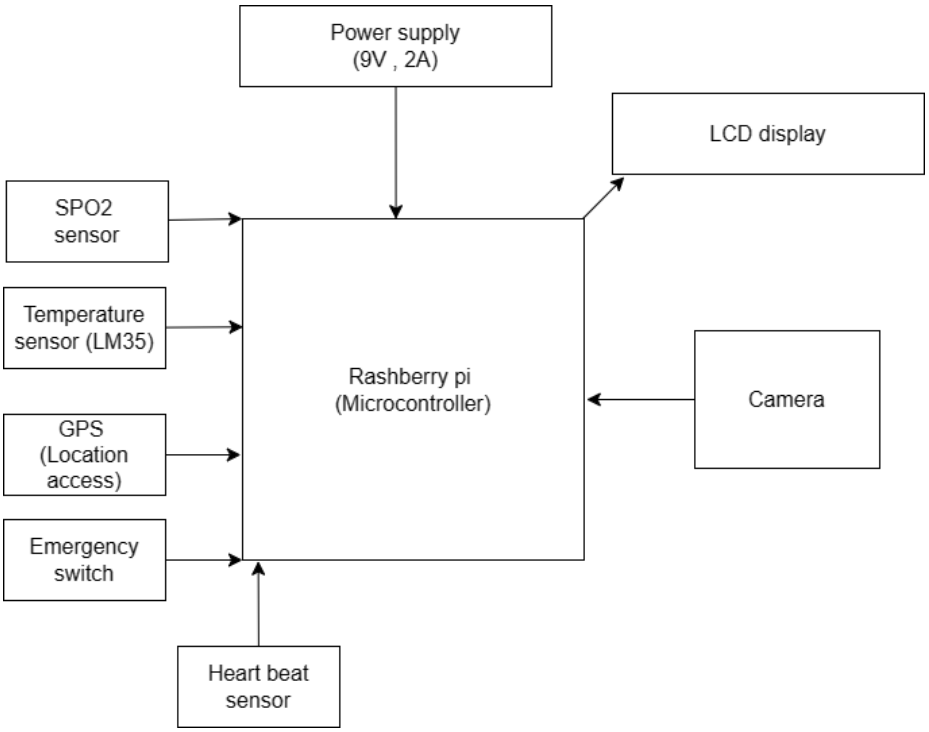

Figure 2: Proposed block diagram for the wearable health monitoring system.

The information on the components are provided in this section,

A. *Temperature Sensor (LM35):*

The LM35 is a precision analogue temperature sensor that has become a standard in many electrical systems due to its reliability and widespread usage. This sensor, made by Texas Instruments, is based on a tried-and-true linear temperature measuring technique. It is very user-friendly since no external calibration or signal conditioning is required. The LM35 can operate in temperatures ranging from -55 degrees Celsius to 150 degrees Celsius, making it applicable in a wide variety of settings.

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The LM35's remarkable accuracy is one of its main selling points, with a mean inaccuracy of just 0.5°C at ambient temperature. Because it has already been calibrated, users don't have to worry about performing any further calibration steps before integrating it into their own electrical designs. The sensor's low self-heating characteristic means it won't have much of an effect on temperature readings, and its low quiescent current makes it great for applications where power is at a premium, such those that rely on batteries. The LM35 provides a linearly-varying analogue voltage output in relation to the measured temperature. It is simple to transform temperature readings into electrical signals since the output voltage varies by just 10mV per degree Celsius. The sensor's adaptability is boosted by the fact that it may be purchased in a number of different packaging, including TO-92 and surface-mount varieties.

The LM35 is used in many different kinds of devices, from consumer electronics to industrial automation to automobiles to weather stations to medical equipment, all because of its ease of use, precision, and low cost. It is widely used in temperature-monitoring and regulation infrastructure. It is often used in applications that need for accurate temperature sensing because to its simple interface with microcontrollers and analogue-to-digital converters. As a result of its accuracy and reliability in temperature monitoring, the LM35 has found broad use in a wide variety of electronic systems.

B. ***Heart beat sensor:***

A heart rate sensor is a specialised piece of equipment used for continuous monitoring of a person's heart rate. Photoplethysmography (PPG) is only one example of a technology used to measure blood volume changes in the vessels and hence determine the heart rate. These sensors are widely used in fitness trackers, smartwatches, and medical gadgets to keep tabs on the user's heart rate as they exercise or undergo diagnostic testing. The information gleaned by monitoring heart rate may be used to keep tabs on how hard you're working out, quantify your stress, evaluate your cardiovascular fitness, and warn you of any irregularities.

C. ***GPS:***

Predicting where COVID-19 patients will be and when they'll move about is a lot easier with the use of GPS (Global Positioning System). Public health and medical officials may keep tabs on people who have tested positive for COVID-19 by following their whereabouts with the use of GPS technology included in cell phones, wearables, or monitoring wristbands. Information like this may be used to pinpoint problem areas and develop more effective strategies for keeping them under control. If a person tests positive for COVID-19, we may obtain their GPS data (with their permission and privacy measures in place) to get a full picture of their whereabouts over the last several days. The health department may then utilise this data to pinpoint areas, modes of public transit, and common areas where the sick person may have disseminated the illness. Public health professionals may use this data-driven method to better estimate the risk of transmission in different places and distribute resources accordingly. In addition, GPS monitoring may help with COVID-19 contact tracing by revealing those who have been in close quarters with patients. The epidemic may be contained more effectively if persons who may have been exposed to the virus are notified and tested as soon as possible. This technique may be used to supplement and speed up conventional techniques of contact tracing. However, it is crucial to strike a balance between the advantages of GPS monitoring and people's right to privacy and worries about data protection. The process has to be safeguarded by ensuring proper permission, openness, and compliance with data privacy standards. Anonymized and aggregated data may safeguard individuals' privacy without sacrificing their contribution to public health.

D. ***SPO2:***

Non-invasively detecting SpO2 (peripheral capillary oxygen saturation) using an oxygen sensor is useful in medicine. It monitors COVID-19 patients' health and provides vital data to medical personnel treating them. Patients should be monitored for hypoxia (low oxygen levels) and respiratory discomfort due to COVID-19, which may induce respiratory difficulties. Hospitals utilise pulse oximeters with SpO2 monitors to assess haemoglobin-bound oxygen. This measurement lets doctors rapidly and precisely evaluate a patient's respiratory state. Pulse oximeters and SpO2 sensors are considerably more important in-home care and remote monitoring during the COVID-19 pandemic. Portable pulse oximeters can monitor oxygen levels for mildly ill or isolated patients. They can identify substantial SpO2 drops early, signalling the need for medical intervention or hospitalisation. Telemedicine lets doctors watch patients remotely and get real-time SpO2 data to spot problems. SpO2 sensors give critical data for patient care and improve COVID-19 case management, but they cannot anticipate patient location. These sensors monitor respiratory health, improving patient outcomes and pandemic healthcare.

E. ***Emergency switch:***

In case of the breathing problem, unable to speak or woke up the patients is provided with the emergency switch, if the person is pressed it will alert the doctors with the location of the patient.

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F. *Camera:*

Facial recognition technology with a Raspberry Pi camera module can identify people in real time. The Raspberry Pi camera, a small, affordable camera module, can capture high-resolution photos and video for face recognition. The technology uses facial recognition algorithms and machine learning models to match faces with pre-registered names to identify people. The Raspberry Pi camera module captures photos or video. The facial recognition algorithm extracts unique facial traits and develops a facial signature for each recognised face. Associating recognised faces with names or identities may train the system. This training helps the system recognise patients. The algorithm employed for the face recognition is the haar features. It extracts the eyes, mouth and nose features. Based on these features the facial region is extracted from the image or a video from the camera. Once the facial regions are identified by the haar cascade classifier, the viola jones algorithm makes use of the Local binary pattern to predict the name of the patient. If the patient is in database the name is displayed or else the unknown will be popping to the authority. This helps in monitoring the patient, to mimic the authorities some patients may hang over the band to the other family members, due to this advancement the authority can predict the face of the patient. Due to the GPS tracker if the patient leaves the home the authorities receive the message saying the patient is moving outside the home and this helps the authority to control the spread of covid-19 or any other pandemic diseases in spreading the infection. The algorithm for the face is provided in the below,

The initial step is to identify the pixels of the faces and it is identified by the haar features and these features are fed to the haar cascade classifier to predict the facial regions. The algorithms of the haar features extraction is as follows, Haar cascade face detection requires Haar feature extraction. It detects objects, notably faces, using a collection of basic Haar-like properties. Haar-like filters are rectangular. These computationally efficient features detect edges, lines, and textures. Haar features are calculated by subtracting the filter's white and black rectangles' pixel intensities. These filters are moved over the picture in all conceivable locations and scales to extract features. Haar-like characteristics identify facial features like eyes, nose, mouth, and edges in face identification. Haar-like features might show the difference between the eyes and cheeks. These characteristics are used to generate a Haar cascade classifier, a sequence of cascading weak classifiers that assess whether the features are present in an area of the picture, during face identification. The Haar cascade classifier effectively narrows picture areas of interest, decreasing computing burden and accelerating face identification. It swiftly discards areas that don't match Haar-like traits and focuses on face-like regions. This cascade mechanism enables real-time face identification in surveillance, biometric, and computer vision applications.

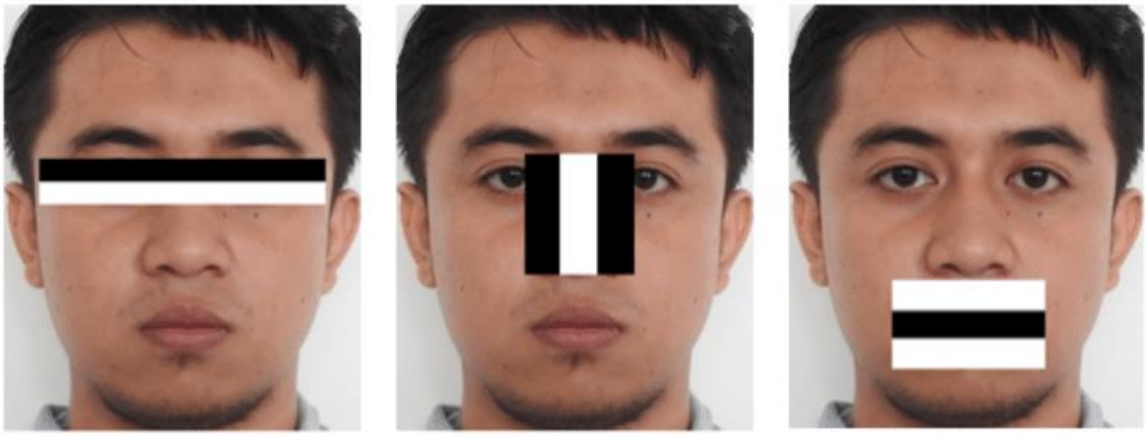

Figure 3: Haar features extraction [14].

The pseudo code for the viola jones algorithm to detect person is as follows,

Step 1: Obtain the original test image
Step 2: Image with the face indicators as rectangles using Haar cascade classifiers.
Step 3:
For i=1 to number of scales in pyramid of images
Do
    Down sample image to create image
    Compute integral image,
    For j=1 to number of shift steps of sub-window do
        For k=1 to num of stages in cascade classifier do
            For l=1 to number of filters to stage k do
                Filter detection sub-window

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```
                    Accumulate filter output
                End for
                If accumulation fails per stage threshold, then
                    Reject sub window as face
                    Break this k for loop
                End if
            End for
            If sub window passed all per stage checks then
                Accept this sub-window as a face
            End if
    End for
End for
```

E. ***Telegram bots:***

The bots in the telegram are controlled by using the HTTP requests from the python coding, it is same as opening the website address such as google maps search, search sentences. The collected reading is pushed to the telegram group through http request. For example, @Covid Band (information). As a bot developer, one can interact with Telegram's intermediate server using a straightforward HTTPS-interface and Bot Application Programming Interface (API). This interface offers a streamlined version of the Telegram API called the Bot API, which may be used to communicate with your bot, modify its configuration, and carry out other similar operations.

IV. PROTOTYPE OF THE MODEL

The model with all the sensors such as temperature, heartbeat, oxygen level, GPS, Pi Camera interfaced to the microcontroller is as shown in the below figure,

Figure 4: Prototype of the model.

The initialization of the device when the patient wearing the covid band, it displays the covid band on the lcd to make the patient understand that the model is ready to provide signals to the authority and convey the same to the patient.

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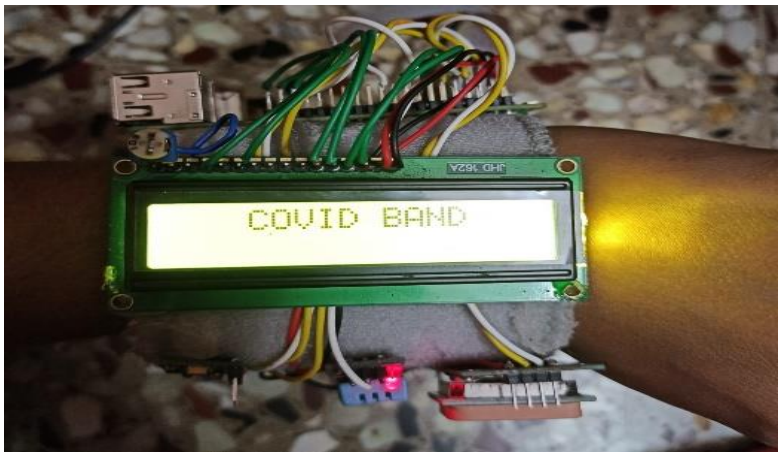
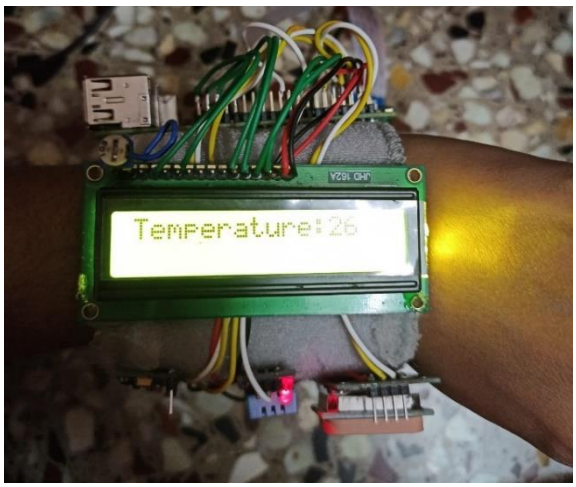
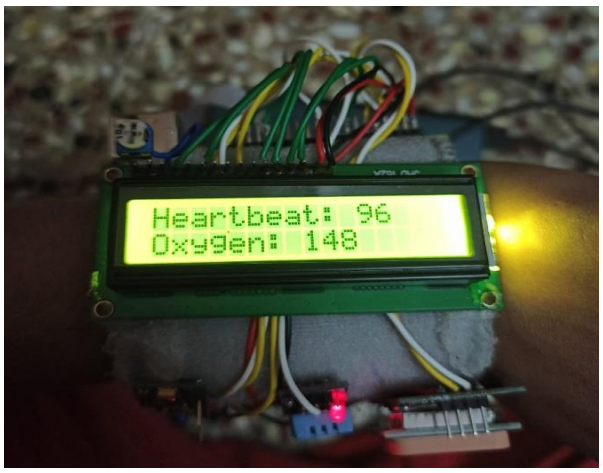


Figure 5: Model initialization.

Once the device is ready it captures the temperature, analyse the heart beat and the level of the oxygen present in the blood is analysed using the SpO2 all these reading are tracked in real time.



a)



b)

Figure 6: Reading fetched real time from the patient.

When the patient is in emergency conditions, they are allowed to press the switch when the patient uses the emergency switch it is notified to the authority along with location. The location and the output window are showed in the simulation results.

Figure 7: Emergency switch notification.

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V. SIMULATION RESULTS

The monitoring the patient can be made twenty-four hours, which provides the information of the patient temperature, heart pulse, oxyen level.Gps location, emergency calls from the patient.

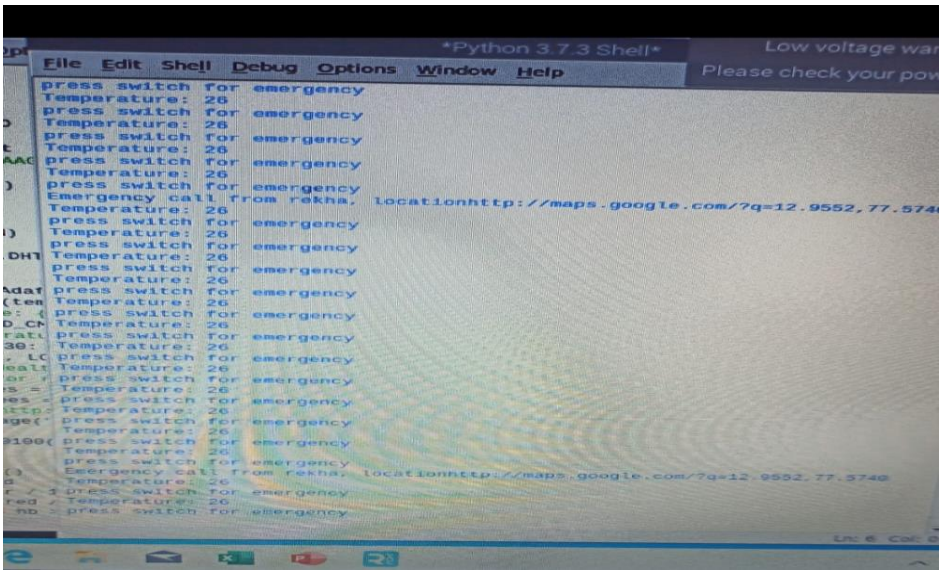

Figure 8: Live Monitoring the patient's health 24*7.

The notification is sent to the authority through Telegram bot application, when the temperature, oxygen and heartbeat of the patient increases or decrease from the threshold and the same is as shown in the below figure,

Figure 9: During unhealthy conditions.

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By chance the patient moves away from the home or a quarantine location the authority is informed and it is trackable in real time.

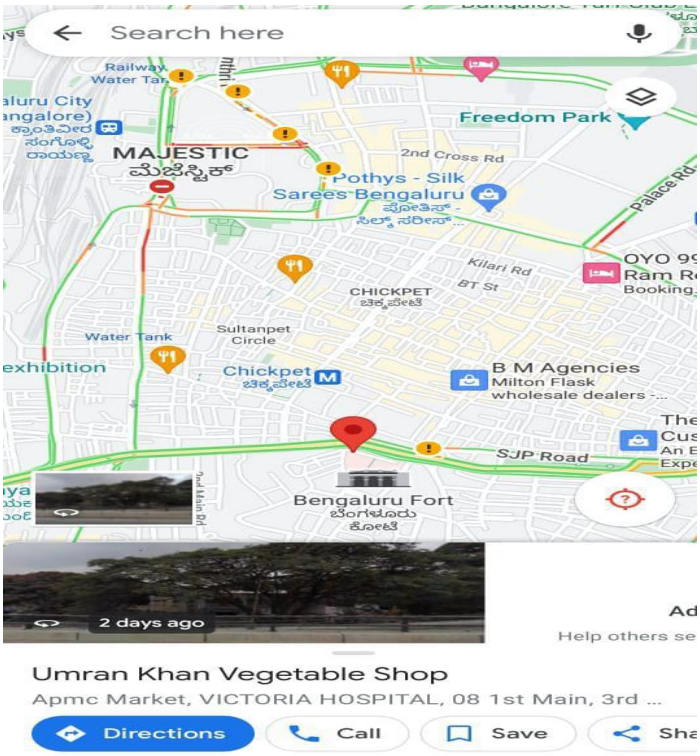

Figure 10: Live location trackable.

When the patient tries to bypass this module by providing another healthy patient's health reading, & also to know whether the same patient is wearing the band or not, by using pi camera the face of the person who is wearing the band can be identified.

If the face of the patients does not match with the database, immediately alert message will be sent to the medical staff along with the unknown person image & also same being displayed on the band.

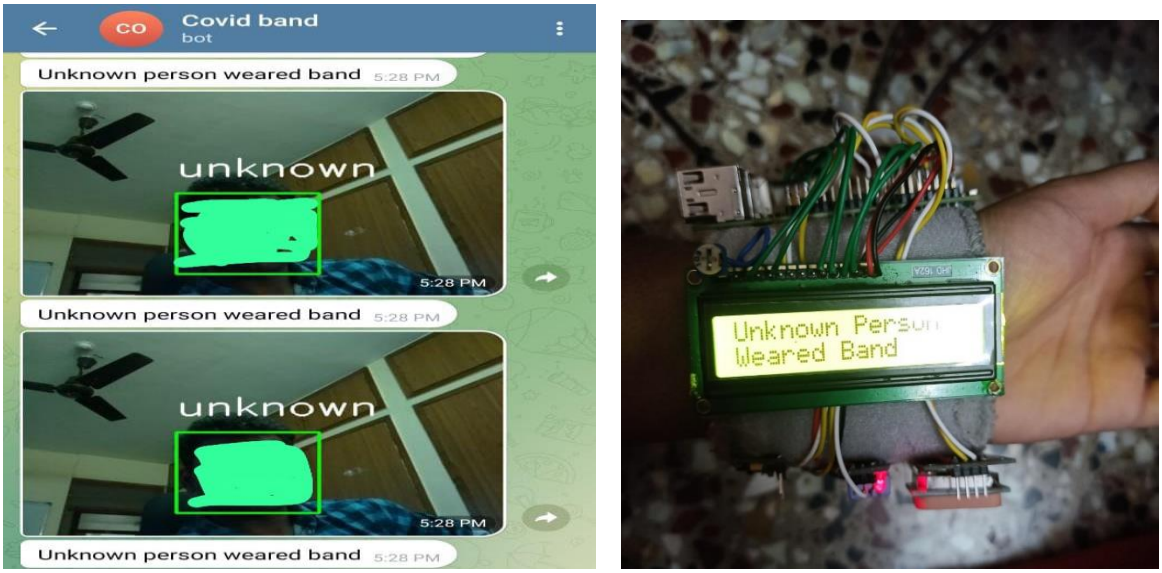

Figure 11: Unknown person detection along with image of the person.

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VI. CONCLUSION AND FUTURE WORK

The worldwide health crisis caused by the COVID-19 outbreak is killing thousands of people every day. According to a WHO report [15], COVID-19 has been responsible for over 2 million fatalities and over 10 million verified cases over the globe. The epidemic affected both wealthy and poor nations equally. The spread of COVID-19 has prompted worries about the virus's potential social and economic effects, as well as its potential effect on world health. The mortality rate may be lowered if appropriate treatment is administered promptly. The patient's heart rate, oxygen saturation, and body temperature are all being monitored on a frequent basis to make sure the treatment is working. Wearable technology will be utilized to remotely check the health indicators of possibly infected individuals for Covid-19 throughout the quarantine period. A wearable body sensor, a cloud layer, and a frontend layer make up the architecture of an automated health care system that aims to alleviate stress and facilitate communication between physicians, medical authorities, and family members. The wearable sensor layer monitors vitals such as temperature, heart rate, oxygen saturation, and the number of times a person has coughed. In addition, medical staff receives real-time updates on the patient's GPS position & also through pi camera which is being fixed in band can help to know whether the same patient is wearing band or not and notifying the hospital staff, & loved ones helps ease tension. The little wearable gadget is convenient for a potentially infected patient to take about, it reduces the cost of the treatment and it enhances quality of life by reducing the transmission of COVID-19. The health monitoring capabilities of the wearable gadget are reliable.

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