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Security System for Door Locks Using YOLO-Based Face Recognition

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***Abstract*—In the age of technological advancement and sophisticated algorithms that make people's life easier, a facial recognition smart lock is a system that employs one of the aforementioned algorithms and addresses a security concern in smart home technologies. It can be installed near doors to monitor homes, companies, and universities. The issue with current face recognition smart lock solutions is that they are not fast and precise enough. The door is a component of a building whose needs to be considered in security to prevent the attempt theft. Buildings that have a lot of space must have a door with a strong security system, one of it is a hotel. The tool that often used to access hotel rooms is RFID. The RFID cars have many drawbacks, including that guests often leave their RFID cards in the room so they can no longer enter the room and must report to the receptionist first, the RFID cards also easily lost so guests who lose the RFID cards will be fined as card replacement fee. Therefore, a door security system was created using face recognition with the YOLO algorithm. The YOLO algorithm is used to detect the face of anyone who wants to access the door. The test result is system can detect faces with an accuracy rate of 94,4%. This face recognition digital lock enhances security and convenience.**

***Keywords*— Security system, face recognition, YOLO**

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I. Introduction

Security systems in this day and age are increasingly sophisticated [1]. Doors are also a component of a building whose security needs to be considered to avoid the entry of someone who wants to make theft attempts [2]. Replacing mechanical locks with technology-based electronic locks is one way to maintain door security [3]. The security system that is currently often used is face recognition technology [4]. One of the buildings that must have a high security system is a hotel.

Hotel is a building that provides lodging services for guests and all facilities in it are intended for the general public. The method used to access the room is with RFID or with a password [5]. However, RFID or passwords also have several disadvantages, one of which is the weak memory of each individual [6]. RFID cards are often left in the room so that guests cannot enter the hotel room and must report to the receptionist. As reported on the website of the Ministry of Religious Affairs of the Republic of Indonesia, it was stated that one of the Indonesian Hajj pilgrims was unable to enter the hotel room because the RFID card was left in the room. Reporting from Kompas.com, for guests who lose the entry access card must replace paying a fine depending on the policies of each hotel. As in the Bandung Anti Purnamasar Hotel, the hotel sets a fine of IDR 50,000 for the loss of the hotel room key. In addition, RFID cards can also be duplicated by irresponsible people to break into the room door [7]. Reporting from the news reported on detiknews, the case of money theft that occurred at Hotel Nagoya Plasa Batam was carried out with the mode of duplicating hotel room keys by hotel staff.

The implementation of face recognition has been carried out by many researchers, one of which is [8]. In addition, in research [9] and [10] the results obtained are a series of hotel room locking systems and devices using IoT-based E-KTP that can facilitate and help guests and hotel staff to open and close hotel rooms. In previous research [11], the method used is You Only Look Once (YOLO) version 3 which can simplify and speed up the face recognition process. In research [12], the method used in research is the fisherface method. The results obtained from this study can distinguish faces with a percentage of the success of the resulting system is 80% for each user. Research [13], discusses the M-YOLO Algorithm which is used to detect the number of cars in the parking lot [14], [15]. The results obtained are the Modified YOLO (M-YOLO) algorithm can detect the number of cars correctly seen from the 100% accuracy results. Research [16], also uses the YOLO method with the results obtained is the accuracy level of face identification with various viewing angles has 100% accuracy. The angles of the faces tested were from the front, right, left, top, bottom with a distance of approximately 5 cm to 100 cm. Research [17], making face recognition for navigation that gets good results with 90% accuracy. In this study made a navigation application that utilizes face recognition in order to facilitate blind people to move indoors and outdoors. Research [18] discusses the YOLO method that has been applied to detect objects on Automated Teller Machine (ATM) machines. Researchers make object detection when the user enters the ATM. The results obtained are that when a specified object is detected such as helmets, hats, masks, sunglasses, and cigarettes, YOLO will sound "sorry, please release + object name + you". Research [19], discusses the YOLO method used to monitor and detect objects. The result obtained is that the YOLO algorithm is successful in detecting objects. Research [20], discusses a security system that uses face recognition. The tool used is Raspberry Pi. The results obtained by the system can work quickly and accurately. The accuracy obtained from the test results is 100% with a time of 0.5 - 0.8 seconds. In research [21] discussing a home door security system using ESP32 Cam based on face recognition algorithms is intended so that access to entering the house can be safer by distinguishing between residents and non-residents of the house.

From some of the studies described above, it is known that the face recognition framework that is currently developing is capable of producing high accuracy [22]. One of them is YOLO, which provides high performance and has been widely used. The YOLO method can be used for face recognition which can be utilized to improve security access [23]. Therefore, this research proposes a security system on door locks with facial recognition for access validity. This system consists of hardware including webcam, ESP32, and electronic lock. Meanwhile, YOLO as the software responsible for face recognition is run on a cloud server [24].

II. Materials and Method

A. *Description of Door Security System*

The door security system using face recognition is made with the aim of being able to improve the security system [25]. This system has an output in the form of opening a solenoid lock if the prediction made reaches ≥ 50%. This research is designed using several components [26]. The main component used is ESP32cam as the microcontroller. To determine the performance of the system, testing will be carried out with several scenarios, namely testing with face recognition accuracy, testing with reference to distance variations, testing the system with two people at once, and testing with variations in face angle.

B. *System Model*

In designing a door security system using face recognition carried out in the early stages, namely planning to make a system block diagram to the system circuit scheme [27]. The purpose of designing a system block diagram is to facilitate the manufacturing process of each part, so that the appropriate system will be formed. The system model that has been made can be seen in Figure 1 below.

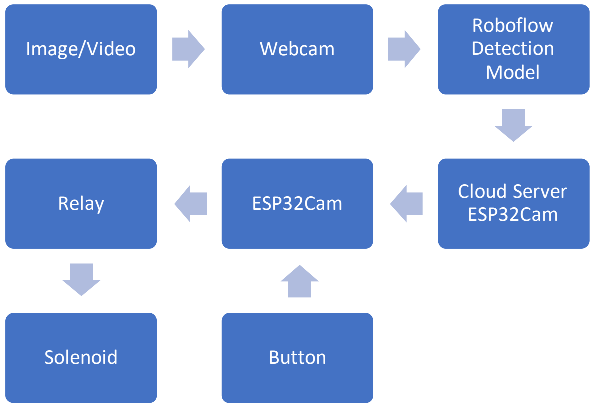


Fig. 1 System Model

The way the system works from the block diagram above is as follows:

a. Webcam takes pictures in real time.
b. Images that have been taken are then predicted using the roboflow model.
c. If the registered face is detected, an HTTP Request command will be sent to the ESP32cam cloud server.
d. When ESP32cam receives the HTTP Request command, ESP32cam will send a command to the relay.
e. After the relay gets the command, the relay will activate the solenoid lock. Then the face detection process is complete.
f. When the button is pressed, ESP32cam will receive a signal if the button is being pressed, then ESP32cam will send a command to the relay.
g. After the relay gets the command, the relay will activate the solenoid lock.

During the prediction process using the roboflow model, several stages are needed first so that the system can make predictions. The first stage is dataset collection. Datasets are collected from 12 different respondents. After completing collecting the dataset, what is done is processing the dataset. Dataset processing is done using the roboflow platform. Figure 2 below is a flowchart of dataset processing.

The process of processing the dataset in roboflow is as follows:

1) Image. At this stage what is done is to enter or upload face images that have been taken by a smartphone camera. Each face has approximately 200 photos. When taking pictures, the distance between the camera and the respondents was around 30 cm. The smartphone that used for taking pictures was the iPhone 11.

2) Bounding Box. At this stage a bounding box will be given in roboflow which functions to mark the object to be detected. Furthermore, on each face a labeling process will also be carried out. The name labeling consists of 12 classes, namely Salwa, Kartika, Ano, Richard, Dira, Aca, Tegar, Rita, Tama, Ruqoi, Bummu. After labelling, the image will be preprocessed by reducing the image size so that the level of roboflow delay in recognizing faces can be better overcome. If the size is too large, roboflow will take longer.

3) *Training*. After completing the bounding box and labeling, the next process is training the model on the entire dataset. The training process is carried out to recognize object detection as expected with a high level of accuracy. Training is done directly in roboflow using the YOLOv5 model. The number of datasets trained is 40.000 photos with 12 classifications dan training was carried out 3 times.

4) *Classification Result Database*. After the training is complete, there will be a classification result database containing a collection of data that has been trained to produce output that matches the predetermined class. Then the user will get an API Key containing datasets that have been trained. The API Key can be entered into the program [28] in jupyter.

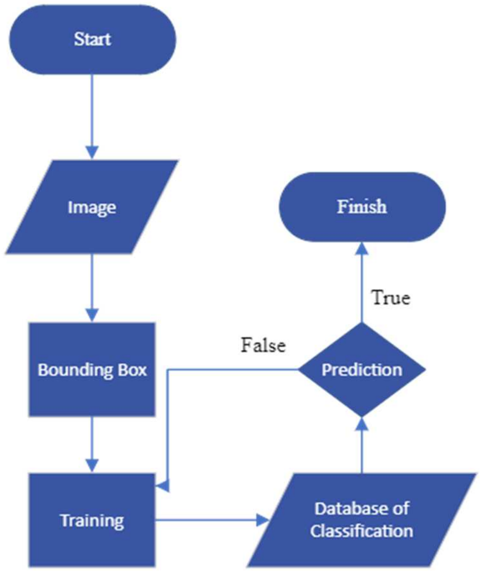


Fig. 2 Flowchart of data set processing

C. *Software Suites*

In this study, the design of a door security system using face recognition was made using jupyter [29]. The camera used to capture images is a laptop webcam. The programming language used is python. Python loads the roboflow model using the API Key obtained after completing training the model [30]. Then the label registered in the database is also included according to the class name in the roboflow database to get labelling when prediction is done. Then the system will make a prediction and draw a bounding box. The bounding box is in the form of a rectangle which contains the name label and confidence score. Confidence used in this research is 50%.

Every image that has been received by the webcam, a prediction will be made by the system. If a prediction is detected, a bounding box will appear along with the name label and confident score. If the prediction label is registered, the ESP32cam will receive a command to save the image. The prediction_matrix file that stores the image is shown in Figure 3 below.

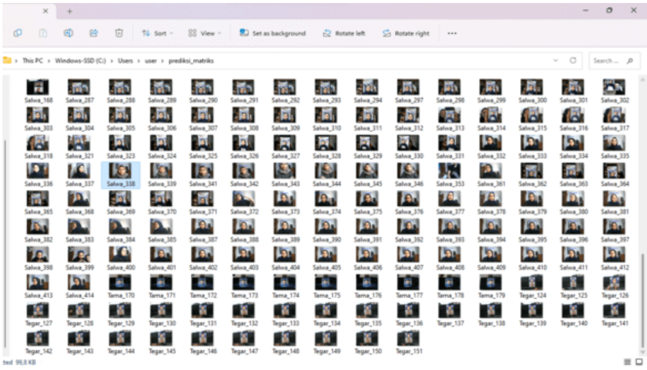


Fig. 3 Test results

D. *Hardware Set*

This door security system using face recognition consists of several components, namely ESP32cam, FTDI232, Relay, Solenoid Lock. This system uses ESP32cam as its microcontroller. The schematic circuit of the proposed door security system can be seen in Figure 4 below.

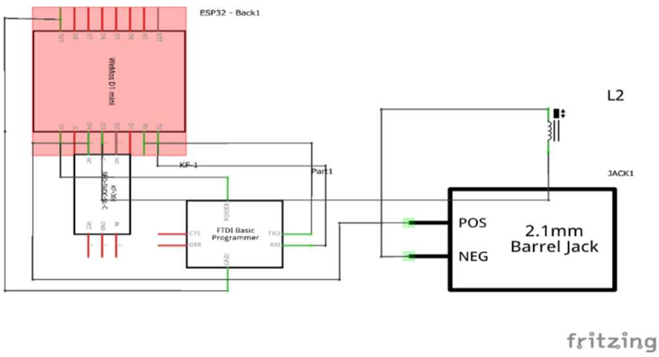


Fig. 4 Systematic circuit of the system

The function of each component in the door security system schematic circuit is as follows:

a. ESP32cam, as a microcontroller used to control electronic devices. Python on ESP32cam will predict the model that is being tested with the training model.
b. FTDI, as a link between ESP32cam and laptop, because ESP32cam does not have a USB port.
c. Relay, as a connector and breaker of electricity. In this study, the relay functions to activate and turn off the door lock solenoid. The command to activate and turn off the door lock solenoid sent by ESP32cam.
d. Push button, as a button that connects and disconnects the flow of electricity. In this study the push button is used to activate and turn off the door lock solenoid.
e. Barrel Jack, as a medium for providing electrical voltage to Arduino.
f. Solenoid, functions as an electronic lock actuator. The electronic lock will work when it gets a voltage of 12V.
g. The adapter is used as the power supply or main voltage source of the system.

III. RESULTS AND DISCUSSION

This section contains a presentation of the results of the realization and testing of the system followed by a discussion for each test. System testing is intended to determine the success rate of the system design that has been made. Testing is done using images on smartphones and real time capture of respondents' faces. Testing is also carried out on 12 classes that have been classified in the roboflow platform. The class consists of Salwa, Kartika, Ano, Angel, Dira, Richard, Aca, Tegar, Rita, Bummu, Tama, and Ruqoi. The test scenarios performed are listed in Table I below.

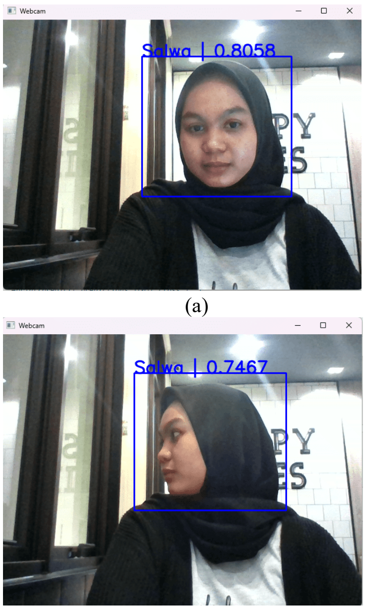
TABLE I
TEST SCENARIO

No.	Scenario
1	Testing based on face recognition success rate
2	Testing with reference to distance variation
3	Testing the system with two people at once
4	Testing with face angle variations

When the program is first run, a new window will appear displaying the camera scan. If the system successfully finds the face area, it will continue with the face recognition process. Next is decision making by displaying the name label. The confidence threshold used in this test is 50%. If the predicted image has a confidence score below 50%, the door lock solenoid will not open. The prediction time required is approximately one second.

A. Testing the Accuracy of the System in Finding Face Areas

This test aims to determine the accuracy of the system in finding the face area. Figures 5 and 6 below are the application display when run where the bounding box is visible, which means the system is able to detect the face area.



(a)

(b)

Fig. 5 (a) Front View Face Recognition Testing (b) Side View Face Recognition Testing

The YOLO method in face recognition results can detect well and the confidence obtained is high. The YOLO method can also detect faces in front or side view even with different confidence scores.

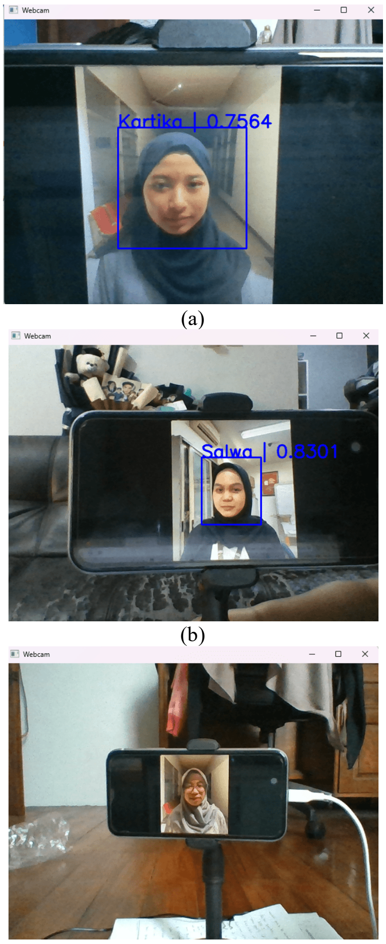
B. Testing Based on Distance

In testing through a webcam camera, there are references that are applied in the data collection process. The first reference carried out is with a reference camera distance of about 10 cm, 20 cm, and 30 cm. The purpose of this test is to find out how far the webcam can detect faces. Table II below is the result of data collection using the camera distance reference.

TABLE III
TEST RESULTS WITH REFERENCE DISTANCE

Respondent	Distance (cm)	Detected	Undetectable
1	10	√	
	20	√	
	30		√
2	10	√	
	20	√	
	30		√
3	10	√	
	20	√	
	30		√
4	10	√	
	20	√	
	30		√
5	10	√	
	20	√	
	30		√

The data collection process with reference to the distance of the object with the camera is carried out by taking a distance of 10 cm, 20 cm, and 30 cm. The data collection process was carried out with five different respondents and each respondent was tested to take data at a distance of 10 cm, 20 cm and 30 cm. For example, taking pictures from various camera distances can be seen in Figures 6 (a) and (b).



(a)

(b)

(c)

Fig. 6 (a) Testing at a distance of 10 cm (b) Testing at a distance of 20 cm (c) Testing at a distance of 30 cm

From the data taken above, it shows that the results of the YOLO method can detect good faces at a distance of 20 cm. Confident score obtained by python at the highest touches 80% while the lowest touches 50%, so if the confident score ≥ 50% solenoid door lock will open. Because the webcam used has the capacity to capture images with a slight blur, the testing distance of 20 cm sometimes the image must be slightly zoomed so that the system can detect faces. Figure 6 (c) is a test scenario at a distance of 30 cm. But at a distance of 30 cm the image cannot be detected. Thus, the face recognition process with a distance of 10 cm and 20 cm is still running well. In accuracy testing, face recognition has a different percentage of data at each distance. However, the overall average result can still be calculated for each respondent.

C. Testing Two Faces at Once

Testing with two people at once on a webcam is only for the purpose of testing the system. The scenario carried out in this test is to combine two photos with two different people registered in the database, and with only one person registered in the database. This test is done by showing two images on a smartphone where both images are in the roboflow database. The running results of the test with two faces registered in the database can be seen in Figure 7 below.

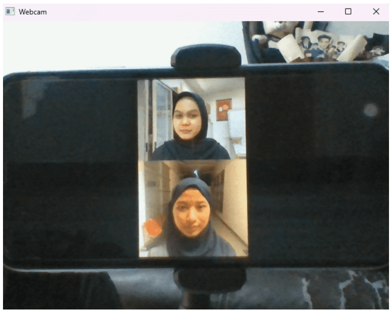


Fig. 7 Test results with two faces registered in the database

In this test, the result obtained is that the YOLO method cannot recognize all faces in the image, this is indicated by the absence of a rectangle containing name labels around the face. Testing with one of the faces registered in the database is done by showing two images on a smartphone, one of which is in the roboflow database. The running results of the test with one of the faces registered in the database can be seen in Figure 8 below.

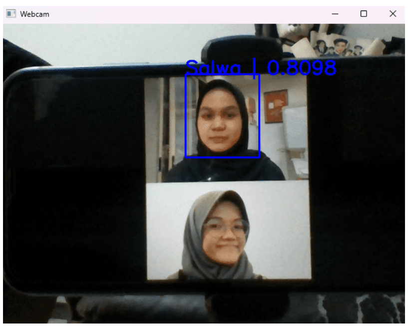


Fig. 8 Test results with one face registered in the database

The test results show an image where only one of the faces is registered in the roboflow database. The test results obtained are that the YOLO method can still recognize faces registered in the database, this is indicated by the rectangle around the face area containing the name label. In testing with this distance reference, one of the references used in recognizing faces is the camera angle reference. The data collection process is taken with the face looking front, looking right, and looking left. Testing is done using images on a smartphone. Table III below is the test result based on the camera angle.

TABLE IIIII

TEST RESULTS WITH REFERENCE TO CAMERA ANGLE

Respondent	Face View	Detected	Undetectable
1	Front view	√	
	Right view	√	
	Left view	√	
2	Front view	√	
	Right view	√	
	Left view	√	
3	Front view	√	
	Right view	√	
	Left view	√	

The data collection process in this angle variation reference was carried out with three different respondents, each of which was tested with three facial angle scenarios, namely front view, right view, and left view. Figures 8 and 9 below are the test results on the first respondent, namely the "Salwa" classification.

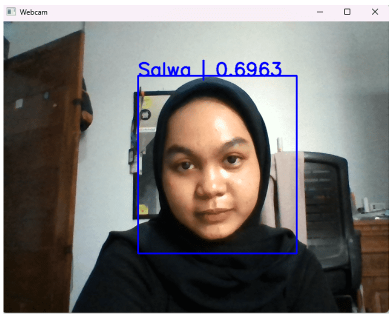


Fig. 9 Front view of salwa testing

Fig. 10 Side view of salwa testing

The confusion matrix is a table used in classification to evaluate the performance of a model. It summarizes the results of a classification problem, showing the number of true positive (TP), true negative (TN), false positive (FP), and false negative (FN) predictions made by the model. In the context of face recognition: (1) True Positive (TP). The model correctly identifies a face as belonging to a specific individual. (2) True Negative (TN). The model correctly identifies that a given image does not contain the face of the individual in question. (3) False Positive (FP). The model incorrectly identifies a face as belonging to a specific individual when it does not. (4) False Negative (FN). The model incorrectly identifies that a given image does not contain the face of the individual in question when it actually does. The confusion matrix is typically organized as Table IV follows.

TABLE IVV
THE CONFUSION MATRIX

	Predicted	
	Positive	**Negative**
Actual positive	TP	FN
Actual negative	FP	TN

Accuracy is a measure of how often the model is correct, calculated as the sum of true positives and true negatives divided by the total number of predictions. High accuracy indicates that the model is performing well in both identifying positive and negative instances. Accuracy equation is shown in (2).

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} x\ 100\% \qquad (1)$$

Precision is the proportion of correctly identified positive instances out of the total instances predicted as positive. It gives an indication of how many of the predicted positive instances are actually true positives. Precision is particularly important in face recognition because it measures the model's ability to avoid false positive identifications. Precision equation is shown in (2).

$$Precision = \frac{TP}{TP+FP} x\ 100\% \qquad (2)$$

The confusion matrix provides a comprehensive view of the model's performance, and accuracy and precision are metrics derived from the confusion matrix to assess the overall correctness and reliability of a face recognition system.

F1 score is a metric that combines both precision and recall into a single value. It's particularly useful when you want to balance the trade-off between precision and recall in a classification task. The formula for F1 score is shown in (3).

$$F1 = 2x\frac{PrecisionxRecall}{Precision+Recall} \qquad (3)$$

The results of the test in the picture above show that the YOLO method has succeeded in recognizing faces from the front view and left view accurately and well. Confident score obtained when taking data looks left looks decreased than the front face, but still above 50% so that the solenoid door lock can still open. For testing on the second and third respondents have the same results as the first respondent, namely the YOLO method managed to recognize the face from the front view and left view accurately and well, although the confident score on the side view decreased. To find out what the average precision and accuracy obtained in testing with reference to variations in the angle of the front, right, and left.

$$Precision = \frac{TP}{TP+FP} x\ 100\% = \frac{34}{36} = 94,4\%$$

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} x\ 100\%$$

$$Accuracy = \frac{34+0}{34+0+2+0} x\ 100\% = \frac{34}{36} x\ 100\% = 94,4\%$$

$$F1\ Score = 2x\frac{PrecisionxRecall}{Precision+Recall}$$

$$F1\ Score = 2x\frac{(\frac{TP}{TP+FP})x(\frac{TP}{TP+FN})}{\frac{TP}{TP+FP}+\frac{TP}{TP+FN}}$$

$$F1\ Score = 2x\frac{(\frac{34}{36})x(\frac{34}{34})}{\frac{34}{36}+\frac{34}{34}} = 2x\frac{(1)}{1.94} = 103\%$$

High F1 score indicates a good balance between correctly identifying positive instances (faces) and avoiding misidentification of negative instances (non-faces). The next test is the confusion matrix. The matrix aims to find out how many classes are detected for the face in each class. The images used for the matrix are images that are not in the dataset. This aims to find out whether the YOLOv5 model can detect other image variations besides those in the dataset. Figure 11 below is the result of the matrix obtained for 12 classes in roboflow.

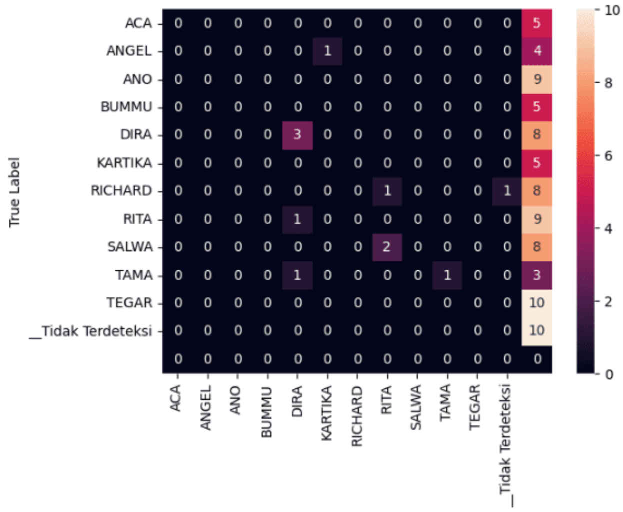


Fig. 11 Confusion matrix

Based on the picture above, from the results of testing the roboflow model that has been trained, there are still many faces that are wrongly predicted. For the label _Not Detected_ means that the entered image has no bounding box, which means that the image is not detected at all by the YOLOv5 model. Only Dira's face has three correct predictions. Table V below is the result of the confusion matrix in Figure 11 above.

TABLE V
CONFUSION MATRIX RESULT

Respondent	Prediction	
	True	**False**
Aca	0	0
Angel	0	1
Ano	0	0
Bummu	0	0
Dira	3	0
Kartika	0	0
Richard	0	2
Rita	0	1
Salwa	0	2
Tama	0	2
Tegar	0	0
Undetectable	**0**	**0**

IV. Conclusions

This research has designed and realized a digital door lock with face authentication. Face recognition is done in real-time using the YOLO method on the cloud server. Users who are registered and then recognized by the system will activate the solenoid so that the door can be opened. Based on the test results, it is concluded that the roboflow model used in the system produces an accuracy performance of 94.4%. Changes in the distance of 10 cm, 20 cm, 30 cm between the object and the camera are quite influential in the face recognition process. The proposed system optimally detects faces well at a maximum distance of 20 cm while at a distance of 30 cm the accuracy of the system decreases. For testing with two images facing the camera can only be detected if one of the faces is in the training data. Another scenario is testing with the front face has a higher confidence score than the right or left face. With this face recognition-based digital lock, it is expected to increase security and ease of use.

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REFERENCES

[1] H. J. Mun and M. H. Lee, "Design for Visitor Authentication Based on Face Recognition Technology Using CCTV," *IEEE Access*, vol. 10, no. October, pp. 124604–124618, 2022, doi:10.1109/access.2022.3223374.

[2] T.-N. Do, C.-L. Le, and M.-S. Nguyen, "IoT-Based Security With Facial Recognition Smart Lock System," in *2021 15th International Conference on Advanced Computing and Applications (ACOMP)*, 2021, pp. 181–185. doi: 10.1109/acomp53746.2021.00032.

[3] T. V. Dang, "Smart home Management System with Face Recognition Based on ArcFace Model in Deep Convolutional Neural Network," *J. Robot. Control*, vol. 3, no. 6, pp. 754–761, 2022, doi:10.18196/jrc.v3i6.15978.

[4] F. E. Ayo, A. M. Mustapha, J. A. Braimah, and D. A. Aina, "Geometric Analysis and YOLO Algorithm for Automatic Face Detection System in a Security Setting," *J. Phys. Conf. Ser.*, vol. 2199, no. 1, 2022, doi:10.1088/1742-6596/2199/1/012010.

[5] A. Hadi and H. Kasral, "Design and Build a Hotel Service Reservation and Verification System using Web-based e-KTP," *jartel*, vol. 13, pp. 355–359, 2023, doi: 10.33795/jartel.v13i4.640.

[6] A. Khusnah, "Use of Radio Frequency Identification (RFID) System in Supporting Borrowing at Sidoarjo Regency Library and Archives Agency," *J. Pendidik. Adm. Perkantoran*, vol. 6, no. 2, pp. 169–173, 2018.

[7] Mardianus, A. Y. Rangan, and Salmon, "Prototype Smart Security on Doors using RFID with Telegram Monitor NodeMCU Based," *Tepian*, vol. 2, no. 1, pp. 7–11, 2021, doi: 10.51967/tepian.v2i1.293.

[8] M. Y. A. Thoriq, I. A. Siradjuddin, and K. E. Permana, "Human Face Detection Based on One-Stage Detector Using You Only Look Once (Yolo) Method," *J. Teknoinfo*, vol. 17, no. 1, p. 66, 2023, doi:10.33365/jti.v17i1.1884.

[9] Yulisman, N. Iman, E. Sabna, and H. Fonda, "Automatic Door System Using E-KTP Based on Internet of Things (IoT) in Hotel Rooms," *SATESI J. Sains Teknol. dan Sist. Inf.*, vol. 1, no. 2, pp. 85–91, 2021, doi: 10.54259/satesi.v1i2.60.

[10] A. Giovanni, W. Indrasari, and H. Firmasyah, "Face Detection as a Room Security System," vol. XI, pp. 33–38, 2023, doi:10.21009/03.1101.fa06.

[11] H. O. K. Sugianto, M. A. D. Widyadara, and A. B. Setiawan, "Implementation of Face Recognition for Attendance Using Yolo V3 Method," *Semin. Nas. Inov. Teknol.*, vol. 6, no. 2, pp. 50–55, 2022.

[12] F. Y. Sitorus, A. Ahmad, and D. Maryopi, "Design and Implementation of Door Security System Using Face Recognition with Fisherface Method," *e-Proceeding Eng.*, vol. 9, no. 4, pp. 1885–1893, 2022.

[13] Jupiyandi Saniputra, F. R. Pratama, and Yoga Dharmawan, "Development of Car Image Detection to Find Out the Number of Parking Spaces Using Cuda and Modified YOLO," *J. Teknol. Inf. dan Ilmu Komput.*, vol. 6, no. 4, pp. 413–419, 2019, doi:10.25126/jtiik.201961275.

[14] S. Ordonia, "Detecting cars in a parking lot using deep learning," M.S. thesis, San Jose State University, San Jose, CA, USA, 2019.

[15] D. Carrasco, H. Rashwan, M. García, and D. Puig, "T-YOLO: Tiny Vehicle Detection based on YOLO and Multi-scale Convolutional Neural Networks," *IEEE Access*, vol. PP, p. 1, 2021, doi:10.1109/access.2021.3137638.

[16] M. S. Hidayatulloh, "Face Recognition System Using Yolo Method (You Only Look Once)," pp. i–43, 2021.

[17] P. M. Kumar, U. Gandhi, R. Varatharajan, G. Manogaran, J. R, and T. Vadivel, "Intelligent face recognition and navigation system using neural learning for smart security in Internet of Things," *Cluster Comput.*, vol. 22, no. s4, pp. 7733–7744, 2019, doi: 10.1007/s10586-017-1323-4.

[18] A. R. Wasril, M. S. Ghozali, and M. B. Mustafa, "Making Object Detection with You Only Look Once (Yolo) Method for Automated Teller Machine (ATM)," *Maj. Ilm. UNIKOM*, vol. 17, no. 1, pp. 69–76, 2019, doi: 10.34010/miu.v17i1.2240.

[19] F. A. Saputra and J. C. Chandra, "Prototype of Automatic Server Room Security System Using ESP32CAM and You Only Look Once (YOLO) Algorithm," *J. TICOM Technol. Inf. Commun.*, vol. 11, no. 1, pp. 62–67, 2022.

[20] F. A. Azhari and R. Mukhaiyar, "Door Security System Using Biometric Face Recognition Technology," *Ranah Res. J. Multidiscip. Res. Dev.*, vol. 3, no. 3, pp. 166–173, 2021, doi: 10.38035/rrj.v3i3.397.

[21] Humaira, A. Maulana Ibrahim, and A. Alanda, "Cloud Computing-based Home Door Security System," *JITSI J. Ilm. Teknol. Sist. Inf.*, vol. 3, no. 1, pp. 23–29, 2022, doi: 10.30630/jitsi.3.1.56.

[22] M. Sya'roni, "Design of Residual Network Based Face Recognition System," no. 14, pp. 63–65, 2018, doi:10.15900/j.cnki.zylf1995.2018.02.001.

[23] N. Hidayat, S. Wahyudi, and A. A. Diaz, "Individual Recognition Through Face Identification Using the You Only Look Once (YOLOv5) Method," *E-prosiding Semin. Nas. Mat. Geom. Stat. Dan Komputasi*, pp. 85–98, 2022.

[24] D. P. Sari and A. H. Mirza, "the Detection of Face Recognition As Employee Attendance Presence Using the Yolo Algorithm (You Only Look Once)," *J. Darma Agung*, vol. 30, no. 3, p. 41, 2022, doi:10.46930/ojsuda.v30i3.2187.

[25] K. Wahyuddin, D. Wahiddin, and D. . Kusumaningrum, "Door Security Face Detection System Using Arduino-based Convolutional Neural Network (CNN) Method," *Sci. Student J. Information, Technol. Sci.*, vol. 4, no. 1, pp. 15–23, 2023.

[26] A. A. Arrizal, S. W. Suciyati, A. Surtono, and G. A. Pauzi, "Design and Build Entry Access Restriction System Laboratory Using Radio Frequency Identification (RFID) and Keypad Technology," *J. Energy, Mater. Instrum. Technol.*, vol. 3, no. 2, pp. 57–62, 2022, doi:10.23960/jemit.v3i2.101.

[27] H. Pranoto and O. Kusumawardani, "Real-time triplet loss embedding face recognition for authentication student attendance records system framework," *Int. J. Informatics Vis.*, vol. 5, no. 2, pp. 150–155, 2021, doi: 10.30630/joiv.5.2.480.

[28] I. M. D. Maleh, R. Teguh, A. S. Sahay, S. Okta, and M. P. Pratama, "Implementation of You Only Look Once (YOLO) Algorithm for Object Detection of Orang Utan Nests in Sebangau National Park," *J. Inform.*, vol. 10, no. 1, pp. 19–27, 2023, doi: 10.31294/inf.v10i1.13922.

[29] A. I. Dzhangarov, M. A. Suleymanova, and A. L. Zolkin, "Face recognition methods," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 862, no. 4, 2020, doi: 10.1088/1757-899X/862/4/042046.

[30] L. M. Kurniawan, "Face Recognition Method for Personnel Identification Based on Facial Image for Online Presence Needs of Semarang State University," *Sci. J. Informatics*, vol. 1, no. 2, pp. 210–220, 2015, doi: 10.15294/sji.v1i2.4027.