Best Machine Learning Model for Face Recognition in Home Security Application

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Abstract: Particularly since the COVID-19 outbreak, Indonesia has seen an annual surge in criminal prosecutions. To increase home security, many technological advances have been made. Face recognition served as the main form of security for almost all of them. Face detection, face segmentation, and face recognition are the three steps in the face recognition process. To avoid misclassification and increase system dependability, accurate recognition of faces becomes crucial in security systems. The optimization tool Grid Search CV produces using a number of machine learning methods that are proposed. Each machine learning has been created using its best model and has attained accuracy levels of at least 90%. The most effective strategy is SVM, which has 100% accuracy rates. A technique for choosing the best model is an alternative. Machine learning model can be alternative implementation in real system, that can proposed more simple machine learning model than deep learning.

Keywords: Face Recognition, Machine Learning, Home Security

Abstrak: Terutama sejak wabah COVID-19, Indonesia telah mengalami lonjakan tuntutan pidana setiap tahunnya. Untuk meningkatkan keamanan rumah, banyak kemajuan teknologi telah dilakukan. Pengenalan wajah berfungsi sebagai bentuk keamanan utama untuk hampir semuanya. Deteksi wajah, segmentasi wajah, dan pengenalan wajah adalah tiga langkah dalam proses pengenalan wajah. Untuk menghindari kesalahan klasifikasi dan meningkatkan keandalan sistem, pengenalan wajah yang akurat menjadi sangat penting dalam sistem keamanan. Alat pengoptimalan Grid Search CV menghasilkan menggunakan sejumlah metode pembelajaran mesin yang diusulkan. Setiap pembelajaran mesin telah dibuat menggunakan model terbaiknya dan telah mencapai tingkat akurasi minimal 90%. Strategi yang paling efektif adalah SVM, yang memiliki tingkat akurasi 100%. Model pembelajaran mesin dapat menjadi alternatif penerapan dalam sistem nyata, yang dapat mengusulkan model *machine learning* yang lebih sederhana daripada *deep learning*.

Kata kunci: Pengenalan Wajah, *Machine Learning, Home Security*.

1. Introduction

Home security is a very important issue lately due to the increase criminal after the Covid-19 pandemic. Criminal cases have increased by 7.3% in 2022 compared to previous year in Indonesia[1], so further prevention is needed to solve this problem. Many things have been done to improve home security, from adding monitoring systems such as

CCTV[2]–[4], until developing smart lock doors to monitor who enters the house[5]–[8]. All these systems are supported by face recognition technology to monitor who is in the house.

There are three processes to do face recognition, face detection, face segmentation, and face recognition [9]. The first step, the face detection process, must do, with searching for the face component in every pixel in the image. After that, to get the face feature, face segmentation is executed. That feature is used to recognize many classification method options[2]–[5], [8]–[10]. Accuracy identification face becomes most important in the security system to prevent miss classification and make the system more reliable.

A previous study [5] has designed a home security system with deep learning methods, in this case CNN is used to recognize householders and strangers. That system creates a good classifier model with an accuracy reach of 99%. Nevertheless, CNN was implemented is a complex method, so another method must be available to become option to implemented in real time system for example machine learning. Several machine learning methods have been used to recognize faces [11], [12], although some of them don't have good accuracy. One of example is KNN which has an accuracy below 90%, that could be due to the inaccurate model hyperparameter used. Therefore it is necessary to get the correct hyperparameter to product good model machine learning.

This research elaborates on several machine-learning models that can be used for face recognition. Optimization operation has been added to produce the best model in each machine learning method. The operation is tuning the best hyperparameter for each model with grid search cv in the SKLearn function. Those are machine learning method AdaBoost, Stochastic Gradient Descent (SGD), Gradient Boosting, Random Forest, Decision Tree (DT), Gaussian Naïve Bayes, KNN, SVM, and Softmax Regression [13]. This research elaborates Optimization machine learning model and compares it with one that has the best performance.

2. Proposed Method

Fig. 1 is shown the proposed method in this research. The input image taken by the raspberry pi camera is converted to a grayscale image. After that, the face detection process is done with the Haar Cascade classifier[8]. If the video captures the face of people, the system crops the face image and then is processed the classification to recognize the face. In the previous research[5], the deep learning method was used for classification, which has complex method, it needed the other option for perform face classification, in this study is machine learning. This study uses a simple machine learning model to look for simple alternatives to recognizing the face. The cropped image matrix is converted to a one-dimensional array used as input features in machine learning. In the end, the system can recognize the subject as who householder or a stranger. Machine learning methods include AdaBoost, Stochastic Gradient Descent (SGD), Gradient Boosting, Random Forest, Decision Tree (DT), Gaussian Naïve Bayes, KNN, SVM, and SoftMax Regression[11]. Each machine learning method optimize with Grid Search CV to get best model.
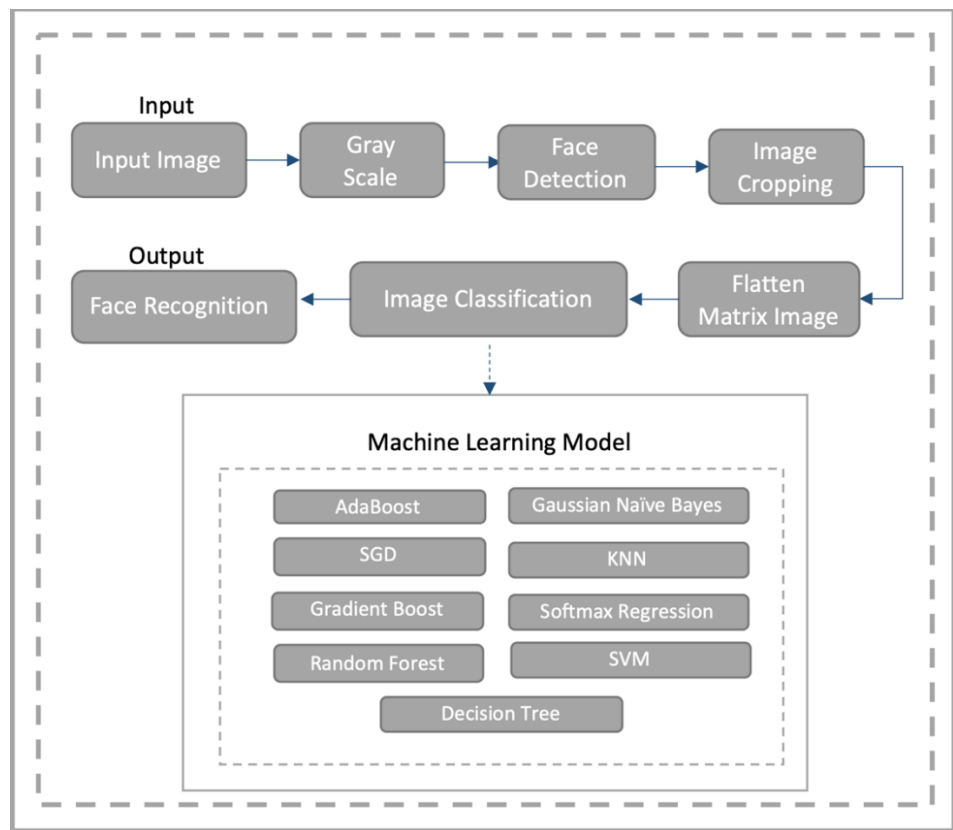
Gambar 1. Proposed method

3. Materials and Methods Algorithm

The Materials and Methods Algorithm elaborate proposed method, the dataset subject used for the classification model, and all of the face detection and recognition methods.

3.1. Collecting the Dataset

This research is expanded from previous research[5], which has a system that must recognize people's faces who live in the house or strangers before the system unlocks the door. The dataset image of the face is needed subject to the learning process machine learning model to recognize the system. The dataset is collected with hardware, are Raspberry Pi v2 8Mp camera module, and Raspberry Pi 4. The distance from camera to face of subject between 40 cm until 70 cm. The dataset consists of five subjects who register as a householder and one label with images of strangers' faces. Table 1 shows the information on dataset image instances for every subject used for learning processes. Every subject's image has variances, representing the angle subject face. The total image used in the learning process is 3914, with an image size of 100x100 Pixels. The dataset's source is taken from the previous study[5], which used deep learning to build home security for lock doors with face recognition..

Tabel 1. Face image dataset

Subject Classes	Number of Image
Subject 1	400
Subject 2	400
Subject 3	400
Subject 4	400
Subject 5	400
Stranger	1914
Total Image	3914

2.2. Haar Cascade

Face items in a single image are found using the Haar Cascade method. When training a decision tree or cascade classifier to determine whether or not there are objects in each processed frame, this method employs Haar-like features as needed. A decision tree to identify whether the image contains a face and locate the face object is shown in Figure 2. If each Haar-like feature is satisfied for each condition in the decision tree that the face was recognized, then the Haar-like features scan each pixel in a picture to detect the component face[12].
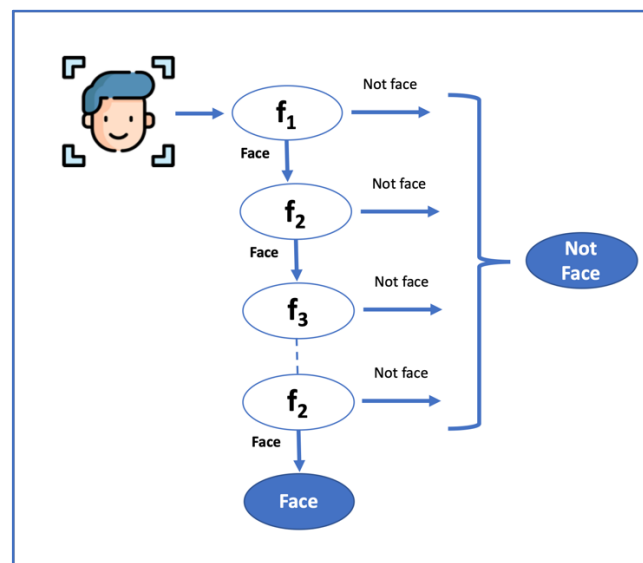
**Gambar 2.** Haar Cascade

2.4. Image Classifier

The image that detects from the Haar Cascade classifier is cropped and then processed into a machine-learning model to classify every subject which wants to enter the home. Image cropped matrix is converted into one-dimensional data as input in machine learning. This research looks for the best machine learning model to recognize every subject's face image. Each machine learning method has the best model from tuning hyperparameters with the Grid Search CV function in SKLearn Library[13]. Grid SearchCV does several training processes with all possible hyperparameters for each model and choose best hyperparameter to create best machine learning model. The best model for each method is selected from the high accuracy of the training process. The best model from each method is compared to get the most suitable machine learning method for face recognition. Those are machine learning method AdaBoost, Stochastic Gradient Descent (SGD), Gradient Boosting, Random Forest, Decision Tree (DT), Gaussian Naïve Bayes, KNN, SVM, and Softmax Regression[11].

4. Results

This section may be divided into two section. Those section are each model result and bast model detail result. In each model result describe how to achieve the best model for each model, and perform analysis to get the most suitable machine learning method for face recognition. The other section elaborate more detail result from the best machine learning method.

3.1. Each Model Result

Dataset has been detect and cropped than convert into one-dimensional array. Because size of image is 100x100 pixels than number of feature is used 10000 features. Dataset of six classes of subjects split became two parts for training and validation proposed. Using Grid Search CV, optimization is done to get the right hyperparameter for each machine learning method. Tuning hyperparameter process use 80% dataset from all datasets. Result of that process is tested again with 20% data test to validate if that hyperparameter has product the best model. The result of each machine learning model is shown in Fig 3. Optimization that has done has product the best model for machine learning method, it can be seen from almost all of accuracy classifier model. As comparison, CNN included in the result.
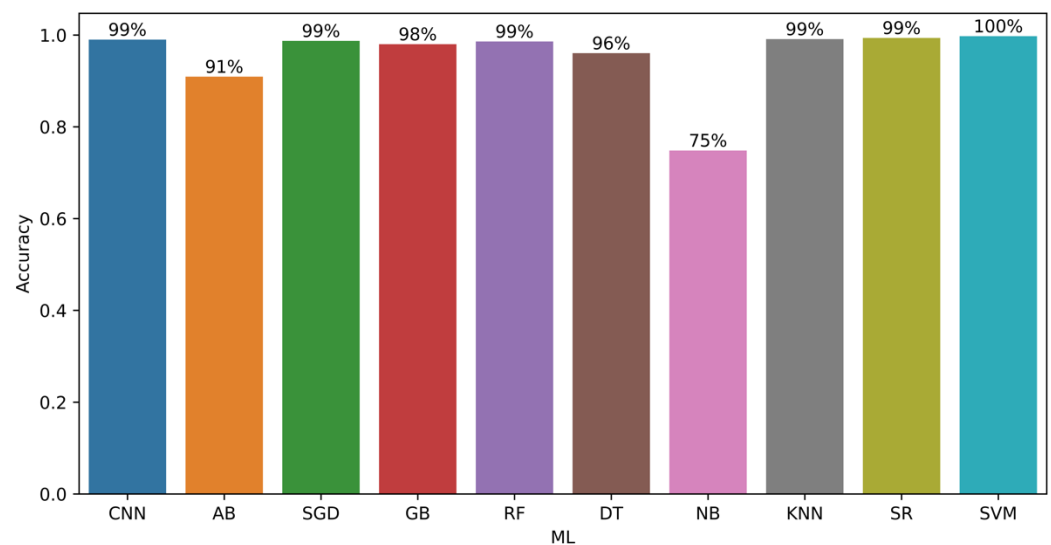

Gambar 3. Accuracy each machine learning model

Almost all of machine learning model has accuracy more than 90% except Gaussian Naïve Bayes with 75%. Stochastic Gradient Descent (SGD), Random Forest(RF), KNN, and Softmax Regression (SR) reach accuracy 99%. But the best machine learning model is SVM, that get 100% accuracy score. SVM get higher accuracy better than CNN from previous study[5].

3.2. Best Model

SVM is the best machine learning model that produce highest accuracy. To describe more about result SVM as the best machine learning model, have done measure performance that can be seen in Fig. 4 and Table 2. Fig 4. is confusion matrix for SVM face recognition to mapping prediction result with true label of each data test. It can seen there are no miss classification from prediction result. In Table 2, is described Precision, Recall, and F1-score for each classes and can shown 100% score for each class.
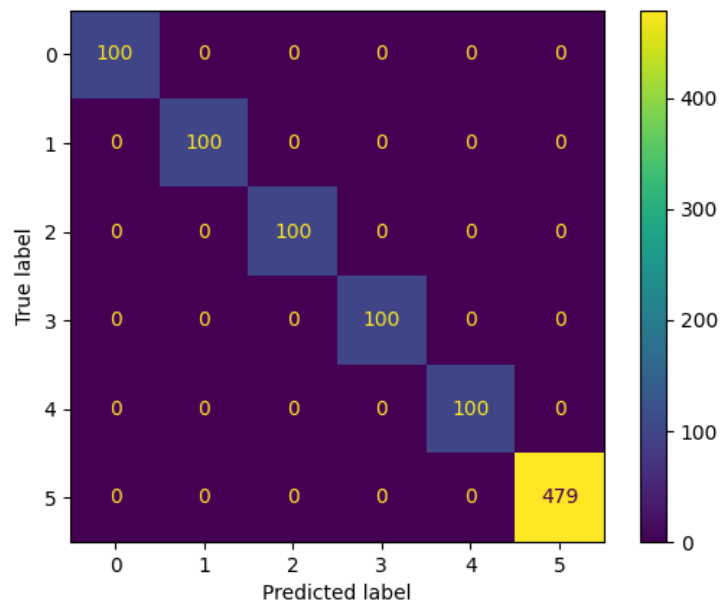
Gambar 4. Confusion matrix SVM Model

Tabel 2. Performance measure SVM model

Subject Classes	Precision	Recall	F1-Score
Subject 1	100 %	100 %	100 %
Subject 2	100 %	100 %	100 %
Subject 3	100 %	100 %	100 %
Subject 4	100 %	100 %	100 %
Subject 5	100 %	100 %	100 %
Stranger	100 %	100 %	100 %

4. Discussion

Compare with the previous research[5], that used deep learning as classifier, this study proposed method used simple algorithm with same dataset that is used, it perform same great result, that reach accuracy almost 100 %, it can seen in Fig.3. Almost all of machine learning model product high accuracy even used simple model, with accuracy more than 90%, better than the previous one[14], [15]. It is caused optimization has been done for each model, that make possible almost all machine learning model as alternative except Gaussian Naïve Bayes. The simple machine learning algorithm like SVM[11], can product model with accuracy 100%, better model then previous research[5]   which has complex CNN model. This research can give alternative machine learning model and possible to reduce computation time because using simple machine learning model. Grid Search CV has proven to be very useful as an optimization tool to generate excellent machine learning models. so this tool can be used for optimization of any machine learning model.

5. Conclusions

This study is an extension of earlier work on facial recognition that has been tested on actual hardware. The search for more simple machine learning models that can be applied, however, is given priority in this study. In this study, a number of machine learning models were created, and the best model was sought after. Each machine learning model has been successfully optimized with the help of the Grid Search CV tool, and as a consequence, almost all of them achieve accuracy levels of at least 90%. The best approach is SVM, which has been able to achieve accuracy levels of up to 100%. An alternative is the

method of selecting the best model. These results will eventually be sent to the real system, and the computation time will be compared to that of more intricate systems. This system only can implement in ideal light conditions, so in the future adjustment have to do to maintain quality of image in every condition so machine learning can perform well in every condition.

Referensi

[1] Rizky Aditya Pramana and Puput Puji Lestari, "The National Police Chief Calls There An Increase In Thousands Of Crime Cases In Indonesia During 2022," Dec. 31, 2022.

[2] A. Nurhopipah and A. Harjoko, "Motion Detection and Face Recognition for CCTV Surveillance System," *IJCCS (Indonesian Journal of Computing and Cybernetics Systems)*, vol. 12, no. 2, p. 107, Jul. 2018, doi: 10.22146/ijccs.18198.

[3] M. Mileva and A. M. Burton, "Face search in CCTV surveillance," *Cogn Res Princ Implic*, vol. 4, no. 1, Dec. 2019, doi: 10.1186/s41235-019-0193-0.

[4] F. M. Dirgantara and D. P. Wicaksa, "Design of Face Recognition Security System on Public Spaces," 2022.

[5] L. Nabila, W. Priharti, and Istiqomah, "Design of Home Security System Using Face Recognition with Convolutional Neural Network Method," in *2022 IEEE International Conference on Industry 4.0, Artificial Intelligence, and Communications Technology (IAICT)*, 2022, pp. 78–83.

[6] N. G. C, A. A. N, and N. C. S, "International Journal of Computer Science and Mobile Computing Enhancing Home Security Using SMS-based Intruder Detection System," 2015. [Online]. Available: www.ijcsmc.com

[7] A. Y. Basuki and M. Fauzi, "Perancangan Door Lock Face Recognition Dengan Metoda Eigenfaces Menggunakan Opencv2.4.9 Dan Telegram Messenger Berbasis Raspberry Pi," 2019.

[8] S. Yedulapuram, R. Arabelli, K. Mahender, and C. Sidhardha, "Automatic Door Lock System by Face Recognition," in *IOP Conference Series: Materials Science and Engineering*, Dec. 2020, vol. 981, no. 3. doi: 10.1088/1757-899X/981/3/032036.

[9] I. Qureshi, "FACE RECOGNITION TECHNIQUES AND APPROACHES: A SURVEY Swarm Optimization View project A Systematic Review of Finger Vein Recognition Techniques View project," 2015. [Online]. Available: https://www.researchgate.net/publication/281838833

[10] M. B. Mirza, "Face Recognition A Survey MALICIOUS SOFTWARE DETECTION View project," *BRIS Journal of Adv*, vol. 2, no. 5, pp. 8–13, 2015, doi: 10.13140/RG.2.1.5020.9443.

[11] A. Géron, *Hands-on Machine Learning with Scikit-Learn, Keras & TensorFlow*, vol. 53, no. 9. 2017.

[12] ACM Special Interest Group on Design Automation., Actel Corporation., and Association for Computing Machinery., *FPGA'09: proceedings of the Seventeenth ACM SIGDA International Symposium on Field-Programmable Gate Arrays, Monterey, California, USA, February 22-24, 2009*. Association for Computing Machinery, 2009.

[13] D. M. Belete and M. D. Huchaiah, "Grid search in hyperparameter optimization of machine learning models for prediction of HIV/AIDS test results," *International Journal of Computers and Applications*, vol. 44, no. 9, pp. 875–886, 2022, doi: 10.1080/1206212X.2021.1974663.

[14] N. Kadek Ayu Wirdiani, P. Hridayami, N. Putu Ayu Widiari, K. Diva Rismawan, P. Bagus Candradinatha, and I. Putu Deva Jayantha, "Face Identification Based on K-Nearest Neighbor,"

Scientific Journal of Informatics, vol. 6, no. 2, pp. 2407–7658, 2019, [Online]. Available: http://journal.unnes.ac.id/nju/index.php/sji

[15]   M. Furqan, A. Embong, S. Awang, S. W. Purnami, and S. Sembiring, "Proceeding of The 5 th IMT-GT Face Recognition Using Smooth Support Vector Machine Based On Eigenfaces 1,2*," 2009.