



Design and Development of IOT Social Distancing and Monitoring Robot for Queue

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KEYWORDS

Coronavirus prevention
Arduino
Ultrasonic Sensors
IR Sensors
ESP32 Camera

ABSTRACT

COVID-19 is the fifth pandemic to be documented since the 1918 flu pandemic. The virus spreads swiftly and evolves over time among humans because it is highly contagious. Since the virus is known to spread airborne, few of the most efficient ways to protect ourselves are by following social distance among individuals and to wear a face mask or shield at all times. These 2 conditions are not followed by some individuals even if the rules are set to be strict and it is impossible for the government to watch over everyone at all times. Companies and other sectors has to be allowed to operated even during the crisis due to economic factors. This is a risky situation for both the companies and the people. As a solution for this situation, a prototype is created to assist with social distance monitoring in public areas to reduce the risk of disease spread. The robot operates by using an Arduino MEGA, IR Sensors and Ultrasonic sensors. The robot comes with a robust and compact design to work in most places with the ability to follow a pre-determined path which gives it a tremendous market potential in all sorts of sectors that involves high number of employees or people.

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1. INTRODUCTION

The social distancing robot is the key to ensuring safe social distancing during this pandemic. The robot's main purpose is to help limit the spread of covid-19 by observing the distance between individuals. An efficient and safe monitoring method is now possible with the help of the Social Distancing Monitoring Robot as the prototype is capable of working up to 24 hours a day with sufficient power supply at any public places (Banks, Public Offices, Malls, Schools) The aim of the project is to monitor the distance between 2 individuals in the queues present. The prototype is designed in a way to notify the individual instantly and also report the individual to the head office with photo proof of violation. The project's aim is to reduce social distancing violations in public in a more efficient way.

2. LITERATURE REVIEW

Gumus, O., Topaloglu, M., & Ozcelik, D. (2016) have proposed a system using a line following function to make technological improvements to the public transportation

system. The main purpose is to increase the number of services and to reduce the time taken between each stops. Sensors that are placed under the Line follower sends environmental information to the Arduino Uno. The Arduino Uno then conveys the received signal with the help of the host computer informing the operator about the environment. The line follower is expected to reduce the number of road accidents and create a stress free working experience to drivers.[1]

Rahul Reddy Nadikattu et al. (2020) have proposed a novel economical social distancing smart device to detect covid19. The main objective of this proposed system is to track humans' position in an outdoor environment based on PIR sensors using an innovative localization method and detecting COVID 19 symptom patients with the help of artificial intelligence. This proposed system consists of PIR sensor, micro-controller, and mobile to display and alert as well. The microcontroller would trigger the alarm to give alert to the person if the PIR sensor detects that someone in the critical range of six feet around him. The project can also calculate the body temperature in the range of the person and the device would detect that the person has

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COVID -19 symptoms or not using a Machine learning algorithm. [2]

Ho Yun Faang et al. (2021) proposed IoT-Based Automated and Contactless Shopping Cart During Pandemic Diseases Outbreak in a research article. This system's goal is to eliminate item scanning at cashiers and long lines at payment counters while also providing vital budget monitoring for daily expenditure. RFID sensor, weight sensor, microcontroller, LCD display, and keypad make up the system. Every product had a radio frequency identification (RFID) tag attached to it, which was immediately scanned anytime it was placed in a shopping basket. [3]

Maria Fazio et al. (2020) developed a proximity-based indoor navigation system to address the COVID-19 social distancing measures based on the research article. The goal of this suggested system is to demonstrate an efficient and cost-effective indoor navigation system for moving people around huge smart buildings (smart cities, smart buildings, beacons, proximity-based positioning). The suggested system uses an emerging short-range wireless communication technology based on the Internet of Things, Bluetooth Low Energy (BLE), and exploits BLE Beacons throughout the environment to offer mobile users with a smartphone with directions on how to get to their destination. The suggested system's prototype was created using ESP32 microcontrollers as IoT beacons and a Raspberry Pi 3 Model B+ as an Edge node. Each Beacon has a dual-mode BLE-Wi-Fi capability. The script supports a dual-mode implementation utilizing the Arduino IDE and the C programming language. [4]

Adarsh Kumar et al. (2020) proposed a drone-based networked system and approaches for controlling the coronavirus illness (COVID-19) pandemic in a research article. The goal of this suggested system is to cover a broad area for sanitization, thermal image collecting, and patient identification in a short amount of time (2 kms in 10 minutes) using an airborne route for the Covid-19 operation. Using real-time and simulation-based scenarios, this drone-based system suggested an architecture for dealing with pandemic crises. [5]

Mohammed Ghadhban Al-Hamiri et al. (2021) where he proposed the Applications of artificial intelligence with cloud computing to promote social distancing in order to combat COVID-19 by maintaining the social distance with effective monitoring for suspected cases. This proposed system consists of RFID Sensor, web server (Apache), database server (MySQL), Arduino, Wi-Fi Module, Ultrasonic Sensor, Buzzer, Solenoid Lock, relay and IR temperature sensor. When a student near the door and use RFID tag to open the door, the system will read and identify the number of students inside is lesser than the total allowed number and check the temperature of the student. If the student registered in the system under total allowed number and temperature of the student under the limit, the system will open the door. Otherwise, the door will be closed and will start the alarm by sending the notification on the cloud page if the temperature of the student is above the limit. [6]

Manuel Martinez et al. (2020) proposed the system Helping the Blind to Get through COVID-19: Social Distancing Assistant Using Real-Time Semantic Segmentation on RGB-D Video. The objective of this proposed system is to develop a system that helps blind people to maintain physical distance to other persons using a combination of RGB and depth cameras.

The system consists of lightweight backpack, a Lenovo ThinkPad Yoga 14 laptop, the KR-Vision glasses, and RGB-D camera. This proposed system use a real-time semantic segmentation algorithm on the RGB camera to detect where persons are and use the depth camera to assess the distance to them; then, system provide audio feedback through bone-conducting headphones if a person is closer than 1.5 m. [7]

Shih Huan Tseng et al, (2016) was proposed Service Robots: System Design for Tracking People through Data Fusion and Initiating Interaction with the Human Group by Inferring Social Situations. The objective of this proposed system is to develop a new system that enables a robot to determine whether or not it should approach the aforementioned human group and interact with them after identifying the current social situation. The proposed system consists of laser range finder (SICK LMS 100), motion detector, Kalman filter, ARIO (Agile Robot In Office) robot with sensors for human-oriented detection, RGB-D camera (ASUS Xtion Pro), and web camera. The system is mainly to fuse depth-related data to track the positions of a group of people, extract social cues of those people by using depth-related data and a decision network (DN) model, and the main challenge lies in understanding the social cues of the group and the current underlying social situation concerning the relation between the robot and the group. The proposed system proceeds once a group of people are detected and the social cues of that target group of people are extracted, the corresponding social situation is appropriately inferred, and in turn the robot decides whether it should initiate conversation with the group based on rules to be specified later [8].

3. METHODOLOGY

Figure 1 shows the block diagram of the proposed system. The main controlling unit of the system is Arduino MEGA and it will be powered by a 12V battery. Ultrasonic and IR sensors will give input to the Arduino regarding the obstacle detection and the distance between individuals in a queue respectively. Arduino will analyse the inputs received and control the output to the scissor lift and social distance detection system accordingly. DC motors are to be powered by a 12V Lithium Polymer batteries; the motors will be used for the movement of the robot. Arduino will control the motor to move in a predetermined direction by using IR Sensors. If distance between individuals in queue is less than 3 feet, the ultrasonic sensor detects it and sends signal to Arduino to activate the scissor lift, red LED, ring LED and buzzer. To report the violation, images are taken using ESP32 camera module to be sent to the user's cloud storage to be viewed.

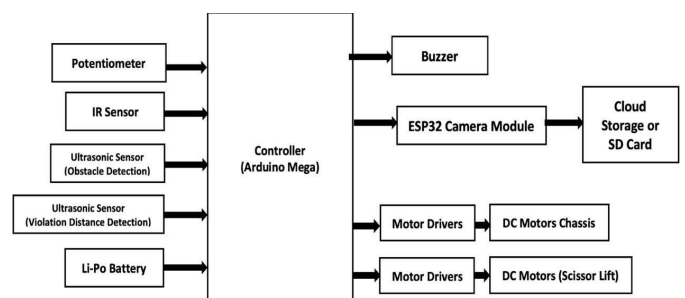


Fig. 1. Block Diagram of Project

3.1 Circuit Diagram

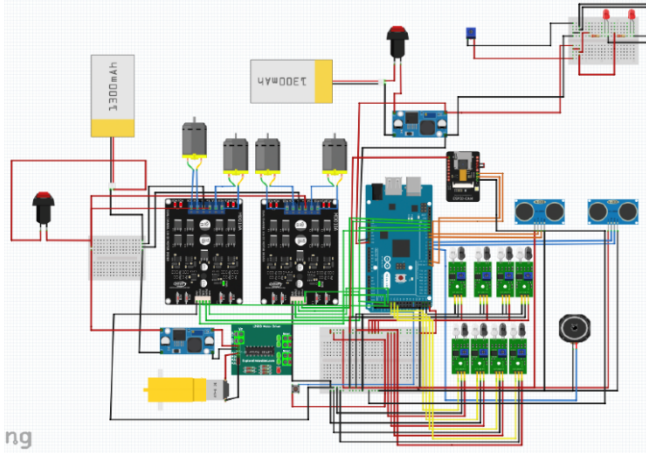


Fig. 2. Circuit Diagram of Project

A. Scissor Lift System

A scissor lift model as shown in Figure 3 is built for the robot as taking pictures from a lower height might be inappropriate depending on an individual's outfit. A scissor lift model also allows the camera to have a better scope of the face when taking a picture as it is extended to a higher level from the ground. The scissor lift is fully built using wooden sticks. The scissor lift will be controlled by a DC motor in order to move up and down.

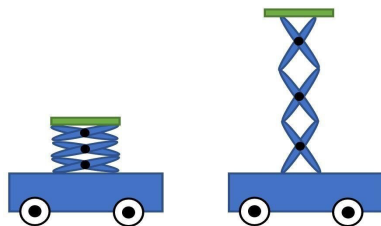


Fig. 3. Scissor Lift Model

3.2 Individual Distance in Queue detection

The ultrasonic sensor detects presence of an object in front of it by bouncing back the soundwave. The project utilizes the presence of returning soundwave to identify if there is a person in front the sensor or not. Similar to the use of ultrasonic sensors to count a person passing by, in this case the robot moves in constant speed allowing the sensor to do the same. As shown in Figure 4, initially the sensor receives back a sound wave where it knows there is presence of a person. During this time, whenever it comes into contact with a person, a timer is started until it reaches the second person. During the travel time from person 1 to person 2 there are no receiving sound wave (due to limited range) which allows the robot to know that there is no person in between the specified queue distance (3 feet in this case) as shown in Figure 5. The robot takes 2.5 seconds in order to reach person 2 from person 1, through trials, an estimated time it takes for the robot is set. The robot will be programmed in a way to respond to whatever sound wave it receives back before 2.4 seconds. This way it can detect the space between each individual and efficiently send out outputs such as buzzer, LCD and also take pictures when a violation is detected.

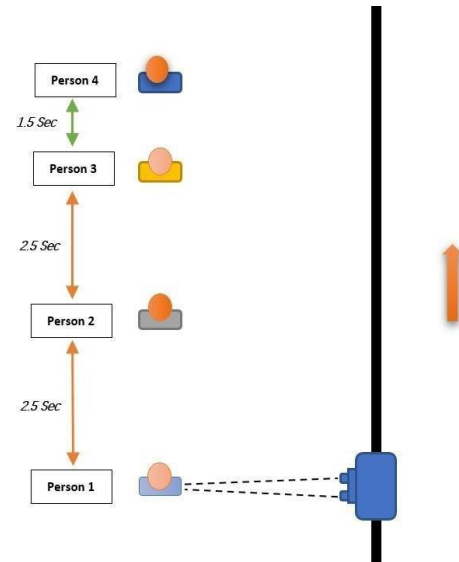


Fig. 4. Sensor receiving back soundwave

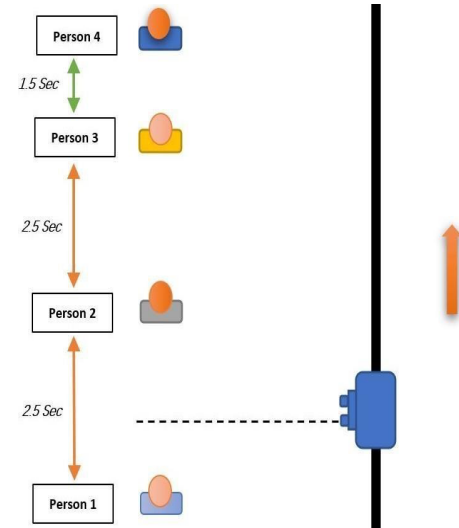


Fig. 5. Sensor not receiving back soundwave

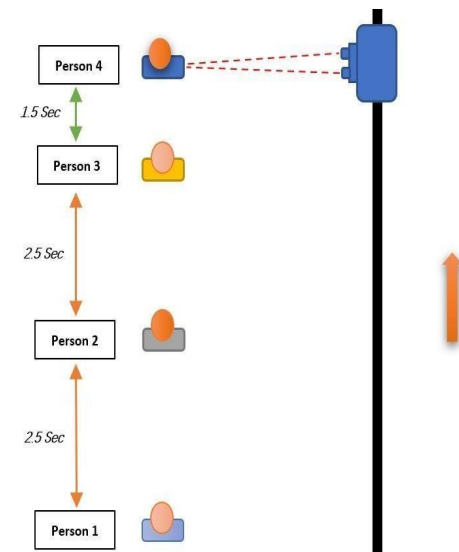


Fig. 6. Sensor takes less time to receive back signal

3.3 Flowchart

The flow charts in Figure 7 and Figure 8 shows the steps taken to develop the code to operate the proposed system. The controller starts operating, If no failure of controller is detected, the IR Sensor starts operating. The IR Sensor scans the floor for the black line. If the line is not detected, the prototype continues to detect the line until found. Once the black line is found, the prototype moves to the end of the line. During the moving process, if any obstacle is found blocking the path, the prototype will instantly stop and alarm a buzzer until the obstacle is removed. If no such obstacle is found on the path, the prototype's Ultra Sonic sensor (for social distance violation) starts monitoring the individuals in the queue. If social distance violation is detected, the robot's scissor model starts operating, the dc motors extends the scissor model to a higher level to take a photo, alarms a buzzer. Taken images of the violation are then reported/sent to the head office.

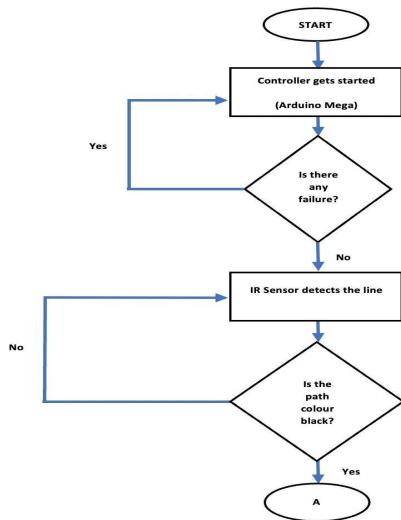


Fig. 7. Flowchart of the project (Part A)

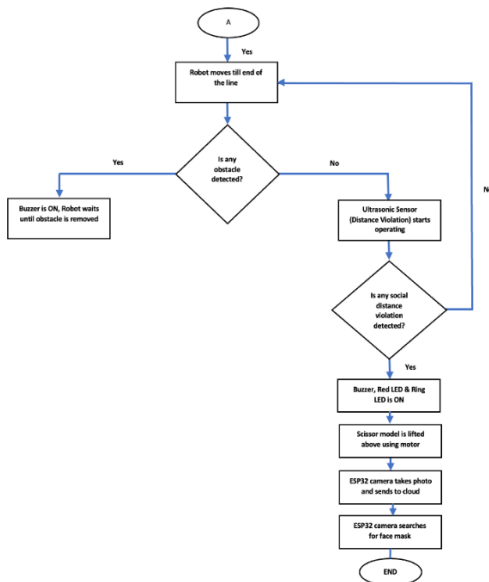


Fig. 8. Flowchart of the project (Part B)

4. RESULTS

4.1 Line Following Mechanism

This robot is capable of moving on a predetermined line autonomously to move along the queue. Figure 9 shows the images of the robot moving.



Fig. 9. Prototype following predetermined line

4.2 Kalman Filter and People Count

The social distance detection works by using time as a constant in order to calculate the distance between the individuals in the queue and also the distance from the robot to the queue. As shown in the Figure 10, raw data is collected from the ultrasonic sensor and smoothed version of a simplified Kalman Filter.

Arduino also sends sensor, ultrasonic feedback to the esp32 via serial monitor using wired serial communication. From this value we can estimate the distance between each individual and count the number of people in the queue as shown in the serial monitor of Figure 11. This also helps the ESP32 to receive and parse data to perform said functions.

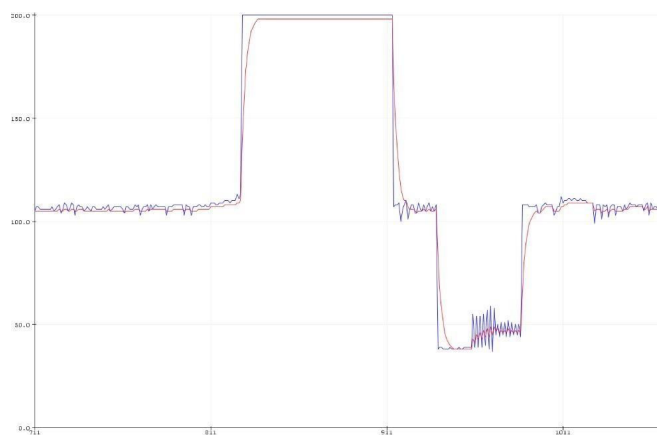


Fig. 10. Kalman filter application onto Ultrasonic Sensor's raw data

```

19:33:32.222 -> People :
19:33:32.222 -> 1 1 1 1 1 1 0 261
19:33:32.222 -> People :
19:33:32.222 -> 1 1 1 1 1 1 0 201
19:33:32.255 -> People :
19:33:32.255 -> 1 1 1 1 1 1 0 161
19:33:32.255 -> People :
19:33:32.255 -> 1 1 1 1 1 1 0 135
19:33:32.255 -> People :
19:33:32.255 -> 1 1 1 1 1 1 0 134
19:33:32.290 -> 1 1 1 1 1 1 0 117
19:33:32.290 -> People : 3
19:33:35.307 -> 1 1 1 1 1 1 0 106
19:33:35.307 -> People : 4
    
```

Fig. 11. Serial Monitor output of queue distance detection and people count



Fig. 14. Conditions that violates Social Distancing Distance in Queue



Fig. 15. Condition that does not violate Social Distancing Distance in Queue

4.3 Social Distance Detection

The prototype requires a predetermined path in order to follow the queue perpendicularly. A black tape is used as a predetermined path in this case and pieces of black tape is attached 3 feet apart each other to indicate individuals in the queue to identify where to stand. Figure 12 shows the proper way the individuals should stand in the queue and Figure 13 shows the conditions where the social distance violation is detected. Meanwhile, Figure 14 until Figure 18 shows the testing conditions of the robot.

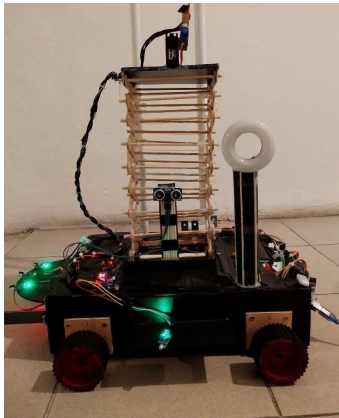


Fig. 12. State of robot when Social Distance violation is not detected

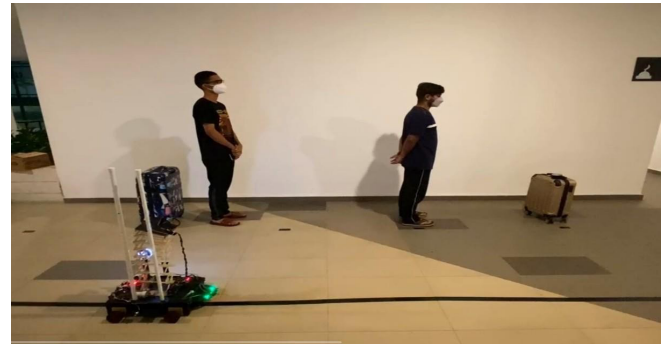


Fig. 16. Robot detecting Social Distancing violence from individual A

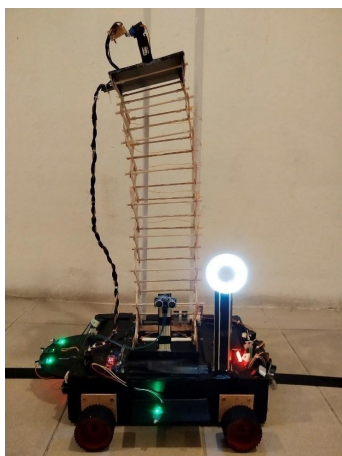


Fig. 13. State of robot when Social Distance violation is detected

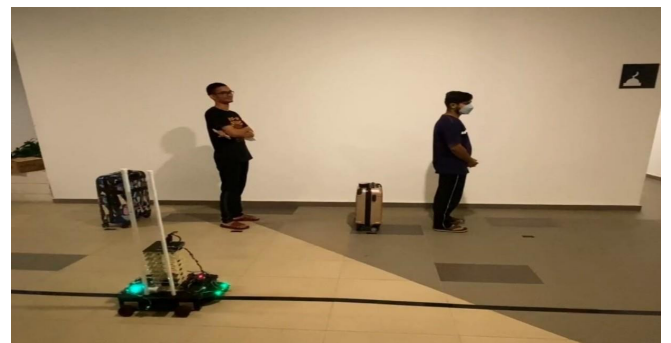


Fig. 17. Robot not detecting Social Distancing violence from individual A

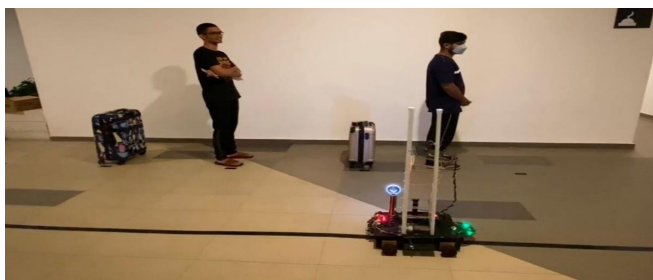


Fig. 18. Robot detecting Social Distancing violation from individual B

using real-time semantic segmentation on rgb-d video. *Sensors*, 20(18), 5202.

- [8] Tseng, S. H., Chao, Y., Lin, C., & Fu, L. C. (2016). Service robots: System design for tracking people through data fusion and initiating interaction with the human group by inferring social situations. *Robotics and Autonomous Systems*, 83, 188-202.

5. CONCLUSION

As a conclusion, Covid-19 has impacted everyone's lives in an unthinkable way, in terms of work, school, financially and it also took away freedom of movement. This prototype is able to limit the number of disease spread by monitoring the distance between the individuals in a queue. The prototype also alerts the user regarding the violation using photographic evidences that will be sent to the user's cloud storage. The objectives of the project is achieved successfully and the camera development of the project is under progress to implement better quality captures.

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REFERENCES

- [1] Gumus, O., Topaloglu, M., & Ozcelik, D. (2016). The use of computer controlled line follower robots in public transport. *Procedia Computer Science*, 102, 202-208.
- [2] Nadikattu, R. R., Mohammad, S. M., & Whig, D. (2020). Novel economical social distancing smart device for COVID19. *International Journal of Electrical Engineering and Technology*, 11(4).
- [3] Faang, H. Y., Yaakob, N., Elshaikh, M. E., Sidek, A. K., Lynn, O. B., & Almashor, M. (2021, July). IoT-Based Automated and Contactless Shopping Cart During Pandemic Diseases Outbreak. In *Journal of Physics: Conference Series* (Vol. 1962, No. 1, p. 012051). IOP Publishing.
- [4] Fazio, M., Buzachis, A., Galletta, A., Celesti, A., & Villari, M. (2020, July). A proximity-based indoor navigation system tackling the COVID-19 social distancing measures. In *2020 IEEE Symposium on Computers and Communications (ISCC)* (pp. 1-6). IEEE.
- [5] Kumar, A., Sharma, K., Singh, H., Naugriya, S. G., Gill, S. S., & Buyya, R. (2021). A drone-based networked system and methods for combating coronavirus disease (COVID-19) pandemic. *Future Generation Computer Systems*, 115, 1- 19.
- [6] Al-Hamiri, M. G., Abdulsada, H. F., & Abdul-Rahaim, L. A. (2021). Applications of artificial intelligence with cloud computing in promoting social distancing to combat COVID-19. *Indonesian Journal of Electrical Engineering and Computer Science*, 24(3), 1550-1556.
- [7] Martinez, M., Yang, K., Constantinescu, A., & Stiefelhagen, R. (2020). Helping the blind to get through covid-19: Social distancing assistant