Implementation of Transfer Learning-based Mask Detector on Smart-Locked Door with Raspberry Pi

by Eki 10

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***Abstract*— The status of covid 19 as a pandemic by WHO has not been revoked, not even downgraded into endemic. The masks and vaccinations are still consider as "the most effective weapons" against the virus. Using masks indoors is still mandatory. This paper designed a device that turns an ordinary door into a smart door that only gives access to people who wear masks. A camera and monitor is installed in front of the exisiting door and solenoid lock is added as additional displays. TensorFlow and OpenCV on Raspberry Pi is used to detect whether someone is wearing a mask or not. Based on the test results, the effective distance of the device is 2,7 m with 98,11% accuracy.**

***Keywords*— Mask Detection, Tensow flow, Raspberry Pi, Machine Learning.**

I. Introduction

Up to the time this paper was written, WHO still has not revoked the pandemic status of the Covid-19 virus. New variant of virus still coming out from countries all over the world[1]. The good news is that infection and death rate has already under control. In mainly because the vaccination rate in the world keeps increasing, making the herd community scenario being closer to reality.

Aside from vaccination[2], wear a mask is still consider as "the most effective weapon" in fight against covid 19 virus. While the obligation for wearing a mask outdoor has already eliminated, wear a mask indoor remains mandatory. It is one concrete preventive act as citizen to keep the spread of virus remains low in Indonesia.

Ever since the first outbreak of Covid-19, people are already competing to built a face mask detector with various methods and devices that suitable them most, because everyone and everyplace has their own resources and requirement. Several algorithm has been used in detecting face mask; You Only Look Once (YOLO)[3][4], Haar-Cascade[5][6], Deep Learning-CNN[7], Retina Face Mask[8], or even the combination of them[9].

This research using Transfer Learning method to optimized object detection process, since it has a short training time[10][11]. Transfer learning is suitable for a simple dataset, making it actually implementable in a real-world context, which is exactly what this paper is focused on.

Other researches has built face-mask classifier combining with notification in Telegram[8], or alarm/buzzer[7], or make a prototype with small door[12]. This research emphasize on the implementation in the real environment. In this case, we installed the Raspberry Pi in our Electrical Engineering Laboratory Door to prevent student from not wearing mask inside the lab when during the learning process. The output is solenoid lock, which will open only and if only the visitor use face-mask.

II. Research Method

This study mainly aims to prevent airborne transmission of the virus indoor. The idea is to install a device on the existing door so that the door will only open if and only if the visitor is wearing a mask. The method used is transfer learning, which is use pre-training when doing training so that the layered and long train process can be completed faster. The initial step is the collection of photo data of people in masks and not. Then training is carried out using deep learning with the Tensorflow / Keras library. The train results will be stored on disk / memory in the form of a model which implemented on the Raspberry Pi, with a webcam serve as sensor and a solenoid door lock as output. The overall system diagram block is found in Fig 1.

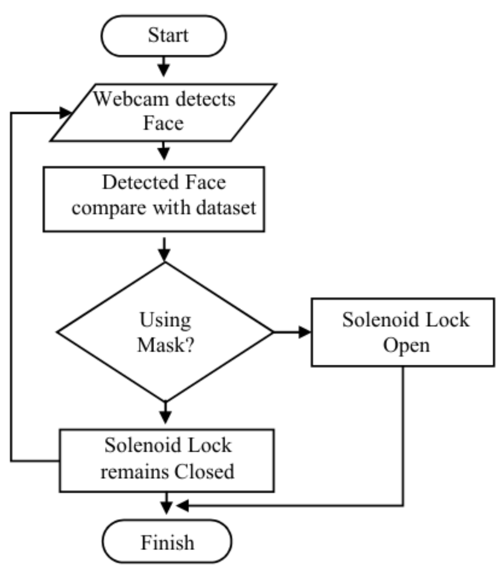
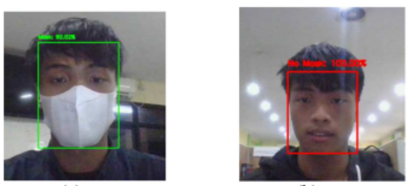


Fig 1. Block Diagram of system

The object used in this paper is the captured image from webcam. The device works as follows : the webcam capture the image of visitor and then displayed it in the monitor. The image then compared with the dataset from the pre-trained model. If a visitor is detected using mask, a green bounding box (Fig 2.a) will be drawn in the monitor and Raspberry Pi will instruct solenoid lock to open. But when someone is detected unmasked, a red bounding box will be drawn in the monitor (Fig 2.b) and solenoid lock remains close. A number will appear in the top of the bounding box, showing the similarity of the image inside the coloured box with the data set. A relay is installed in the top of the door, thus when the visitor close the door, the relay will be pushed automatically and the lock will return in close condition. The hardware design can be seen in Fig. 3.



(a) (b)

Fig 2. Sample of (a) masked and (b) unmasked face

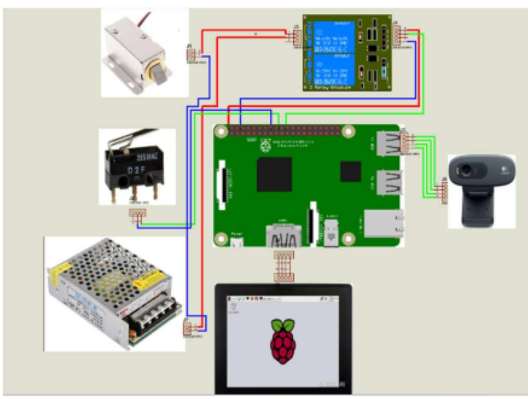


Fig 3. Hardware design

The design consists of Raspberry Pi 4 as the main processor with 8 GB RAM. We decided to use Raspberry Pi 4 because the process required high computational cost, otherwise the detection may experience significant lagging. The sensor is Logitech Webcam and WaveShare monitor is used to show the output of camera. Next, a relay module is connected to limit switch to control solenoid lock. Every time the solenoid lock is open, the switch has to be pushed so that solenoid lock return to its initial position.

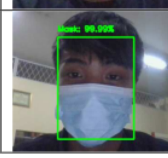
III. Result and Discussion

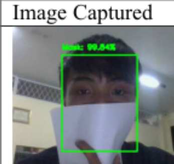
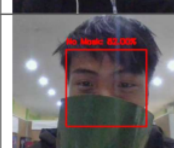
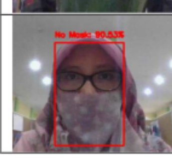
This section contains two main parts, first is discussing the model itself, and then about the performance after the device is implemented.

A. Model Evaluation

Before implemented in the Raspberry, the dataset is tested in the computer first. TensorFlow is used for learning from 1916 image of masked people and 1925 image of unmasked people. We tested the model with 3 scenarios, first to find what kind of mask that works best, second one is to test the model with another objects that might resembled mask, and the last one is test the model with various ways and condition of wearing mask. The result is as shown in Table 1-3.

TABLE I. Experiment Result With Various Mask Colour And Type

No	**Treatment**	**Image Captured**	**Result**
1	Green KF 94 mask		Mask 99,64%
2	White Duck bill mask		Mask
3	Blue Surgical Mask		

No	Treatment	Image Captured	Result
1	White Paper		
2	Hands		
3	Books		
4	Veil		

Of all the masks that used in the experiment, none of them are failed to detect. It means that the model can run correctly regardless of mask colour and type. In the second experiment, the result is not always the same. For instance, face with hands and veil are sometimes detected as mask, and sometimes not. It most presumably happen because of the training data used only contain two classes (masked and unmasked face) and does not contain images of person with those object on face. This result is pretty much the same with the last scheme, where the result is inconsistent. Especially when we lower the mask under the nose, sometimes we got green box and sometimes red. This mostly because we did find some images in "masked" class are an image of people who wears the mask under the nose.

This is essential because actually what can be effective in preventing the spread of the virus is when masks are wear correctly in the face. This means that if someone who is not wearing a mask properly is still allowed to enter, the model will be inadequate. The proposed solution is by adding another data category for data training, including image of face with another object, and various position of wearing a mask. Then we can set a rule that only a person with a correct position of mask can be classified into "masked". That way we can make a more precise model.

TABLE II. EXPERIMENT WITH LIGHTING VARIATION

No	Treatment	Image Captured	Result
1	Natural Light		
2	Low Light		
3	Lower mask under the nose		
4	Lower mask under the mouth		

The model only works with suitable lighting, for when the light is low, camera cannot capture any image so that nothing can be compared with the dataset. Hence, a LED is added above the webcam to assist the lighting when the experiment is held on the evening, since the laboratory is open until 9 pm.

B. Implementation result

Device implementation in the laboratory door is shows in Fig. 4. Raspberry Pi 4 and solenoid lock is installed inside the door while the webcam and monitor is sticked in front of the door.

Fig 4. Implementation of Face Mask Detector in Electrical Engineering Laboratory Door

After the device is installed completely on the door, first experiment is to find the effective distance between camera and visitor. This camera is installed in the inner door of laboratory, where the distance of main door and inner door is 2,7 m, making it the maximum testing distance. The experiment is performed by stepping backwards every 30 cm.

TABLE III. EXPERIMENT RESULT OF EFFECTIVE DISTANCE TESTING

No	Distance (cm)	Result
1	30	Detected
2	60	Detected
3	90	Detected
4	120	Detected
5	150	Detected
6	180	Detected
7	210	Detected
8	240	Detected
9	270	Detected

Experimental results show that even at the farthest distances, the camera is still able to detect masks from visitors, as long as the lighting is adequate (Table 4).

Next step is to find out the performance of the implemented device. It involve 25 respondents, each person is tested using 3 kind of mask and the experiments is divided into two kinds of lighting conditions. Mask 1 is white KF 94, Mask 2 is black duck-bill mask and mask 3 is blue surgical mask. All of the experiment is successfully detected as masked face and the solenoid lock is always open when the green box appear in the monitor.

TABLE IV. EXPERIMENT RESULT OF DEVICE IMPLEMENTATION

Respondent	Mask 1	Mask 2	Mask 3
1	100	99	100
2	99	99,7	100
3	99,9	99,6	99,95
4	100	99,97	99,9
5	99,45	99,77	99,5
6	99,97	99,75	100
7	94,56	97,94	99,99
8	99,74	99,82	100
9	99,81	93,55	100
10	99,97	95,72	99,95
11	89,32	98,42	85,49
12	99,75	97,73	99,85

Respondent	Mask 1	Mask 2	Mask 3
13	89,79	97,42	99,34
14	94,92	97,29	99,74
15	83,92	87,10	99,56
16	99,77	97,24	99,72
17	97,86	92,48	99,96
18	90,48	99,72	99,86
19	100	99	100
20	100	99	100
21	99	99	99
22	99	99,7	100
23	99	99	100
24	100	99	99,94
25	100	96	99

Table 5 contains the experiment result, with the number inside the table is the successful percentage of mask detection. The number represent the similarity between the image captured and the dataset. The average accuracy of all data is 98,11%, with highest value of 100% and lowest value is 83,92%.

While the device accuracy is highly acceptable, there is still room for improvement. The door is still needs to open and close manually, making a virus transmission still possible to happen through door handle. Thus an additional tool can be added to make the door close automatically, for instance a hinge hidarulic.

IV. CONCLUSION

This study has succeeded in designing a smart door that can classified masked and unmasked people with accuracy of 98,11 %, regardless of colour and type of mask. Instead of making a prototype, we have achieved to implement a face-mask model to the existing door, making it easy, affordable and suitable for academic environment (since we don't need to buy and install a new door). When the experiment is performed in the evening, we use LED for lightning assistance, and the result as just the same with morning experiment. The solenoid lock works perfectly well with 100% accuracy, which means every time a visitor is detected using mask, the solenoid lock always open.

However, there are some issues that draws attention, concerning the model dataset. When the model is tested with non-mask object, it still classified it as mask. It can lead to a misuse of this device because the visitor can use other object to open the lock. Another one is when the mask is not properly wear, for instance when the nose is still visible, the model still consider it as masked people, whereas the mask is only effective when it wear correctly. Most presumably because the image data used for training does not contain images of people with other object and the wrong position of mask, for the model design does not accommodate that kind of possibility. Thus the solution is make a new model with more categories so that it can identified object other than mask and classified it as "unmasked". This can be done in a further research.

Another improvement, database can be added to store the image captures, so that it can be a training data for other project. Also we can add hidraulik hinge in the top of the door so it can close automatically.

REFERENCES

[1] J. N. Bhiman, A. Glass, D. P. Martin, B. Jackson, and A. Rambaut, "Emergence of SARS-CoV-2 Omicron lineages BA.4 and BA.5 in South Africa," *Nat. Med.*, 2022.

[2] R. M. El-Shabasy, M. A. Nayel, M. M. Taher, R. Abdelmonem, K. R. Shoueir, and E. R. Kenawy, "Three waves changes, new variant strains, and vaccination effect against COVID-19 pandemic," *Int. J. Biol. Macromol.*, vol. 204, no. January, pp. 161–168, 2022, doi: 10.1016/j.ijbiomac.2022.01.118.

[3] A. Kannan, "Face mask detection using yolo v5," *Int. J. Nov. Res. Dev.*, vol. 7, no. 5, pp. 390–395, 2022.

[4] W. Jian and L. Lang, "Face mask detection based on Transfer learning and PP-YOLO," *2021 IEEE 2nd Int. Conf. Big Data, Artif. Intell. Internet Things Eng. ICBAIE 2021*, no. Icbaie, pp. 106–109, 2021, doi: 10.1109/ICBAIE52039.2021.9389953.

[5] G. A. Anarki, K. Auliasari, M. Orisa, and F. T. Industri, "Penerapan Metode Haar Cascade Pada Aplikasi Deteksi Masker," *JATI (Jurnal Mhs. Tek. Inform.*, vol. 5, no. 1, pp. 179–186, 2021.

[6] F. L. Ahmad, A. Nugroho, and F. Suni, "Deteksi Pemakai Masker Menggunakan Metode Haar Cascade Sebagai Pencegahaan COVID 19," vol. 10, no. 1, pp. 13–18, 2021.

[7] T. Radhi, M. Fitrah, and Y. Nurdin, "Rancangn Bangun Pengembangan Pintu Otomatis Pendeteksi Masker dan Suhu Tubuh Menggunakan Raspberry Pi 4," *KITEKTRO J. Komputer, Inf. Teknol. dan Elektro*, vol. 6, no. 2, pp. 7–14, 2021.

[8] M. Mu'minim Lambacing and Ferdiansyah, "Rancang Bangun New Normal Covid-19 Masker Detektor Dengan Notifikasi Telegram Berbasis," *DINAMIK*, vol. 25, no. 2, pp. 77–84, 2020.

[9] M. Loey, G. Manogaran, M. Hamed, N. Taha, N. Eldeen, and M. Khalifa, "A hybrid deep transfer learning model with machine learning methods for face mask detection in the era of the COVID-19 pandemic," *Measurement*, vol. 167, no. May 2020, p. 108288, 2021, doi: 10.1016/j.measurement.2020.108288.

[10] A. Oumina, N. El Makhfi, and M. Hamdi, "Control the Covid-19 Pandemic: Face Mask Detection Using Transfer Learning," *2020 IEEE 2nd Int. Conf. Electron. Control. Optim. Comput. Sci. ICECOCS 2020*, 2020, doi: 10.1109/ICECOCS50124.2020.9314511.

[11] F. Mercaldo and A. Santone, "Transfer learning for mobile real-time face mask detection and localization," *J. Am. Med. Informatics Assoc.*, vol. 28, no. 7, pp. 1548–1554, 2021, doi: 10.1093/jamia/ocab052.

[12] M. Abdul Rahman Irham Harfi and D. A. Prasetya, "Prototipe Pendeteksi Masker Pada Ruangan Wajib Masker Untuk Kendali Pintu Otomatis Berbasis Deep Learning Sebagai Pencegahan Penularan Covid-19," in *Simposium Nasional RAPI XIX Tahun 2020 FT UMS*, 2020, pp. 47–55.

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