Evolution in Electrical and Electronic Engineering Vol. 2 No. 2 (2021) 265-274
© Universiti Tun Hussein Onn Malaysia Publisher's Office

EEEE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

Mobile Patrol Robot for Temperature Measurement and Mask Detection using Deep Learning

Muhamad Yusuf Johari[1], Mohd Norzali Hj Mohd[1]*,

[1]Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/eeee.2021.02.02.032
Received 04 July 2021; Accepted 25 August 2021; Available online 30 October 2021

Abstract: Wearing a mask especially in a crowded place is a must now days in order to prevent from the Covid-19 virus to spread wider but people tend to take lightly about wearing mask. The objective of this study is to develop a face mask detector and temperature sensor patrol robot which can moves on its own. Raspberry Pi 3b+ was used as the main component for mask detection and temperature measurement while Arduino Uno was used to control the motor movement based on input it receives from IR sensor. The mask detection system has achieved 58% to 73% accuracy when people wear a mask and 58% to 66% accuracy for the people who were not wearing a mask which was using a Tensorflow Lite algorithm of pre-trained Mobilenet SSD model. The pre-trained model has high accuracy for not wearing mask detection compares to wearing mask detection and also have a delay of 4 seconds for every video frame inputs. This study can be improved by using a Raspberry Pi 4 board which have higher computational power that can run the pre-trained model much faster and less delay.

Keywords: Mobile Patrol Robot, Temperature Sensor, Mask Detection

1. Introduction

According to the Ministry of Health Malaysia, there were approximately 22,225 total COVID-19 cases documented up till October 20, 2020, with 193 people dying as a result of the virus. The COVID-19 virus is primarily disseminated by contact and respiratory droplets, according to the World Health Organization website. According to the WHO, one of the best strategies to prevent virus transmission is to keep at least 1 meter between people and to wear a face mask in certain scenarios such as public venues, restricted spaces, and crowded places.

When going out, the general population is encouraged to wear a face mask, especially in situations where distancing is impossible. This is because, in comparison to not wearing one, it can at least protect you against virus transmission. When a person wearing a face mask sneezes in a public setting with a lot of people, it can at least stop most of the bacteria from spreading to others but some people tend to

**Corresponding author: norzali@uthm.edu.my*

take lightly about the importance of wearing a mask and either they not wearing one or they will wear it not properly.

In this study, a face mask detector and temperature sensor patrol robot using an IR sensor was developed. The face mask detection was applied using deep learning and the accuracy of it also had been analyzed. The face mask detection and temperature measurement were controlled by Raspberry Pi 3b+. Pi camera was used as vision system for mask detection while temperature sensor was used as the input for temperature measurement system. For motor movement was controlled by Arduino Uno based on the input it received from IR sensor. This study is limited to indoor usage only with planar floor.

1.1 Object detection method

Deep learning is an improved version of machine learning in which additional depth is added to the model and a range of functions are used to alter the data in a hierarchical manner [1]. It has a far more complicated structure and allows for a lot more parallelization than machine learning, therefore it can tackle much more complex problems [2]. This algorithm aids in the reduction of regression error while simultaneously increasing the model's accuracy.

SSD use a feed-forward convolutional network to construct bounding boxes and identify objects within them based on their classes. According to Wei Liu et al. (2016), they improve the base network model by adding multiscale feature maps for detection, convolutional predictors for detection, default boxes, and aspect ratio to the SSD base network [3].

In terms of training results, Wei Liu et al. (2016) discovered that there is a difference between training the SSD model and a standard object identification model that uses region proposals [3] in their research. They must assign the data to the detector's output. When the model has completed assigning the required information, backpropagation and a loss function will be applied to it.

1.2 Line detection method

The infrared obstacle avoidance sensor operates by projecting infrared light wavelength from its transmitter onto an impediment, which is then reflected back to the sensor's receiver and it will decide to follow the black line track [4]. And because there is no ambient infrared light, IR sensors are suited for indoor use.

1.3 Temperature sensing method

The infrared temperature sensor is one of the accurate for mobile devices application [5]. It senses temperature by focusing infrared energy from an object onto a photodetector. The photodetector will then convert the infrared energy generated by the object into electrical energy. according to When used to test the tool-chip interface temperature, the infrared temperature sensor can detect temperatures up to 525 degrees Celsius.

2. Materials and Methods

This section will present the materials and also the methodology that were used in this study to develop a mask detection, temperature measurement and also the line detection system. The first subsection will explain the materials used in this study while subsection 2 will explain the methodology for this study.

2.1 Materials

For the hardware, the main component for mask detection and temperature measurement were Raspberry Pi 3b+ while the pi camera and temperature sensor will be the input. Red LED and a buzzer will activate when the system detects Arduino Uno was used in order to control the motor movement by using motor driver and it is based on the IR sensor data input. As for software utilization, Arduino Uno IDE and Anaconda is used.

2.2 Methods

Figure 1 below shows how the mask detection system works by using the Mobilenet SSD pre-trained model which was using the Tensorflow Lite algorithm.

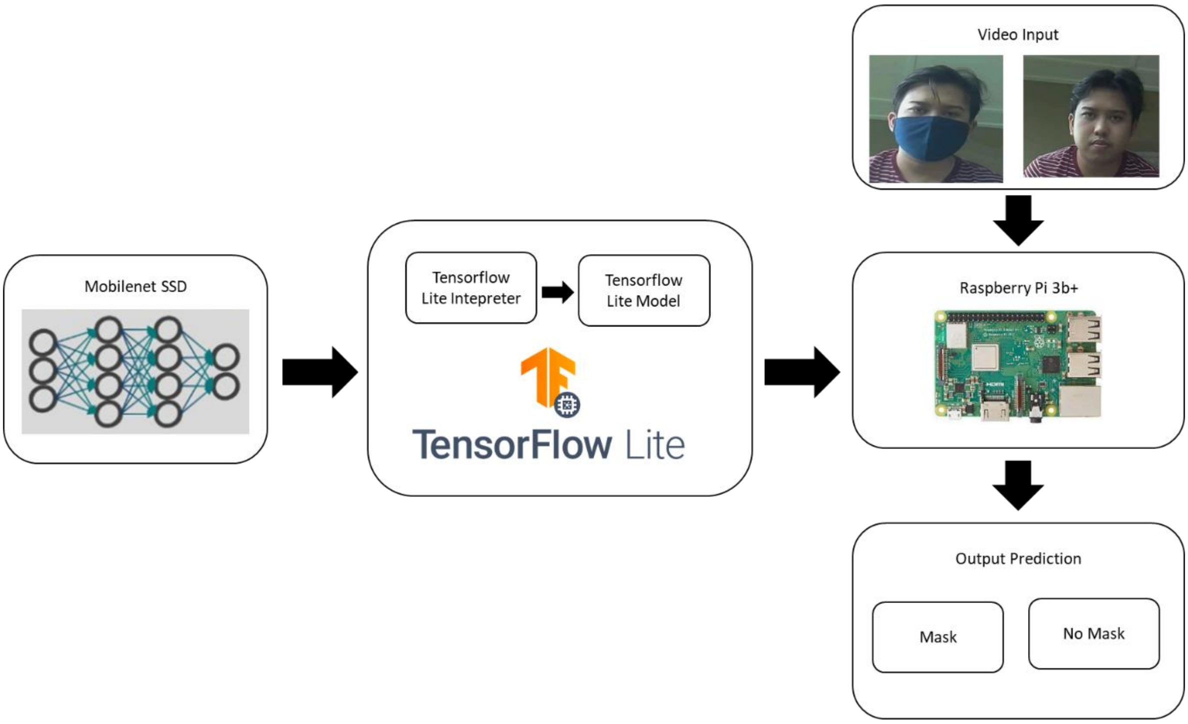


Figure 1: Model architecture of Tensorflow Lite algorithm using Mobilenet SSD model

Figure 1 shows the model architecture utilized in the Raspberry Pi 3b+ application. Mobilenet SSD's pre-trained model was embedded with the Tensorflow Lite technique to enable it to run on embedded Linux boards like the Raspberry Pi. This reduces the complexity of the method, making the model lighter and faster to execute on the Raspberry Pi. Please keep in mind that while the processing speed has increased, making it possible to run real-time applications, the model's accuracy has decreased. For mask identification, the model will be loaded onto a Raspberry Pi 3b+ with the Tensorflow Lite method integrated. The Raspberry Pi 3b+ will take real-time video input, process it, and identify whether or not the person is wearing a mask.

The mask detection system in this study that use Mobilenet SSD algorithm works by creating a grid cell in each input images. Each grid cell is responsible for predicting the location and also the class of object that we have set within the grid region. In each of the grid cell of image can be assigned with anchor box. The anchor box that has highest degree that overlap with object in the image will be responsible to classify the classes of object within it. If the system detects no object that matches the classes within the region inside each grid, the region will be considered as background.

Figure 2 shows how the project works which will involve the mask detection, temperature measurement and also line detection system.

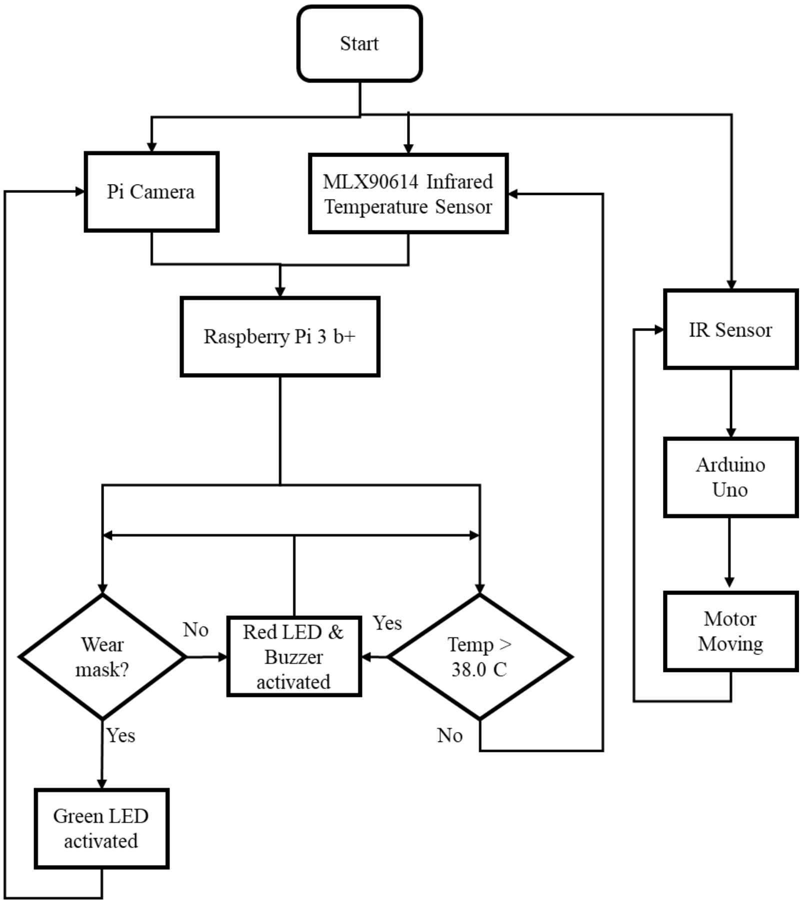


Figure 2: Flowchart of the overall process

Based on Figure 2, we can see that there will be 2 main components involve which is raspberry Pi 3b+ board and Arduino Uno. The Raspberry Pi 3b+ board will receive the input from Pi camera and temperature sensor. The input from Pi camera will be sent to Raspberry Pi for it to analyze either the person is wearing mask or not. If the person does not wear mask, the red LED will blink and the buzzer will be activated. If the person wears mask, only the green LED will be lights up. Next, temperature sensor will send the data reading to Raspberry Pi to determine either a person who walks beside the temperature sensor is having a temperature above 38.0 degree Celsius or not. If the person's temperature is 38.0 degree Celsius or higher, the red LED will blink and buzzer will be activated and if below than that, nothing will happen. As for line detection system, first the Arduino Uno will receive input data from IR sensor then the Arduino Uno will control the motor movement based on the inputs.

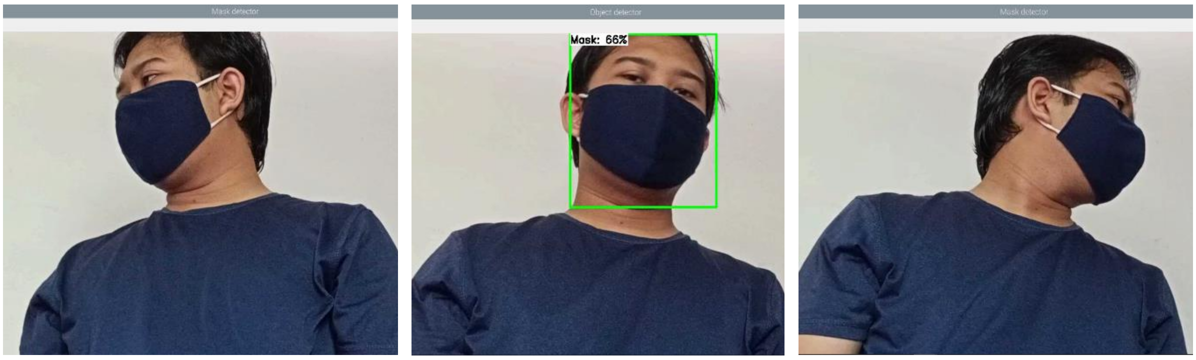
3. Results and Discussion

Subsection 1 in this part will explain the results that were obtained from this study. Subsection 2 will focus on the discussions based on the results obtained.

3.1 Results

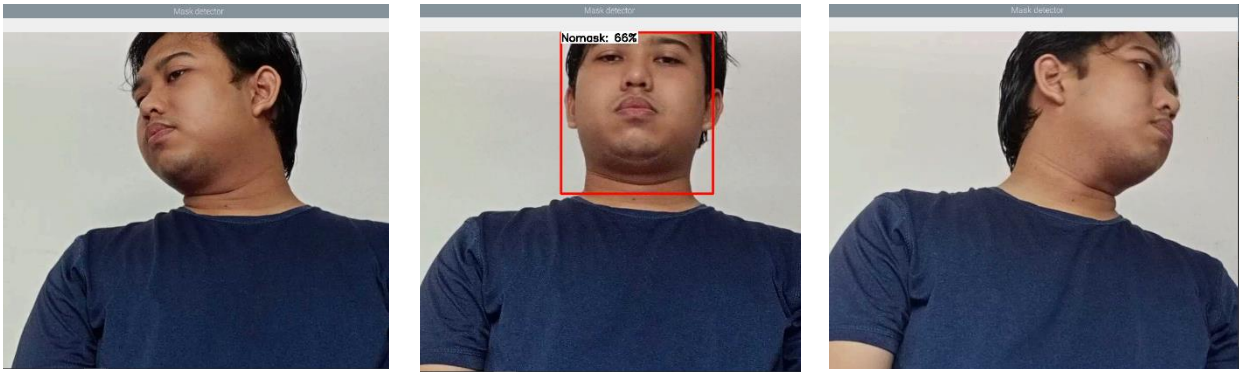
In this section, results of mask detection, temperature measurement and also line detection system is shown in table and figure. Figure 3 shows the results for have mask and no mask detection of Person 1. Figure 4 shows the facing position which is facing Right, Front and Left when the person is wearing a mask. Figure 5 shows the facing position which is facing Right, Front and Left when the person is not wearing a mask.

Figure 3: Person 1 mask detection results



(a) (b) (c)

Figure 4: Mask detection test accuracy – (a) right, (b) front and (c) left



(a) (b) (c)

Figure 5: No mask detection test accuracy – (a) right, (b) front and (c) left

Table 1 shows the detection accuracy table per frame for have mask detection. Table 2 shows the detection accuracy table per frame for no mask detection. Table 3 shows the position of model from camera which consist of nine different point.

Table 1: Detection accuracy table per frame for have mask detection

Frame	Facing Right	Facing Front	Facing Left
1	0	0	0
2	0	58	0
3	0	58	0
4	0	0	0
5	0	66	0
6	0	66	0
7	0	58	0
8	0	66	0
9	0	73	0
10	0	66	0
11	0	66	0
12	0	58	0
13	0	58	0
14	0	0	0
15	0	66	0

Table 2: Detection accuracy table per frame for no mask detection

Frame	Facing Right	Facing Front	Facing Left
1	0	58	0
2	0	58	0
3	0	0	0
4	0	66	0
5	0	66	0
6	0	58	0
7	0	58	0
8	0	0	0
9	0	58	0
10	0	66	0
11	0	66	0
12	0	66	0
13	0	58	0
14	0	58	0
15	0	66	0

Table 3: Position of model from camera

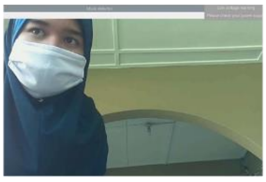
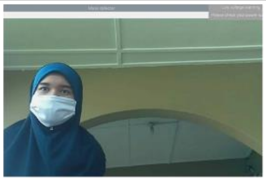
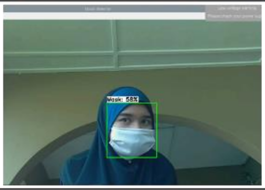
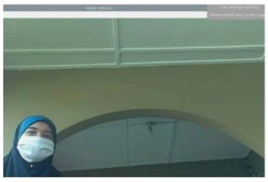
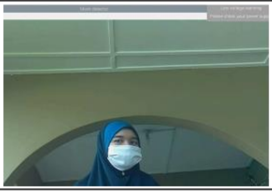
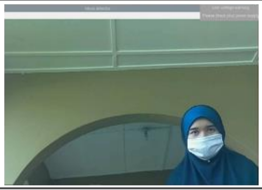
		Postion from camera POV		
		Right	Center	Left
Distance of person from camera (cm)	40			
	80			
	120			

Table 4 shows the mask detection result for person 1 when the subject is wearing a mask. Table 5 shows the mask detection for person 1 when the subject is not wearing a mask.

Table 4: Person 1 has mask detection result

Mask		Distance of face from Camera (cm)		
		40	**80**	**120**
Position of the face from camera POV	**Right**	1	1	0
	Center	1	1	1
	Left	0	1	0

Table 5: Person 1 has mask detection result

No Mask		Distance of face from Camera (cm)		
		40	**80**	**120**
Position of the face from camera POV	**Right**	1	1	0
	Center	1	1	1
	Left	1	0	0

Table 6 shows the data comparison for temperature measurement using MLX90614 Infrared temperature sensor and medical grade temperature sensor where the measurement was taken on the back of the person hand and also at forehead.

Table 6: Person 1 temperature comparison

Distance (cm)	MLX90614 Temperature Sensor (C)	Temperature (C) Medical Grade Infrared Thermometer (C) – Back of Hand measurement	Medical Grade Infrared Thermometer (C) – Forehead measurement
0.5	34.0	36.8	36.8
1.0	33.9	36.7	36.8
1.5	33.7	36.7	36.7
2.0	33.8	36.7	36.7
2.5	33.5	36.7	36.7
3.0	33.5	36.7	36.7
3.5	33.4	36.7	36.6
4.0	33.1	36.7	36.6
4.5	33.3	36.7	36.6
5.0	33.0	36.7	36.6
5.5	32.8	36.7	36.6
6.0	32.7	36.7	36.6
6.5	33.0	36.7	36.6
7.0	32.9	36.7	36.6
7.5	32.9	36.7	36.6
8.0	32.7	36.7	36.6
8.5	32.7	36.7	36.6
9.0	32.6	36.7	36.6
9.5	32.7	36.7	36.6
10.0	32.6	36.7	36.6

Table 7 shows the duty cycle for motor movement control speed and the time taken for the robot to reach 40 cm, 80 cm and 120 cm.

Table 7: Motor control speed

Duty Cycle	Time is taken to reach 40cm (s)	Time is taken to reach 80cm (s)	Time is taken to reach 120cm (s)
30	0.0	0.0	0.0
40	0.0	0.0	0.0
50	0.0	0.0	0.0
60	3.6	6.3	10.3
70	2.8	5.8	9.5
80	2.5	5.3	8.7
90	2.0	4.4	8.1
100	1.6	3.8	7.4
110	1.4	3.6	6.8
120	0.9	3.5	6.5
130	0.5	3.4	6.2

Table 8 shows the different type of tape size which will affect the time taken for the for the robot to reach a certain point.

Table 8: Time taken for the robot to reach certain point by using different tape size

Tape size (cm)	Time taken to reach point intersection (s)			
	A	B	C	D
2.0	4.6	9.3	13.6	18.3
3.5	4.5	9.1	13.5	18.1
4.5	4.7	11	15.6	20.1

3.2 Discussions

Based on the results of Mobilenet SSD pre-trained model which using Tensorflow Lite algorithm, we can say that the model has an accuracy around 58% to 73% when people wearing mask while people not wearing a mask can go from 58% to 66%. From the results, we can say that this model have pretty good level of confidence for mask detection system. As for the position that can improve the accuracy for mask detection, Right, Center Left with the distance of 40 cm to 80 cm were the best position for the system to detect faces.

The temperature measurement result from MLX90614 infrared temperature sensor and medical grade temperature sensor shows there was a gap from the reading. This gap becomes wider as the distance of target from the temperature sensor further away. The medical grade temperature sensor has quite a consistency in its reading while MLX90614 temperature sensor that was used in this study the reading drops as the distance of target form the temperature sensor becomes further. The measurement from medical grade sensor does not have huge gap when measure at the back of the hand and on the forehead.

As for line detection system, the tape that was used for the line reference of IR sensor using 3.5cm width can run perfectly without stopping. The value of 60 for duty cycle was chose as it is the slowest speed the motor can go and the robot was less shaky in that speed. Based on Table 4, the best tape size to use in this study is 3.5cm because the movement of robot was smoother compares to other 2 sizes where 2 cm can make the robot movement not quite consistent when it goes forward while 4.5cm will make it the robot have difficulty at the turning point position.

Based on Table 7, duty cycle of value 60 was chosen in this study as the speed for patrol robot . This is because, the best position for mask detection accuracy is at the distance of 40 cm to 80 cm and beyond than that, the faces are quite hard to detect by the system. The duty cycle value of 60 is the best speed because the time taken for the robot to reach 40 cm near 4 seconds and for it to reach 80 cm, it takes around 6 to 7 seconds. The mask detection system has 4 seconds delay and with the time frame that we got by using the speed of 60 duty cycle, so it gives enough time for the robot to detect face while moving. It also gives enough time for the temperature sensor to detect temperature as it only has 1 second delay.

4. Conclusion

As a conclusion, this project was a success because all of the project's goals were met. This study successfully developed and tested the pre-trained Mobilenet SSD model using the Tensorflow lite algorithm technique. The model was evaluated on a Raspberry Pi 3 b+ and, despite a 4 second delay for each video input frame, it can run as a real-time application. Temperature measurement system can record successfully people temperature even though the readings are quite differs from medical grade temperature sensor reading. Finally, the line detection system helps the robot to move on its own by following the black tape which become the references for the IR sensor.

Acknowledgement

The authors would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] The, S., Ai, S., Dalle, I., & Galleria, S. (2014). *Deep Learning in Neural Networks : An Overview*. 1–88

[2] S. J. Pan and Q. Yang, (2010) "A Survey on Transfer Learning," in *IEEE Transactions on Knowledge and Data Engineering*, vol. 22, no. 10, pp. 1345-1359

[3] Liu, W., Anguelov, D., Erhan, D., Szegedy, C., Reed, S., Fu, C. Y., & Berg, A. C. (2016). SSD: Single shot multibox detector. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 9905 LNCS, 21–37

[4] Zaman, H. U., Bhuiyan, M. M. H., Ahmed, M., & Aziz, S. T. (2016, January). A novel design of line following robot with multifarious function ability. In *2016 International Conference on Microelectronics, Computing and Communications (MicroCom)* (pp. 1-5). IEEE

[5] Keränen, K., Mäkinen, J. T., Korhonen, P., Juntunen, E., Heikkinen, V., & Mäkelä, J. (2010). Infrared temperature sensor system for mobile devices. *Sensors and Actuators A: Physical*, *158*(1), 161-167