Facial Recognition for Car Security System Using Fisherface Method

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Abstract. The increasing crime of car theft proves that there is still a frail security system installed on the car. Apart from the expertise possessed by the car thieves, the crime of car theft can also occur due to the negligence of the car owner in leaving his car. One of the examples is leaving the car when the engine is on. This is the main reason for car owners to have an advanced security system. The application of biometrics technology is expected to be a solution for improving the car security system. One of the biometrics technologies to be applied in car security systems is facial recognition technology. In this study, facial recognition is in real-time using the fisherface method to improve the security system of a car when the engine is still on. The results show that the fisherface method performs well with an accuracy of 83.04%. The results indicate that the facial recognition application using the fisherface method is one of the most effective solutions in improving car security systems.

1. Introduction

The widespread of car thefts and the increasing number of ways by which car thieves carry out their actions, require car owners to be more cautious in maintaining their vehicles. Based on the data from the Regional Police Office of Metro Jaya, car theft is a crime with the highest increase, namely by 17% per year. In 2013, car theft reached 966 cases, an increase of 38 cases from 928 reported cases in 2012. The existing car security system is not enough to provide security for car owners, so many companies provide modern security services such as car alarms, GPS for car trackers and notification sent by cellular providers to alarm car owners when a crime happens. However, in reality, the thieves only need less than 5 minutes to steal a car with alarm as a security system. An advanced car security system is required to maximize the car security to avoid any crime for happening. One of them is implementing biometrics technology. Today, biometrics technology has been widely-applied with distinguishing traits. In general, the distinguishing characteristics are divided into two types, namely physiological or physical characteristics, and behavioral characteristics. Facial expression is one of the behavioral characteristics. The use of biometric technology systems with the characteristics of facial expressions makes it possible to recognize someone, while the basic component for facial expression analysis is the face, face data extraction, dan facial expression recognition [1].

The car security system today has not shown satisfactory results for car owners. The safety technique using an alarm is still easy to break since GPS, and cellular providers are not fast enough to avoid theft, especially when the engine is on. Therefore, it is necessary to increase the security of the
cars to ensure its safety from theft. Facial recognition with biometric technology is the solution to create a better security system of a car.

Research on the application of facial recognition to car security systems has been carried out by Sarvesh Veerappa Arahunasi and Chetana R in 2016 [2]. The study applied the Face Recognition System (FPS) and GSM modules to authenticate drivers if the driver is matched, then the engine will start. While if unidentified face is detected, the engine will not start and the system will send a notification to the owner via SMS. The research was conducted using the PCA (Principal Component Analysis) algorithm.

Nandakumar et al. conducted research on car security system in real time using face recognition technology in 2014 [3]. The study applied the Viola-Jones algorithm as a detection method and a Linear Discriminant Analysis method for extraction.

Seshasayee and Manikandan in 2013 also conducted a study on car security systems with face recognition [4]. The algorithm applied in the system is the SHIFT algorithm or Histogram-Based Tracker. If the camera captures an unknown face in the car, the facial image will be sent to the car owner via MMS.

Another study was also conducted in 2013 by Meeravali et al. In the research, if someone enters the car and his face is not recognized by the camera and starts the engine, the system will send a notification in the form of pictures, location, and speed of the car to the owner. The study implemented the AdaBoost algorithm [5].

Similar research was also carried out by Vishal P. Patil and K.B. Khanchandani in 2013. The study compared several methods in facial recognition. The result showed HMM has an accuracy of 84%, while PCA and Neural Network has a success rate of 98.50% and 95.60% respectively, making PCA as the best method to be applied in facial recognition among the three methods [6]. Lekshmi and Sasikumar (2008) performed facial expression analysis using the Gabor Wavelet Transform (GWT) and DCT methods. The Radial Base Function (RBF) network was used as a classifier [7]. Bashyal and Venayagamoorthy also conducted a study on facial expression recognition using Gabor wavelet to extract the features and combine them with LVQ to recognize seven facial expressions [8]. Kulkarni classified facial expressions effectively based on face parameter input using the committee neural network [9]. Ma and Khorasani (2004) conducted a study using 2-D discrete cosine transform (DCT) to detect features and feed-forward neural networks with one hidden layer as classifiers of facial expressions [10]. Amri and Talita (2016) detected faces using the Fisherface method to support the academic system[11]. While Arisandi et all doing their research on facial recognition in mobile device using fisherman method [12].

All of the previous research has been conducted and give a good result as security system. However, in the reality of the car security system, we still find a gap where a thief still has a chance if the car security using alarm, MMS, or face recognition system which connected to cellular phone. While we found that fisherface is quite powerful, then we try to applied it in the car security system.

2. Methodology
According to Patel and Shruti (2013), fisherface is one of the most successful methods applied for facial recognition [13]. Based on research conducted by R.A Fisher in 1936 , who developed the algorithm, Linear Discriminant Analysis (LDA) or fisherface showed excellent performance in facial recognition. Fisherface is a method that can recognize a face with diverse expressions and different directions of facial lighting [14]. The output is whether or not an input image is recognized as one of the individuals in the database. In the face detection module, color segmentation is performed to obtain a part of the input image that has skin color. In the last module, the identity recognition process was carried out by comparing the required fisherface weights to reconstruct the input images to the images in the training set. Fisherface method conducted the human facial recognition process to identify the face. All face images can be reconstructed from a fisherface combination with different weights. The general architecture of this study can be seen in Figure 1.
2.1. Image Input
Image inputs were taken for training data and test data using webcam camera in real-time. The parameter for data acquisition is the time in seconds. In this study, the time interval for acquiring one image for one identifier is 1 second. The sample of image input can be seen in Figure 2.

2.2. Pre-Processing
After acquiring the input, the next step is preprocessing. Firstly, the system will detect faces on the input images using the haar-cascade detection method that is available in the OpenCV library with an XML file format. The image with the detected face will be resized to a width of 192 pixels and a height of 92 pixels. Then the face image will be converted to grayscale using the default library contained in openCV. The preprocessing process is shown in Figure 3.
2.3. Feature Extraction
After the pre-processing stage, the image will enter the feature extraction process using the fisherface method. In the process of retrieving training data, the feature extraction stage will take the extraction value of the facial image and save it to the database in an XML file with the file name of fisher_trained_data.xml. The features to be taken are the values of mean, eigenvalues, eigenvectors, projections, labels, and labelsInfo. The database file of fisher_trained_data.xml can be seen in Figure 4.

![XML Database File](image)

**Figure 4. XML Database File.**

The explanations of Figure 4 is: Num_Component represents the number of identifiers that are trained to start at number 0; Mean is an example of the average data that has been calculated from the training data; Eigenvalue is the eigenvalue value of face detection; Eigenvector is the eigenvector value of face detection; Projection is projections from training data; and Label is a label of training data related to projections.

2.4. Dataset
The data of this study are facial images obtained using a webcam camera. Facial image data divided into training data and test data. Training data consisted of 20 facial images for ten identifiers and 40 facial images for 15 identifiers. The amount of facial image for training is 800 images. The test data used ten facial images with various poses, namely face facing the camera, face facing down the camera, face facing up, face facing right with an angle of 45°, face facing left with an angle of 45°, and face while mentioning vowels (a, i, u, e, o). Table 1 shows the distribution of facial images used in the study.

| No. | Dataset         | Number of Identifiers | Amount of Image | Amount of Data |
|-----|-----------------|-----------------------|-----------------|----------------|
| 1   | Training Data 1 | 10                    | 20              | 200            |
| 2   | Training Data 2 | 15                    | 40              | 600            |
| 3   | Testing Data   | 26                    | 10              | 260            |
|     | **Total Data** |                       |                 | **1060**       |
2.5. Evaluation Method

An evaluation method is required to see how well the fisherface method in conducting facial recognition. In this study, the proposed evaluation method is the confusion matrix method. There are four parameters in the method, which are True Positive, True Negative, False Positive, and False Negative. Confusion matrix was implemented to measure accuracy, precision, recall, and F-Score of fisherface performance in performing face recognition classification using the equations below:

\[
\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \\
\text{Recall} = \frac{TP}{TP + FN} \\
\text{Precision} = \frac{TP}{TP + FP} \\
F - \text{Score} = \frac{2 \times (\text{Precision} \times \text{Recall})}{(\text{Precision} + \text{Recall})}
\]

An accuracy shows the proximity of the facial recognition result to the real value; precision is the degree of conformity between information that the user wants to get and the answer given by the system; recall is the success rate of the system rediscovering the information needed; while the F-Score is an evaluation of the information that is rediscovered by combining recall and precision.

3. Result and Analysis

The system testing is divided into two parts, which are face detection testing and facial recognition testing. Facial recognition testing was conducted three times. The first test was carried out using 88 test data, the second test with 160 test data, and the third one with 260 test data. The accuracy result of the testing can be seen in Table 2.

| No. | Testing                | Correctly Identified Data | Total data | Accuracy |
|-----|------------------------|---------------------------|------------|----------|
| 1   | Face Detection         | 88                        | 88         | 100%     |
| 2   | Facial Recognition 1   | 72                        | 88         | 81,81%   |
| 3   | Facial Recognition 2   | 144                       | 160        | 90%      |
| 4   | Facial Recognition 3   | 201                       | 260        | 77,31%   |

The result of the accuracy will enter the evaluation stage using the confusion matrix. The evaluation result is shown in Table 3.

| Testing                | Accuracy (%) | Recall (%) | Precision (%) | F-Score (%) |
|------------------------|--------------|------------|---------------|-------------|
| Facial Recognition 1   | 81,81        | 100        | 90            | 94,73       |
| Facial Recognition 2   | 90           | 100        | 89,33         | 94,36       |
| Facial Recognition 3   | 77,31        | 100        | 76,4          | 86,62       |
4. Conclusion and Future Research

Based on the conducted tests, the implementation of the fisherface method on facial recognition for car security systems has an accuracy of 81.81%, 90%, and 77.31% for the first, second and third tests respective. The average accuracy of this system reaches 83.04%, so this method performs well in recognizing and validating the car owners. The result of the preprocessing process has effects on the accuracy of the fisherface method. The higher the amount of training data for one identifier, the higher the accuracy rate. Moreover, the higher the number of the identifier will result in the decrease in the accuracy level.

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