Indoor Monitoring the Spread of COVID-19

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ABSTRACT
COVID-19 Pandemic is the current issue that the world is facing. So there is the challenge of minimizing or controlling the COVID-19 cases as soon as possible. Most affected people are front-line workers, so by using IoT and Robotics problems can be solved. A wheeled robot is developed, which will have some of the important functionalities. These functionalities will help in reducing the spread of COVID-19. Some of the functionalities are Face mask Detection, Body Temperature Sensor, Contactless hand Sanitizer, Emergency Button. While the movement of the robot is in the indoor environment, so the ROS (Robot Operating System) technology is used, this will help in building the map of the environment and will locate itself on the map. It is called SLAM (Simultaneous Localization and Mapping). The whole controlling of the robot will take place remotely.

Keywords
COVID-19, IoT, face mask Detection, W1209 Body Temperature Sensor, ROS (Robot Operating System), and SLAM (Simultaneous Localization and Mapping)

1. INTRODUCTION
The whole world is facing the COVID-19 crisis and many state governments are unlocking the lockdown. But the threat of the COVID-19 is not gone, soa prototype platform wheeled robot is developed which helps the organization to control the spread of COVID-19 by monitoring the people in the organization. This platform robot will be controlled remotely so that there should be minimum physical contact. As the main focus is on the indoor environment, So the platform robot will only help in the indoor environment to limit the spread of COVID-19. Some of the functionalities which are integrated on the robot for limiting the spread of COVID-19 are, Face mask detection in this mobile camera is used to capture the camera data, and the data is sent to the remote user desktop and then the processing takes place for the live stream data. Contactless Hand Sanitizer is built using some of the basic IoT devices like Proximity Sensor, Motor, etc. Body temperature sensor W1209 is used to measure the temperature and if it is high then it will buzz the environment. An Emergency button is used, so for this mobile application is built, through which an emergency message can be sent to the contact saved in the application, Along with it will send the Google map location. For the movement and the location of the robot in the indoor environment, ROS (Robot Operating System) and SLAM are the technologies.SLAM (simultaneous localization and mapping) is the process of constructing or updating a map of an unknown environment while also keeping track of an agent's location within it[2].

2. OBJECTIVES
So the objectives described in this paper are:-

1. The platform robot is developed to prevent the spread of COVID-19, which can be done using indoor surveillance and monitoring.
2. The robot should be controlled remotely using the PC. This can be done by building the common network for PC and the platform robot micro-controller.
3. The robot should use the ROS environment, which is built on the Raspberry Pi.
4. The robot should make a map of the unknown environment using LIDAR. LIDAR should collect the data and send it to ROS to process and display a map on the RViz simulator and localize itself on the map.
5. An unknown environment should be mapped by gridmap. High resolution and high-frequency data are used and odometer data should be ignored[3].
6. For mapping there are two techniques Kalman filter approach and the Particle filter approach[2].
7. The robot should localize itself on the map. So GPS is not required.
8. For the movement of the robot, The Tele-Operation commands are used which are predefined in ROS.
9. Live stream data from the camera is sent to the remote PC and simultaneously Emergency Safety Pro application will be running which will send the emergency message on the contact saved in the mobile application.
10. The W1209 sensor module is used to measure the temperature of the body and alert the environment using a buzzer.
11. Contactless Hand Sanitizer is set up on the robot.

3. EXISTING SYSTEM AND PROPOSED SYSTEM

3.1 Existing System
1. Current existing system papers are using the Gmapping and cartographer technique to build the map of the environment.
2. The robots which were developed earlier will have the Lidar. Which will build the map and will show the accurate position of the robot on the map. But there were no COVID prevention techniques used.
3. An existing system has Cartographer and Gmapping techniques which are low accurate than the Hector SLAM.

4. In some of the existing systems they have used the Kinetic camera to build a 3D map and autonomous navigation is added to the robot.
5. Most of the existing systems for the emergency button or the panic button are highly IoT costs like Arduino Nano, GPS, Wi-Fi module, or the IoT SIM for sending the message. But it is not integrated into the COVID prevention robot.
6. The current existing system dealing with temperature detection uses a thermal camera, It is not accurate and not used in the current paper platform robot.
7. Face Mask detection is done mostly using IoT. In which they will be adding Raspberry Pi, Pi Cam, and etc. So it will cost way more.
8. There are different existing systems and they are not integrated into a single robot.

3.2 Proposed System

1. In the proposed system, development of the map is done using the Hector SLAM technology and though which live obstacle can be detected.
2. The map is developed using YDLidar. The map will be visualized on the RViz simulator. So that the robot will be located on the map. But the robot will contain COVID-19 preventing functionalities like Face Mask Detection, Contactless Hand Sanitizer, etc.
3. The proposed system platform robot is using the Hector SLAM for building the map so that accurate maps will be built[3].
4. In order to move in the environment, the robot is controlled by a wireless setup. The LiDAR is sending the data to a computer system with ROS installed in that computer[3].
5. In the proposed work an android application is developed which has all the saved contacts and by clicking the button the SMS with the Google map location is sent to all the contacts which are saved. This will save the cost of the IoT devices and also the maintenance is low. If any modification is required then it will be done quickly.
6. In the proposed work W1209 temperature module measures the temperature and if is greater than a limit then it will buzz. There is no such contactless temperature.
7. In the proposed platform robot is getting data from the mobile camera and then sent to the desktop user, where all the processing of the live stream data will take place for face mask detection.
8. So proposed system is integrating some of the COVID safety functionalities with platform robot and mapping and movement.
9. The system were the map is going to build Ubuntu 18.04 LTS is installed with ROS Melodic[3].

4. PROPOSED SYSTEM

The paper deals with the development of a robot that will have multiple functions for preventing the spread of the COVID-19 virus. The robot will be controlled remotely using ROS technology. The installation of the ROS is done on the Raspberry Pi, Which is the heart of the robot because the LIDAR data is inputted in the Raspberry Pi and through the network connection which will be done between the Raspberry Pi and remote PC using hotspot given by Raspberry Pi. Then the data is sent to the remote PC, Which has already installed ROS Melodic on the raspberry pi and remote PC. Then the map will be built on the remote PC[3]. The map will be built simultaneously along with the accurate position of the platform robot on the map, Along with it, the dynamic obstacle can be detected on the map.

Hector SLAM is used for building the map. So the working of the hector SLAM is shown in the below figure.

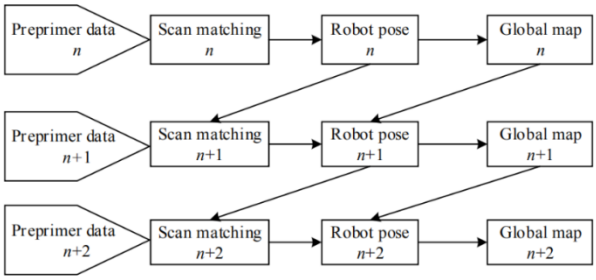

Fig 1: Hector SLAM Working[4]

The location of the robot is done on the three-axis which are x, y, and z, so these are the base link coordinates[9].

The messages are send in an particular fashion in the ROS[9],

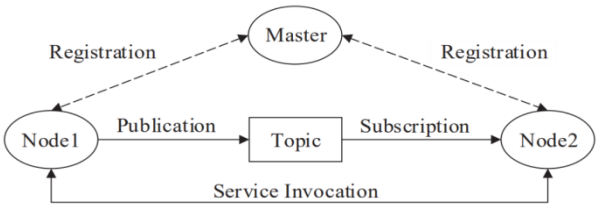

Fig 2: Working of the ROS[9]

As the movement and map building is done for the robot, and then different functionalities are added to the platform robot for preventing the spread of COVID-19 virus.

Face mask detection is the first functionality for preventing the COVID-19, In this the camera live stream data is taken from the mobile phone camera, and then it is sent to the remote PC, Which is connected to the same network. The Iruin application is used for sending the data from mobile phone to PC. The sent data is processed on the remote PC and live face mask detection is done using python.

So two types of the dataset are used, One is the masked dataset and another is the unmasked dataset.

For this face mask detection, Following are the requirements

TensorFlow >=1.15.2

Keras==2.3.1

Imutils==0.5.3

NumPy==1.18.2

OpenCV - python==4.2.0.

Matplotlib==3.2.1

SciPy==1.4.1

There are two phases in COVID-19 face mask detection. The first phase is the Train Face Mask Detector, In this TensorFlow and the Keras are the important requirements because they train the model. In the Keras data augmentation, Loading the MobileNetV2 classifiers, Building a new fully-connected head, Pre-processing, and loading image data are done. Now that the face mask detector is trained[7]. The second phase is the implementation phase, In this the live stream data is inputted and the detection of the faces is done for the face whether the person is a wearing mask or not. So for real-time streaming and processing, OpenCV is used. OpenCV is an open-source library that can be imported. Other requirements like NumPy, Matplotlib, and SciPy are used for the analysis and accuracy checking. For which graph can be plotted.

On the same mobile phone from where the live camera video data is sent for face mask detection, an application named Emergency Safety Pro is executed simultaneously. This will help in sending the SMS, Which has the emergency message and the location of the robot. These messages are sent to contacts which are saved in the application, Google map location link is there in the SMS and for this GPS satellite location is acquired by the mobile application, then for sending the SMS the application contact with the local service provider using GSM/GPRS and at the end SMS is send to the client with the current location of the emergency[8].

Contactless Hand Sanitizer will have the proximity sensor, motor, PNP transistor and power source. This is important because the robot will move in the indoor environment and anybody can use it. Figure 3 shows the connection of the contactless hand sanitizer. The range of the obstacle at which the motor should pump out the sanitizer can vary by the help of proximity sensor. PNP transistor is used to turn off and turn on the current when the obstacle (human hand) comes near or moves away.

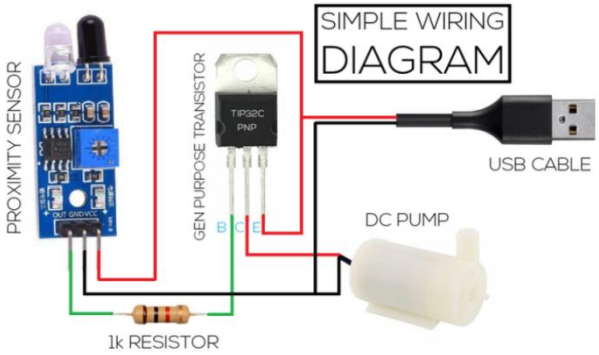

Fig 3: Contactless Hand Sanitizer

W1209 is the module used for the detection of the temperature and if the temperature is greater than the set limit the buzzer will blow and it will alert the environment that the person is having the higher temperature than normal temperature.

Figure 4 displays how the robot will perform its actions like sending commandsover a common network. After sending commands, the visualizing of the map will take place on the Remote PC and for face mask detection also the data will be sent to the remote pc for processing.

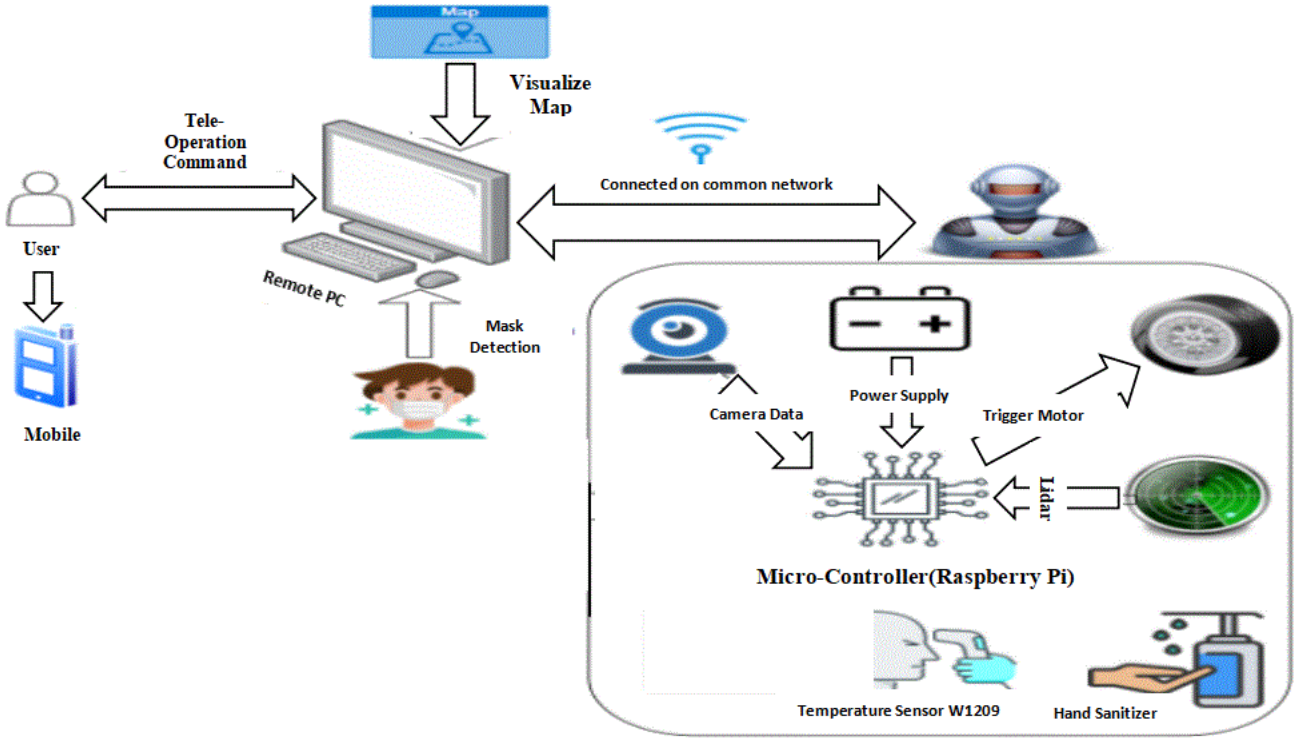

Fig 4: Proposed System Diagram

5. EXPERIMENT RESULT.

All the objectives and the implementations which are mentioned in the proposed system are implemented. There are some of the screenshots, which are displayed in the current section

Figure 5, Figure 6, Figure 7 and Figure 8 maps are built on the ROS Melodic. From Raspberry Pi the Lidar data is collected and the map is built on the remote PC. For visualization of the map, RViz simulator is used, which is inbuilt in ROS. For building these Hector SLAM technique is used and this is the

most accurate technique for building map. In this map the dynamic obstacles can be noticed using the red lines or dots. Dark black lines denote the walls or the permanent obstacle. White patches are the free space where the robot can move freely. The ROS is open-source software, so all the packages for building the map and the movement of the robot can be imported easily. The RViz simulator where the map is displayed is installed with the ROS Melodic.

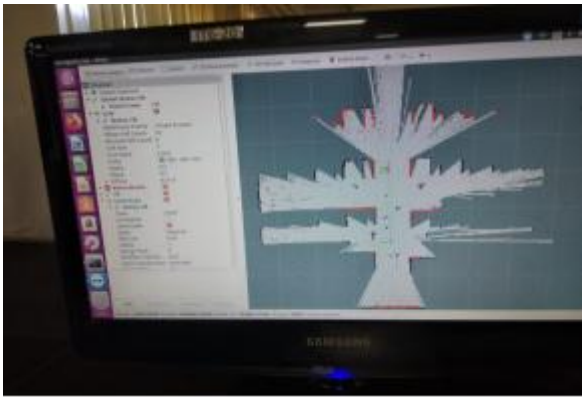

Fig 5: Map of the College Lab

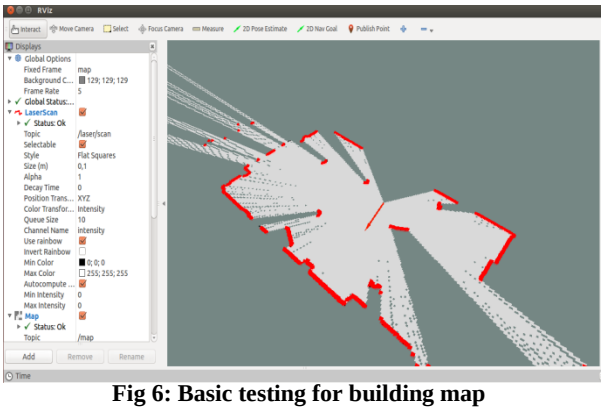

Fig 6: Basic testing for building map

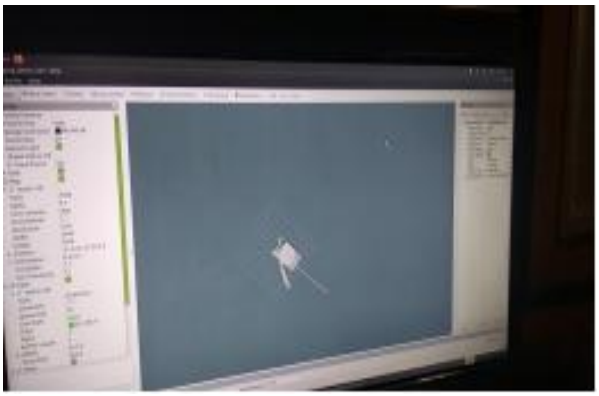

Fig 7: Map of the home

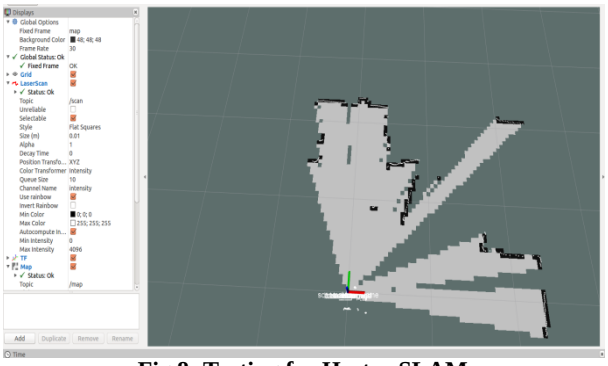

Fig 8: Testing for Hector SLAM

Basically, an occupancy gridmap is used, which is a computer algorithm that is already inbuilt in the ROS[5]. These algorithms build the map in the cell format[5]. The robot moved in different areas for comparison, So that the precision of the map can be noticed, which is built for the indoor environment.

Table 1. Error between actual and mapped data

Area	Actual Length (Meter)	Actual Breadth (Meter)	Map Length (Meter)	Map Breadth (Meter)	Error
A	22.7	10.8	22.6	10.7	0.2
B	26.81	11.53	26.75	11.56	0.11
C	19.15	9.63	19.10	9.61	0.07
Total Error					0.38

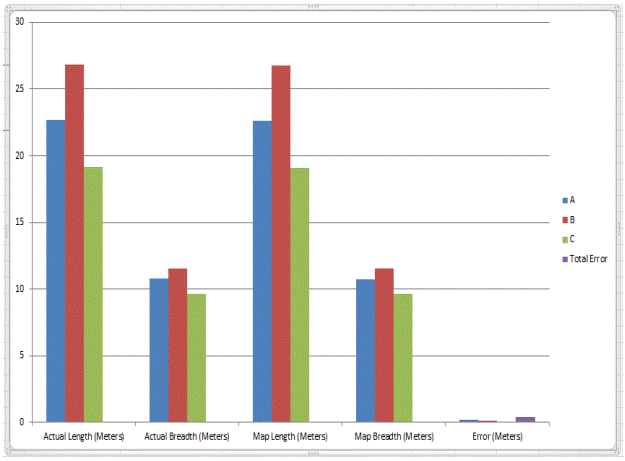

Fig 9: Bar graph analysis for actual and map area

Table 1. Error between actual and mapped data is the table where actual length and breadth of that area is measured and then map length and breadth is measured[5]. As there will not be the perfect map so there are errors. The errors are recorded and plotted a bar graph for analysis in Figure 9.

Table 2. Actual position and map position errors

Positions	Error(Cm)
A	36.5
B	37.4
C	38.3
D	39
E	36.2
F	39.1
G	38

The above table 2 show the error between the actual position and the map position. The analysis for the following errors is given in the line graph in figure 10.

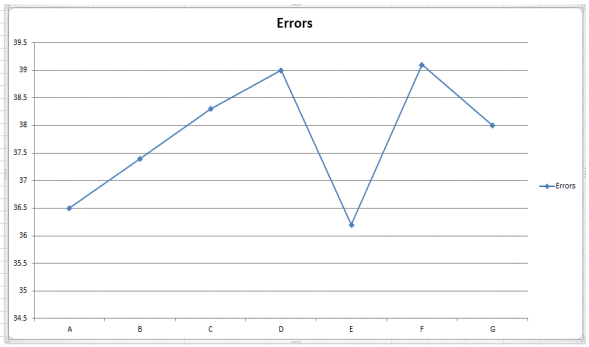

Fig 10: Line graph analysis for actual and map position of robot

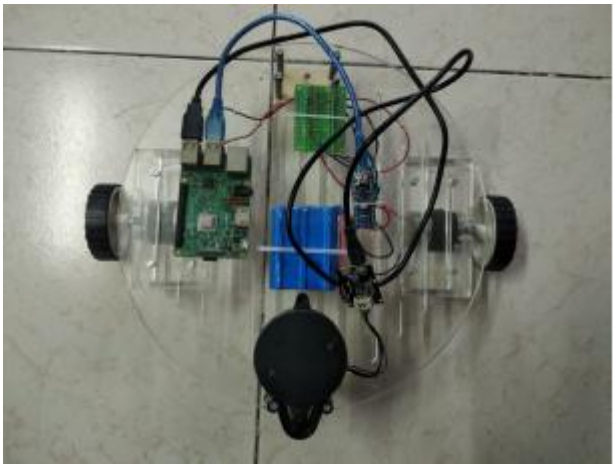

Fig 11: Platform Robot

Figure 11 shows the connection of the platform robot. The Raspberry Pi is connected to the YDLidar, Arduino Nano, and power-bank for the power supply. The Arduino Nano is connected to the Raspberry Pi from which Arduino Nano gets the movement command and the Arduino Nano triggers the movement of the wheel using the motor driver which is connected to the Arduino Nano.

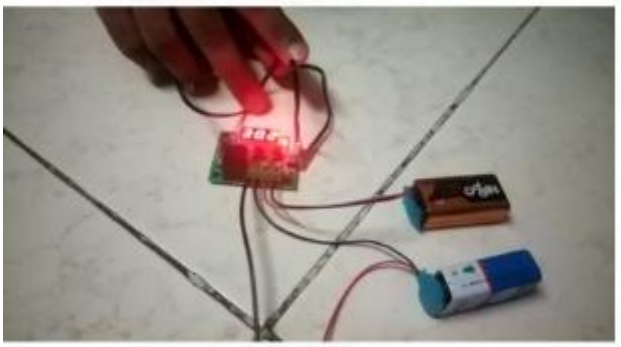

Fig 12: Body Temperature W1209 module

Figure 12 shows the W1209 module which is used to measure the body temperature and if the temperature is greater than the adjusted point then it will trigger the buzzer.

The data of W1209 temperature module is analyzed with the actual thermometer and a bar graph is plotted. It is displayed in Figure 13.

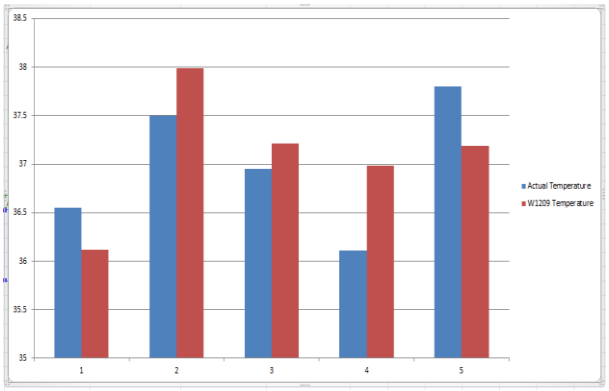

Fig 13: Bar graph analysis for actual and W1209 temperature

Fig 14: Contactless hand sanitizer

The contactless hand sanitizer contains intelligent automatic induction, in Figure 14 shows the contactless hand sanitizer were proximity sensor, PNP transistor, battery and motor, when the object comes near the proximity sensor the sanitizer will pump out using the motor[6]. The proximity sensor can be for the flow of the sanitizer. This is the adjustment for the object near the proximity sensor.

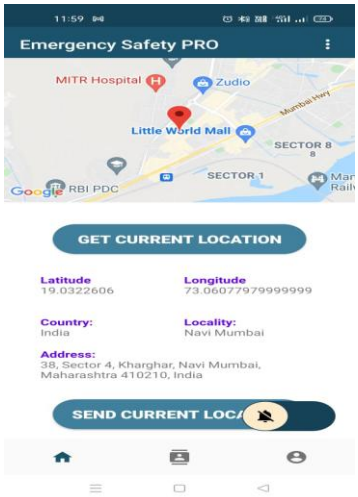

Fig 15: Emergency Safety Pro home page

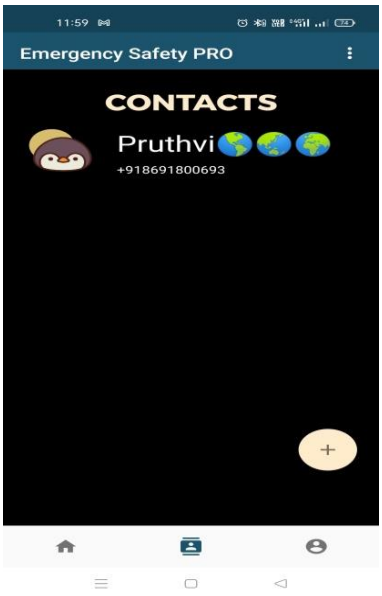

Fig 16: Emergency Safety Pro Contact List

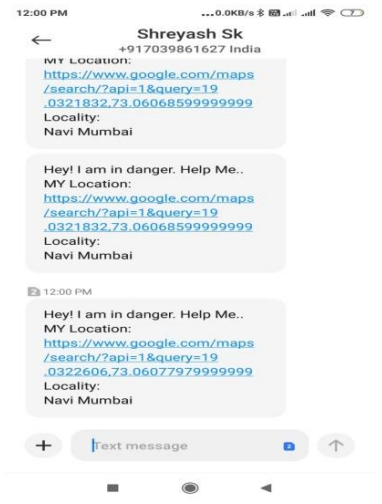

Fig 17: Emergency Safety Pro message sent to saved contact

The above Figures of the Figure 15,Figure 16, and Figure 17 shows the emergency message functionality which is used for the purpose of the emergency. Basically user login to the account or create the account and for this mobile application the Firebase database is used for storing user credentials. Then after login the contact details are added to the application and then after clicking send current location SMS is send to the contacts which are saved[8].

Fig 18: Face mask Detection

Face mask detection is done using the Python language and the face mask detection library is used. This face mask detection library is the inbuilt library and it should be imported for the use. Figure 18 is the captured image of face masks detection. All the detail explanation is given in the Proposed System[7].

While training the face mask detection data, Accuracy was checked and the figure is displayed below in Figure 19.

	precision	recall	f1-score	support
with_mask	0.99	0.99	0.99	383
without_mask	0.99	0.99	0.99	384
accuracy			0.99	767
macro avg	0.99	0.99	0.99	767
weighted avg	0.99	0.99	0.99	767

[INFO] saving mask detector model...

Fig 19: Face mask detection training data accuracy

Training graph is developed for the training loss and the accuracy. So the graph is displayed below in Figure 20. In that graph it is mentioned about training loss, value loss, training accuracy and value accuracy[7].

Fig 20: Face mask detection accuracy and loss graph

6. ACKNOWLEDGMENTS
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7. CONCLUSION
The robot will try to monitor the spread of covid-19 in the organization.The robot is controlled remotely, Robot contain some of the equipment which will help in minimizing the spread of COVID-19. The robot will do all the functionalities like face mask detection, contactless hand sanitizer, Temperature detection and Emergency Button messaging. The emergency button can also serve as an easy access that caters emergency concern such as fire, accident, crime[8]. This robot will help in spreading awareness in the organization as it will be contactless, People will be safe from COVID-19 infection.

In the future more improvements can be done in the robot like autonomous navigation, in the autonomous navigation the robot will be given the destination point and the robot will travel autonomously to the destination. More features for the COVID-19 prevention can be added like monitoring heart rate, monitoring blood pressure, blood oxygen level measurement,ECG andmore health related IoT devices. In future this robot can be built in low cost and provided to government organization and the healthcare industries.

8. REFERENCES
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