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Wearo Proximity Tracer

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Abstract: The COVID-19 pandemic has upraised office and work life, becoming a powerful incentive bringing a change at workplace. Many questions have been raised regarding the sustainability of this new way of working, particularly in terms of workplace productivity due to the sudden and extreme shift in the lives of people. The role and purpose of physical offices in the future is the most fundamental query raised. Newly required policies outlined by government and healthcare agencies around the world must be implemented by the companies in order to return the employees back to work safely. This project aims at developing a wearable design that can be used by the employees at offices for monitoring their oxygen saturation, temperature detection, attendance recording and for self-purchasing at cafeteria. Employees working at offices thereby can return back to their normal working schedule ensuring proper safety measures, thus reducing the global burden caused as a result of the pandemic.
Keywords: Covid-19, proximity detection, contact tracing, privacy

I. INTRODUCTION

A pandemic is a global epidemic that affects a large percent of population. Today, the whole world has come to a standstill due to a pandemic – The COVID-19. Coronaviruses are a group of RNA related viruses belonging to a family called Coronaviridae. Virus strains known as SARS-CoV2 (severe acute respiratory syndrome); MERS (Middle East Respiratory Syndrome) are examples of coronavirus. Experts have found out that the SARS-CoV2 originated in bats. However, in December 2019, the outbreak to a novel strain of coronavirus was traced in humans from Wuhan China's open air wet markets where customers bought fresh meat and fish. The virus can spread through the liquid particles from an infected person's mouth or nose when they cough, sneeze, breath heavily or speak. It can also be transmitted when a person touches the contaminated surface and then touch their nose, eyes or mouth without cleaning the hands. Following some simple precautions like maintaining social distancing, cleaning hands, wearing a mask, disinfecting the surfaces, keeping the rooms well ventilated etc. can help prevent the spread of COVID-19. The pandemic has led to a dramatic loss of human lives across the globe. It has presented humans with an unprecedented challenge to public health, the food systems and the world of work. Many countries have imposed lockdown due to increasing number of COVID cases. New normal has become the way of life. Adapting to the new normal is the only way to get through these tough times. The pandemics can be controlled with the development of a vaccine. A global race is run in search of a cure and some of them have turned out to be successful. Although trials of possible vaccines are underway, it would take long time before vaccines are permitted for public use in a completely efficient manner.

In the present scenario, the role and purpose of physical offices in the future has become a major question to everyone. In order to return employees back to work safely, companies must implement the newly required policies outlined by government and healthcare industries round the world. Early detection and clinical management of COVID-19 infection is the best way for increasing the recovery rate of coronavirus patients. The process by which onward transmission can be reduced by recognizing, assessing and managing the people who have been exposed to a disease is called contact tracing. The challenge associated with contact tracing is that it relies upon human memory which can be inefficient sometimes. Digital technologies have a potential to provide a better approach due to their ability to balance both privacy and accuracy of information. They can address the limitations of traditional contact tracing. It makes use of the electronic information to efficiently detect people who have been in close contact with the infected individuals, so they can be promptly and properly advised on the next steps to follow. Many countries have come up with various technologies to provide information to the authorities to alert users when a confirmed positive case has come into contact. A wearable technology can potentially assist in many regards by providing real time remote monitoring offices where most of the people gather, thus reducing the spread of virus and controlling it to an extent. It has the ability to ensure data security, confidentiality of client information, facilitate identification of clients with COVID-19 through manual or self-reporting processes, ability to send notification to users through automated means. The project deals with an innovative wearable design which implements proximity tracing, oxygen level detection, temperature sensing, attendance recording and a cafeteria concept for self-purchasing mechanism. The Wearo-Proximity Tracer aims at providing in-app notifications through web server to the people through a wearable device.

II. METHODOLOGY

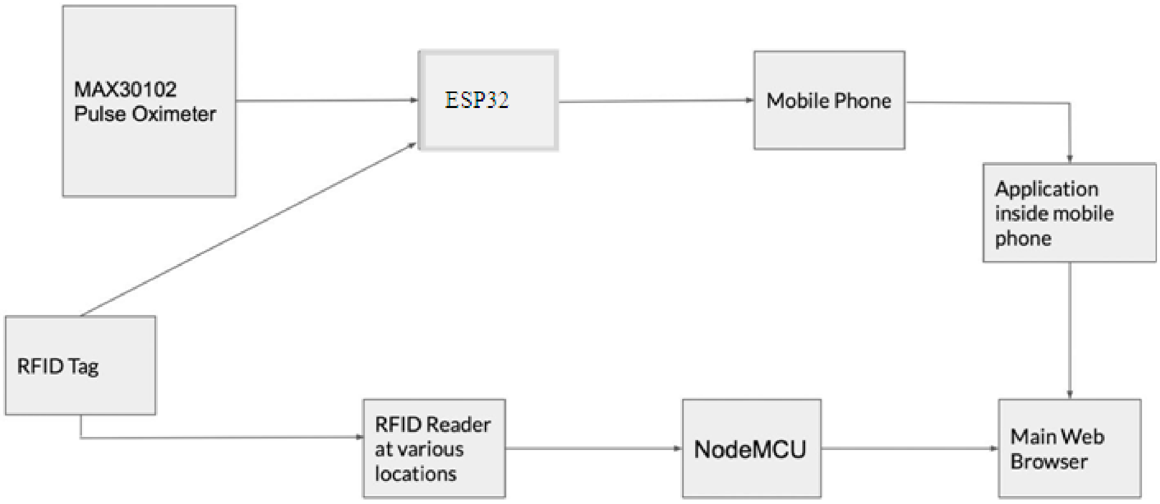

Figure 1: *Block* diagram *showing the working of Wearable Module*

2.1 Hardware used:

- MAX30102 Pulse Oximeter
- Node MCU
- RFID Reader
- RFID Tag
- Raspberry Pi4
- Raspberry Pi Camera
- ESP32

The MAX30102 Pulse Oximeter shown in Fig2 is an integrated biosensor module which consist of photo detectors, internal LEDs and optical elements. It helps in the design-in process for the mobile and wearable devices.

Figure2: *MAX30102*

Node MCU shown in Fig3 is an open-source Lua based firmware and development board which is specially targeted for the applications in IOT. It has a firmware which runs on the ESP8266 Wi-Fi and hardware is based on the ESP-12 module. It operates at 80 MHz - 160 MHz with adjustable clock frequency.

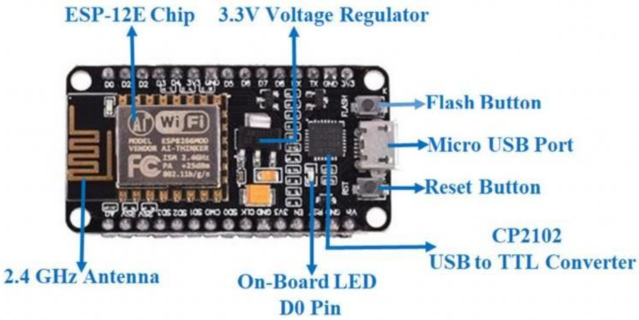

Figure3: *Node MCU*

The RFID reader shown in Fig4 gets captured by a device which stores the collected data in a database. This technology automatically identifies objects and collects information about them. The collected data is entered directly to computer systems without human intervention using radio waves.

Figure 4: *RFID Reader*

RFID Tag shown in Fig5 is built using an antenna and an integrated circuit. It is shielded by protective material which holds all the pieces as together. This protective material also shields the RFID tag from the various environmental conditions. The material of the protected layer depends upon the application used. RFID tags are made in different shapes and sizes and they can either be passive or active.

Figure 5: *RFID Tag*

Raspberry Pi 4 model B shown in Fig6 is the most powerful and feature rich raspberry Pi that is released till date. It shows a drastic improvement from the older versions by offering a ground-breaking increase in processor speed, multimedia performance, memory, and connectivity when compared to the previous-generation Raspberry Pi. It can decode hardware video up to 4K and can store about 4GB of RAM of data with a support of dual-band 2.4/5.0 GHz wireless LAN. The Raspberry Pi 4 offers desktop-class performance providing faster transfer speed rates with more memory options including dual-monitor support and 4K media decoding.

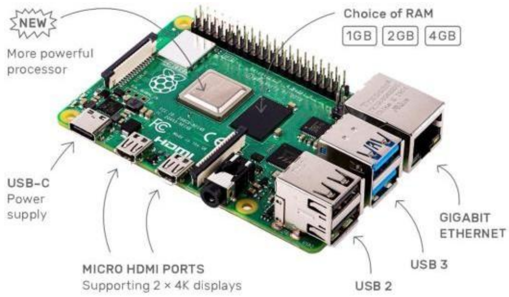

Figure 6: *Raspberry Pi 4*

Raspberry Pi Camera shown in Fig7 is a high-definition camera module that provides high sensitivity, low crosstalk and low noise image capture in a small and lightweight design. It is compatible with all the previous raspberry module designs. The camera consists of a small circuit board with a dimension of 25mm by 20mm by 9mm that connects to the Raspberry Pi's Camera Serial Interface (CSI) bus through a flexible ribbon cable. The camera's image sensor has got resolution of five megapixels and has focus lens that are fixed.

Figure 7: *Raspberry Pi Camera*

ESP32 shown in Fig8 is highly-integrated with in-built antenna switches, power amplifier, low-noise receive amplifier, filters, and power management modules. ESP32 can interface with other systems to provide Wi-Fi and Bluetooth functionality through its SPI / SDIO or I2C / UART interfaces.

Figure 8: *ESP32*

2.2 Software used:

Flask is a web application framework which is written in Python. It represents a group of libraries and modules that enable web application developers to write down applications without worrying about low-level details like protocol, thread management, and so on.

The working of flask includes several steps. Initially create an internet app with flask and connect it to HTML. When any user sends information on internet or goes to the search bar anytime, the HTML connects the user. In a folder called templates, the flask framework looks for HTML files. Python codes are executed which injects variables, code etc. before sending the template over. The Flask framework, also known as micro framework is lightweight and can also be used to create social networks, blogging platforms, hacker’s news clones, normal content sites, and many more. Finally, it can be said that with flask and its features, almost everything can be done for a developer.

2.3 Working:

The block diagram shown in fig1 consists of 2 main parts:

- Wearable module part
- Proximity sensing part.

2.3.1 Temperature, Oxygen Detection:

Wearable module consists of MAX30102 pulse oximeter which is used for obtaining the temperature and oxygen level of the person. It consists of 4 pins which are the VCC, GND, SCL and SDA pins. The pulse oximeter module is connected to ESP32 module through I2C communication. In I2C communication the SDA line or serial data line is used to send and receive data between the master and slave. The SCL line or serial clock is used to carry the clock signal.

Here, following steps take place:

- The master switches the SDA line from high to low voltage thereby sending a start connection to every connected slave before switching SCL line from high to low.
- A 7- or 10-bit address is sent by the master to each slave it wants to communicate along with read or write bit and the slave compares this address to its own address.
- The slave sends back an acknowledgement bit by pulling the SDA line low if this address matches otherwise the slave keeps the SDA line high.
- A data frame is then sent or received by the master. After the transmission the receiving device sends an acknowledgement bit back to the master indicating successful receipt of the frame.
- Finally, the data transmission is stopped when the master sends a stop condition to the slave by switching the SCL line from low to high before switching SDA line high.

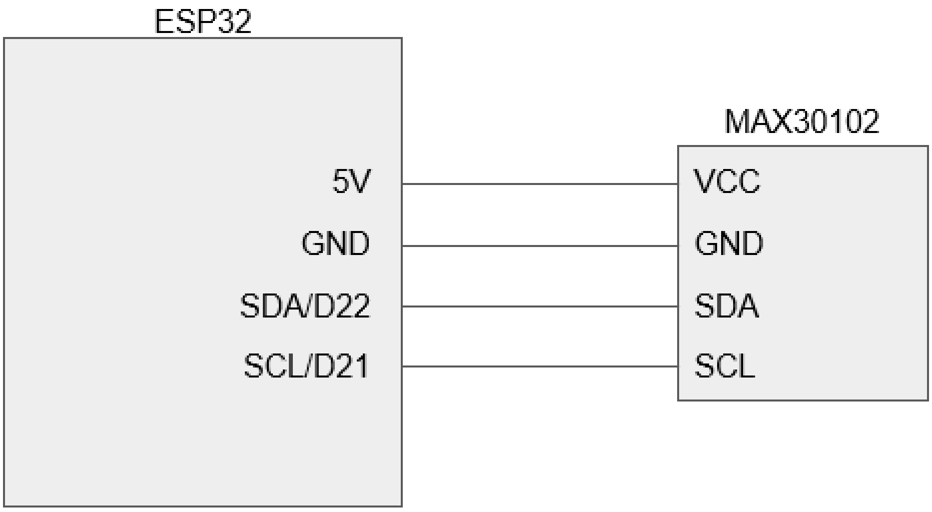

Figure 9: *Interconnection between ESP32 and MAX30102*

The wearable module design is actually a wrist compatible design where the sensor part will be in contact with the person’s wrist. Here the wearable module is continuously recording the temperature and oxygen level, and gives this information to the ESP32 module. The ESP32 module is paired with the mobile phone of respective individual person wearing the module and the information obtained from the pulse oximeter is send to the application inside the mobile phones .The application is programmed in such a way that a time interval and minimum threshold value is set to it, and the corresponding values obtained are send to a server from where the manager can view the information and get alerts in cases of low temperature or oxygen levels of a particular employee. So, in that case the manager can ask the employee to get a COVID check-up or go in quarantine.

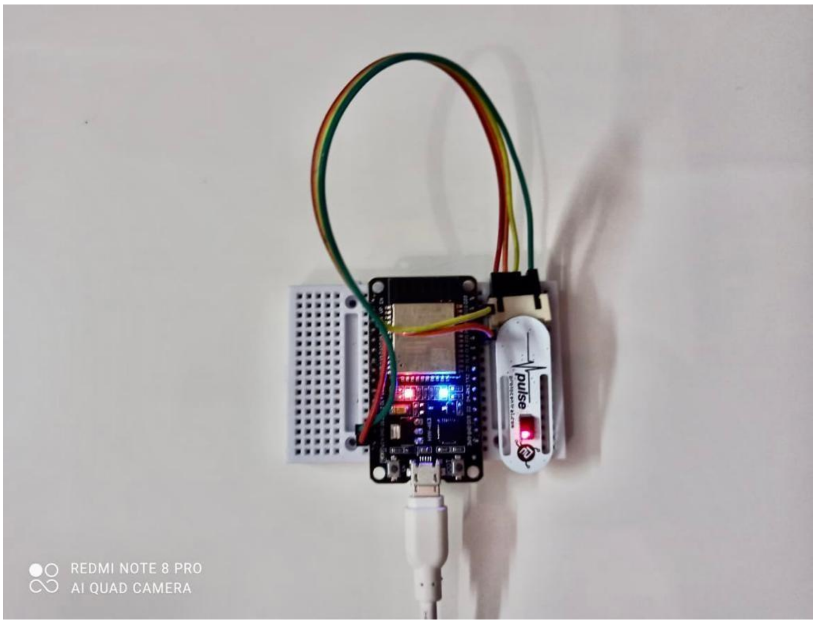

Figure 10: *Temperature, oxygen detection hardware module*

Our heart continuously pumps blood and thus oxygen enters inside our body through the lungs. In our body we have two different types of blood one mixed with oxygen and other which is not mixed with blood. The oxygenated blood has larger volume and the deoxygenated blood has lesser volume. So, when the heart pumps blood, there is an increase in oxygenated blood and when the heart relaxes the volume of oxygenated blood decreases. The amount of partial pressure of oxygen dissolved in arterial blood is called as Pa02.The percentage saturation of oxygen bounded to hemoglobin in arterial blood is known as Sa02.When it is measured by MAX30102 the sao2 is termed as Sp02 that is Sp02 is the percentage of oxygen in the blood. In MAX30102 the oxygen level is detected in terms of Sp02 values.

The MAX30102 has two LED's i.e., red LED and infrared LED also it has a photodetector. Red LED operates in the wavelength of 650 nm and the infrared LED works at 950 nm. The photodetector helps to measure the intensity of the transmitted light at each wavelength of operation. The oxygen containing blood is detected on the basis of the differential absorption characteristics of oxygenated and deoxygenated hemoglobin. According to Beer-Lambert's law, the absorbance is directly proportional to concentration and distance.

The oxygenated hemoglobin absorbs more IR light and it allows more red light to pass through whereas the deoxygenated hemoglobin absorbs more red light and allows more IR light to pass through. Then the oxygen content in blood is calculated by comparing how much amount of red light is absorbed as compared to IR light. Depending on the amount of oxygenated and deoxygenated hemoglobin the ratio of red light absorbed versus IR light absorbed changes. The MAX30102 isolates the pulsatile component of the signal as the blood moves into the tissues with each cardiac contraction there may be a tiny but measurable increase in the distance between the LED and photodiode. The ratio of the pulsatile component of absorbance to the non-pulsatile component of absorbance is defined as R value. This R value is then used to find the Sp02 value using the equation given below:

$$Sp02 = -45.06*R+30.354*R+94.8$$

If the R value is 0.4 then Sp02 is 100%, if R value is I then the corresponding Sp02 is 85%. The normal Sp02 level in blood is typically between 95 to 100%. The temperature is detected directly from the MAX30102. The normal temperature level of human beings is 37 degrees Celsius.

2.3.2 Attendance Recording:

Apart from this, an RFID tag is also placed inside the wearable module and RFID readers are placed at various locations inside the office. The RFID reader used here is the EM18 reader which has RFID reader connected to a Node MCU module and a 5V power supply is given to the Node MCU. This works according to Serial Peripheral Interface protocol which is a synchronous serial communication interface which is used for short distance communication. A Master Slave relationship is used here where the Master is the controlling device and Slave takes instruction from the Master.

It has 4 terminals, these are:
1. MOSI or the Master Output Slave Input terminal which the line used by the master to send data to the slave.
2. MISO or the Master Input Slave Output terminal which is the line used by slave to send data to master.
3. SCLK or the Serial Clock terminal which is the line used for clock signal.
4. SS/CS or the Serial Select/Chip Select which is the line used by master to select the slave for sending the data.

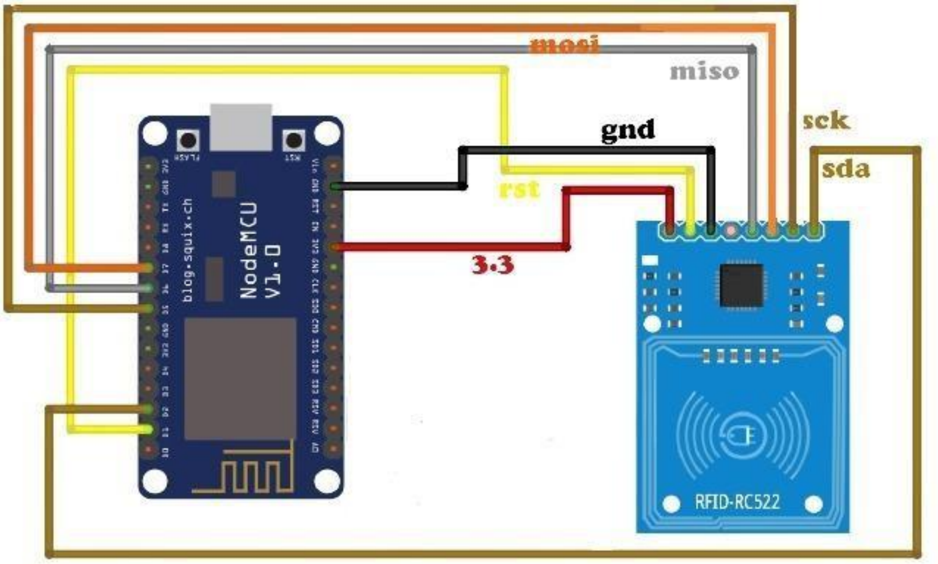

Figure 11: Inter*connection Diagram of RFID Reader and NodeMCU*

How the transmission take place is explained as below:
1. Master sends a clock signal to slave.
2. Master then switches the SS/CS pin to a low voltage state which activates the slave.
3. Master then sends the data one bit at a time to the slave along MOSI line.
4. Finally, the slave returns the response data one bit at a time to the master along the MISO line.

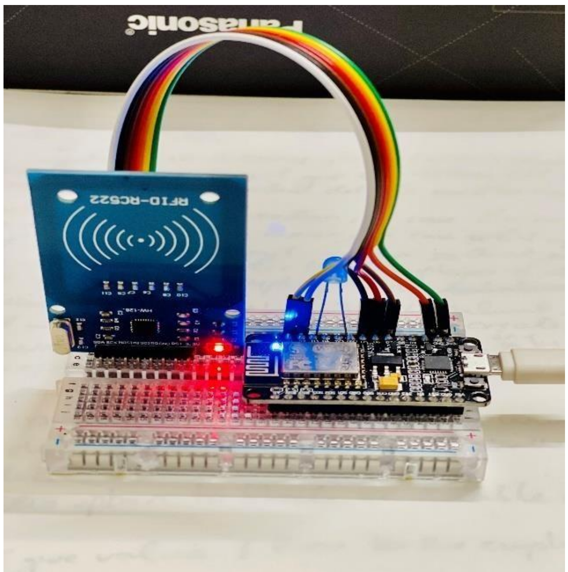

Figure 12: *RFID Reader at different locations*

So that's how the information is sent through SPI communication. When the employee scans their RFID tag in wearable module to the RFID reader, their name and id will be taken by the reader and this information is then send to the web server through the Node MCU module. This way the information from all RFID readers will be sent to the web server and then the manager through his/her admin login can view the locations visited by each employee inside the office on any particular date. Thus, if a particular employee gets infected by COVID 19 then his or her possible chances of contact at different locations can be understood.

2.3.3 Proximity Tracing

Through proximity tracing, the presence of another person within a range of 2 meter can be detected by enabling Bluetooth connectivity. Here the name and ID of the employee will be shown in mobile application and from there the collected information will be send to main web server. Bluetooth have so many advantages such as small size, low cost, lightweight, power saving and it is commonly supported by the smart devices. Therefore, the BLE protocol has become the dominant wireless proximity technology so far. In the BLE protocol it has 40 channels each one having 2 MHz frequency at 2.4 GHz ISM band which are used for the transmission of the messages. The period for the transmission of these messages is so small in order to save battery power. Among the 40 channels, there are three channels which are used for the broadcasting of the advertisement messages. The Received Signal Strength Indicator (RSSI) from the three channels is used for estimating the proximity of the target. The BLE rate of advertising is up to 50 Hz. The transmission power for the BLE beacon is from 0 dB m to −75 dB m. In order to reduce the power consumption rate, the BLE advertising rate and the transmission power are normally less than 10 Hz and −16 dB m respectively. Here dB m denotes decibel milliwatts (dB m) with which RSSI is measured, if the RSSI number is higher, then signal is stronger. The equation shows the relationship between the RSSI measurement and the distance. In the formula the n denotes the propagation constant or path-loss exponent and d denotes the distance) and A is the received signal strength (dB m) at one meter distance apart.

$$\text{RSSI (dB m)} = -10n \log 10(d) + A$$

The Bluetooth app needs to factor the variation in order to have the most appropriate distance between them. Bluetooth devices did not capture the absolute or exact locations of the individuals instead it records and collects if there are any Bluetooth devices with in the radio frequency range. Bluetooth provides more protection against privacy of location.

2.3.4 Cafeteria concept

RFID readers are placed at various locations inside the building. At the cafeteria the RFID reader is used along with Raspberry Pi four instead of Node MCU that is there will be no shop assistant at the cafeteria instead the employees have to take the items they want to purchase and just scan them in front of a RPI camera connected to raspberry pi 4 module. The employee's will also scan their RFID tag to the RFID reader and this data is also sent to the raspberry pi 4 module. From there the whole information is sent to a web or cloud server as mentioned employees before. Finally, at the end of the month they will be able to view the items they have purchased and also the corresponding amount will be displayed. This amount will be deducted from their salary automatically.

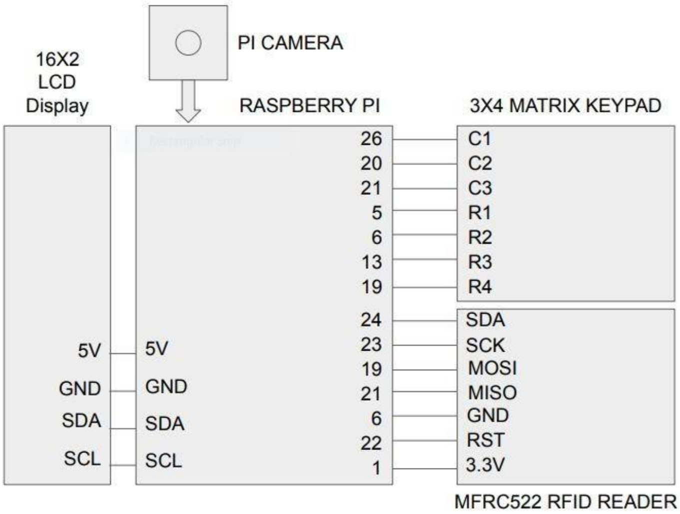

Figure 13: *connection diagram of cafeteria concept*

Cafeteria concept begins with scanning of RFID tag in front of an RFID reader. The RFID reader searches for the employee details in the database when the employee scans their RFID tag. A hash (#) key is used for entering the pin. Each employee has a unique pin which is given to them by the manager.

After scanning the RFID tag, the employee can press the hash key and then enter their pin. This will turn ON the Raspberry Pi camera and the employee can scan the barcode of the product. The details of barcode are already stored in the database. So, when an employee scans the barcode of a particular object, camera can identify the object. It takes the price of that particular product and displays it on the digital monitor. In case more than one product is taken at a time, then the total number of items taken will also be displayed along with the total amount. This information is sent to server through Raspberry Pi Wi-Fi.

In case, an employee enters incorrect pin by mistake, no transaction will take place. The display will show to scan the RFID tag again. Similarly, if an employee wants to cancel a transaction, there is an asterisk (*) key. By pressing on that button, no transaction happens and it will return the process back to its initial stage i.e., scan RFID tag.

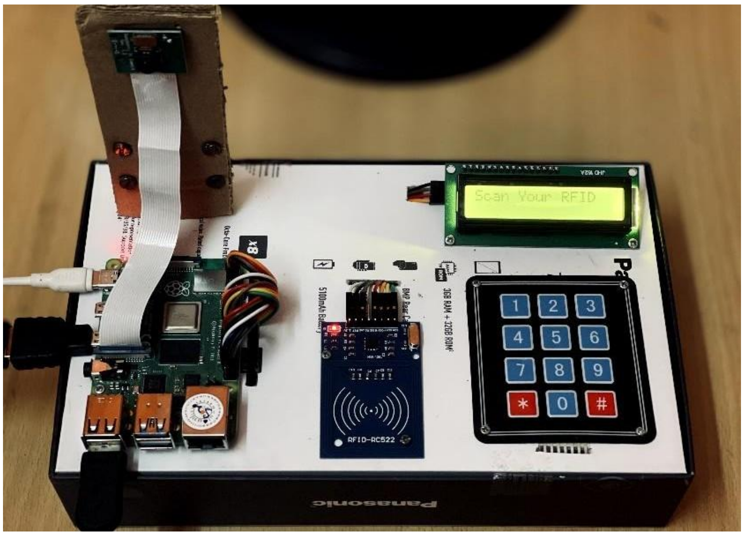

Figure 14: *Hardware of wearable module*

III. PERFORMANCE EVALUATION

The employees can now login to their account created inside the sever where the following information's can be viewed.

Figure 15: *Home page*

As the employee browse into the attendance recording webpage, three dropdown options will appear. In case the selected option is specified null along with start and end date, the corresponding attendance at that timestamp will be displayed. Also, for viewing the attendance at a particular location the select option must be chosen as required (for example select option: conference hall).

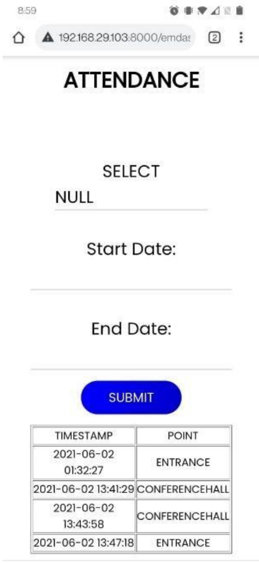

Figure 16: *Attendance recording*

As the employee goes to the sensor reading webpage, he/she can view their temperature and Spo2 readings. In case an employee wants to know his/her sensor readings during a particular time interval, there is an option where they can specify the start and end date and the corresponding values can be obtained.

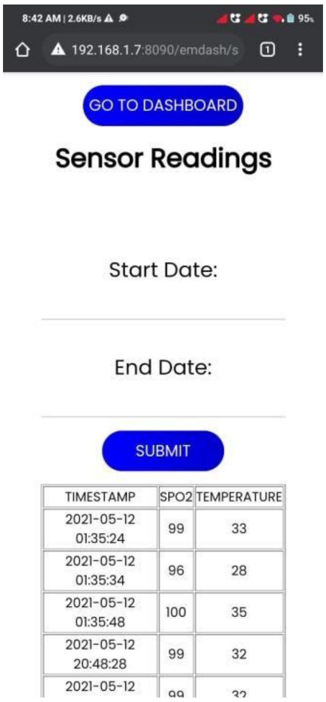

Figure 17: *Sensor reading page*

Now in the proximity reading section, the employees can view details of the people with whom he/she has come in contact. Here when the ID option is left blank, the entire employees contact information will be displayed. In other case if a particular employee ID is specified, then the details of that particular individual will only be displayed.

Figure 18: *proximity reading page*

As the employee goes to canteen transactions page, he/she can view the amount of purchased items. In case an employee wants to know his/her amount history during a particular time interval, there is an option where they can specify the start and end date and the corresponding amount will be displayed.

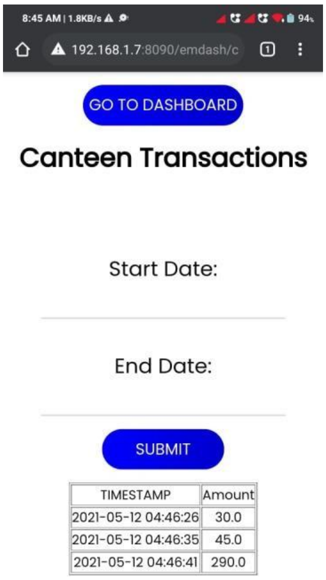

Figure 19: *Canteen transactions page*

The manager can login to his/her account created inside the sever where the following details of the employees can be viewed. This includes attendance, sensor reading, proximity and canteen transactions.

Figure 20: *Manager's page*

The manager can update all the information's related to the employees. Similarly, the manager can update the details of products available in the canteen.

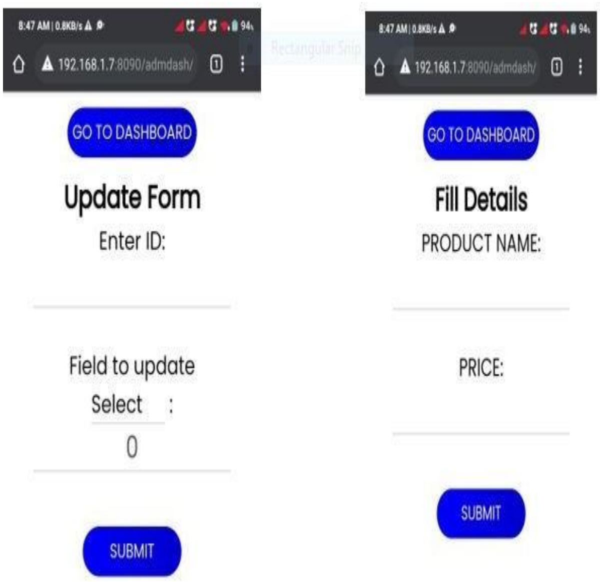

Figure 21: *Updation pages*

IV. CONCLUSION

The coronavirus has hit us by surprise. The whole world is bleeding and the virus is spreading like wildfire. Nobody expected that it would kill so many people and put our life on hold. The only way in which they can be controlled is by maintaining social distancing, cleaning hands, wearing a mask, disinfecting the surfaces etc. Lockdown was imposed in many countries to reduce the number of COVID-19 cases. New normal has become the way of life. Corporations and authorities are left with no other option other than providing flexible environmental conditions like work from home. This has turned out to be one of the biggest challenges the world has ever witnessed. It raised many queries in front of the people. Most important one being the role of physical offices post COVID. A digital contact tracing method can potentially provide an efficient way for real time monitoring of people in offices. The Wearo-Proximity Tracer was developed to provide in-app notification to the people through a web server via a wearable device. The wearable measures some of the early COVID symptoms and records attendance thereby facilitating contact tracing between different people. In addition, it also has a cafeteria concept that helps in self purchasing mechanism which will prevent people from coming in close contact. Thus, the proposed method will help in controlling the spread of disease to an extent.

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