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An indoor video-based for single face identification among people

Indrabayu¹, I S Areni², M Arafah³, Jusman⁴, M P Rachmat⁵ and I Nurtanio¹

¹Informatics Department, Hasanuddin University, Makassar, Indonesia

²Electrical Engineering Department, Hasanuddin University, Makassar, Indonesia

³Informatics Study Program, STMIK AKBA, Makassar, Indonesia

⁴Communication and Information Department, Makassar City Official, Makassar, Indonesia

⁵Student of Informatics Department, Hasanuddin University, Makassar, Indonesia

intan@unhas.ac.id

Abstract. The purpose of this research is to build a system that can detect certain face among several people. The system works using face recognition in searching suspects from a database. 30 images and 9 videos are used for training and testing. In the training process carried out several stages: (1) pre-processing of face images, (2) extraction of facial image training features using the Histogram of Oriented Gradient (HOG) method, (3) face classification using the SVM method. There are several steps for testing process i.e.: (1) video frame extraction, (2) cascade classifier method with the Local Binary Pattern (LBP) feature descriptor, (3) HOG for extracting facial features detected in the frames, and (4) SVM as the face classifier. The processed video data is 1920x1080 pixel resolution which has been recorded using a CCTV camera which is mounted on a wall with height and slope angle of 2.5 meters and 60 degrees. There are two goals implemented in this research. The first goal is to find the highest accuracy from several testing of frame sampling by setting the best threshold value. The second goal is to find the lowest processing time.

1. Introduction

One of the major researches in pattern recognition is facial identification. The face biometric is one of many features that can be used to distinguish people and have high accuracy. It becomes the most trusted authentic security platform for mobile application [1]. Besides for security purposes, technological developments in this field have helped in many cases such as the search for missing people, tracking fugitives, and even become an attractive feature for users of social media. Due to its simplicity and enrich combination, face mimic, like drowsiness can also be detected with high precision [2].

In recent years, face detection technology has been greatly improved and has successfully performed face detection for attendance and monitoring. Ren et al made a prototype for detecting suspicious people using real-time video on one side of the room. If someone is detected beyond the time limit, the person is considered suspicious. Then the system will send information to relevant personnel [3]. Other research by Refik et al proposed a flexible and real-time face recognition-based mobile attendance management system, but the results show that the accuracy of students sitting in front seats are more accurate in comparison to the accuracy of students sitting in the back.



Secondly, the accuracy rates may have decreased due to the blurring caused by vibration while the photo was taken [4]. Another research by Jignesh et al focused on how to detect the face of the user properly before accessing the ATM machine. If any motion is detected inside the ATM cabin, it will start detecting the face. If the face of the user is not detected properly the person will not be allowed to access the ATM [5].

Luan et al analyzed the differences between real faces and spoof images by extracting three types of features, i.e., specular reflection ratio, Hue channel distribution, and texture, to determine whether face images are captured from real faces or spoof images and used SVM to classify genuine face images and fake face images. The detection rate can achieve 20 fps on a PC, experimental results show the efficacy of the proposed method and do not need a complicated computation process, so it can be used in a general-time application [6].

Yu et al studied face detection in video by combining skin color segmentation and AdaBoost. Firstly, calculate the value of Haar-like features of positive and negative samples, and train the classifier based on AdaBoost, Then combine the classifier trained in this paper with the classifier provided by OpenCV to detect the face after skin segmentation. The proposed method can be effectively applied to face detection under complex background, and it has the advantages of high detection rate and fast detection speed, and also has great application value in the aspect of a criminal investigation [7].

Chen et al presented the TFA approach to assist the video-based face identification task. With a single annotation of the target in the video, TFA can retrieve a set of representative face images in the video to create a robust representation of the target. The TFA method leverages a linear Support Vector Machine (SVM). Evaluation results show that the proposed method achieves good performance for the video-based face identification task and the proposed method is capable of associating the face images across multiple shots in a video [8].

Zeng et al proposed a method to solve the face recognition problem with Single Sample per Person (SSPP) using Deep Convolutional Neural Network (DCNN) and becomes a pioneer that use DCNN in SSPP face recognition and demonstrates that DCNN can be used in the task who has single or few training samples [9].

Previous studies only focused on detecting single face, while suspects were usually in the crowd. So it is necessary to conduct research on how to detect suspects among several people. Therefore, this study aims to detect suspects in a laboratory-based crowd.

2. Proposed Method

In this paper, the research focuses on how to recognize suspect faces among many people. The camera is placed on a wall with a height of 2.5 meters and a tilt angle of around 60°. The resolution used in this study is 1920 x 1080 pixel and the system has a training process and testing process. The design of the suspect detection system is shown in Figure 1. The used software in this study is MATLAB R2015a.

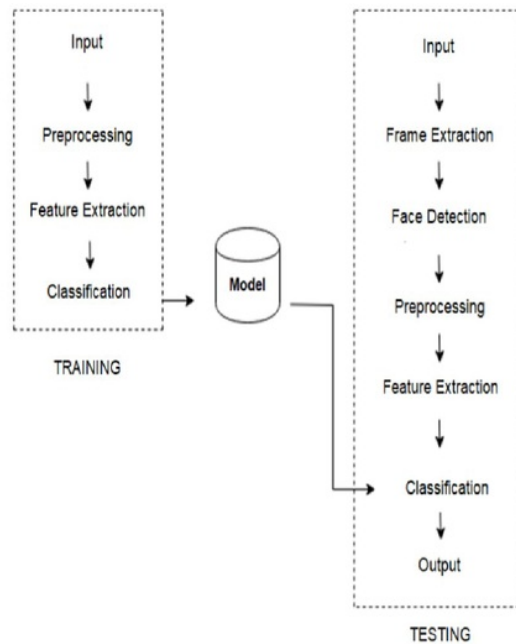


Figure 1. Design System.

2.1. Training Process

2.1.1. *Input of Training Process.* The number of training images used is 30 with three suspect data. Training data examples for each suspect can be seen in Figure 2.

2.1.2. *Preprocessing.* In this process, the RGB image is converted to grayscale. Then, resize the image to 70 x 96 pixels. Preprocessing stage is shown in Figure 3.

2.1.3. *Feature Extraction.* Extraction of facial face image features uses the Histogram of Oriented Gradient (HOG) method because of lower time cost. The resulting output is a vector from the HOG descriptor that is visualized in Figure 4.

2.1.4. *Face Classification.* This stage uses the SVM method. Fitcecoc is used to classify the features and labels of each suspect in the training process using the onevsall model. Then, the probability value of each class can be seen by using `FitPosterior`.



Figure 2. The training data example of suspects: (a) Suspect A (S_A); (b) Suspect B (S_B); (c) Suspect C (S_C).



Figure 3. Preprocessing stage.

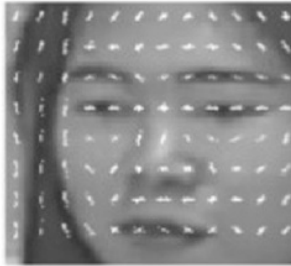


Figure 4. Example of visualizing the image to the HOG descriptor.

2.2. Testing Process

2.2.1. *Input of Testing Process.* In this testing process, the input used is 3 videos for each suspect. The specifications of the video input are a resolution of 1920×1080 pixels, the frame rate of 30 fps, and duration of 7 seconds.

2.2.2. *Video Frame Extraction.* RGB video used has a resolution of 1920×1080 pixels. These video files are extracted and video frames are sorted into sequential digital images so that the video can move to the first frame to the last frame. The result from this process is the RGB frame as shown in Figure 5.

2.2.3. *Face Detection Using The Cascade Classifier Method With The Local Binary Pattern (LBP) Descriptor Feature.* The cascade classifier method consists of several stages, where each stage is an ensemble of weak learners. Weak learners are simple classifiers called decision stumps. Each stage is trained using a technique called boosting that provides the ability to train highly accurate classifiers by taking average decisions made by weak classifiers.



Figure 5. RGB frame example.

Each stage classifier labels the area determined by the current location of the sliding window as positive or negative. Positive indicates that the object was found and negative indicates no object was found. If the label is negative, the classification in this area is complete, and the detector moves the window to the next location. If the label is positive, the classifier passes through the area to the next stage. Detector reports the object found at the current window location when the last stage classifies the area as positive. CascadeObjectDetector detects objects in the image by sliding the window. Then the detector uses the cascade classifier to decide whether the window contains the desired object.

2.2.4. Facial Feature Extraction Detected on the Frame Using the HOG. Face features that have been detected in the frame will be predicted, then compared to the facial features contained in the database class features that have been created in the training process. The property used is Cellsize with a value of [8 8] as in the training stage.

2.2.5. Classification of faces detected in frames using SVM method. After extracting facial features in the frame, the classification process is carried out based on facial features detected according to the data in the training database. The classification in the testing process uses predict command. Testing data for each suspect produces different probability score values because the facial features of each suspect are different. To determine whether a testing data matches the data in the database, the min score is set with a value of 0.5. The class posterior probability for multiclass is calculated based on the following equation.

$$P(s_a) = \begin{cases} 0; & s < \max_{y_k=-1} s_k \\ \pi; & s_k \leq s_j \leq \min_{y_k=+1} s_k \\ 1; & s_a > \min_{y_k=+1} s_k \end{cases} \quad (1)$$

where $P(s_a)$ is the probability of the score on the testing data a , k is Class = $\{-1, 1\}$, $+1$ is a positive class, and -1 is a negative class.

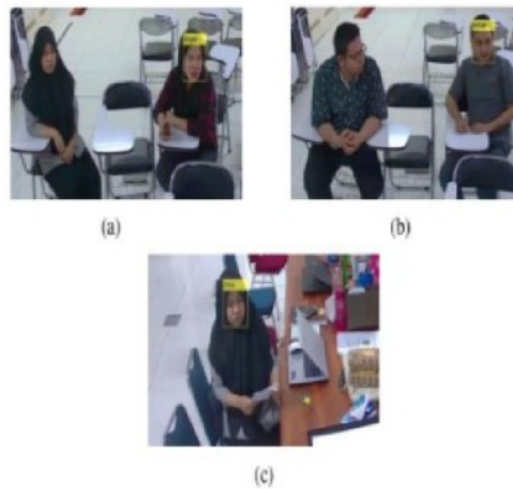


Figure 6. Output display system.

The output of this face recognition system is a video with RGB data types. Figure 6 shows the system display output of suspect a , b , and c . To measure the accuracy level (A_c) of the face recognition system, there are two parameters: the number of suspect face successfully recognized (N_s) and total number of data (N_t).

$$A_e = \frac{N_s}{N_t} \times 100 \quad (2)$$

3. Result and Discussion

This chapter presents the results of face detection and facial recognition system performance. System testing scenario:

- The system will look for the suspect in each room, if the suspect is found, the system will stop.
- If the suspect is not found in the previous room, then the system will look for the suspect in another room.
- The system will search for the suspect by taking every 1st frame of each second of the whole video.

Test data used to detect and recognize a suspect's face consists of 9 video data where each video is 7 seconds long with 30 fps or around 210 frames. In this study, three rooms were used to look for the suspects.

- The search results of suspect A in the first room is shown in Figure 7.
- If suspect A is not found in the previous room, then suspect A will be searched in the second room as shown in Figure 8.
- Then, if suspect A is also not found in the second room, suspect A will be searched in the third room as shown in figure 9.

The result of the suspect search test uses a probability score value with a range of values from 0-1. However, the results of the search test showed many detection errors. So it is necessary to determine the threshold value of the probability score value.

Threshold value aims to determine whether a test data matches the data in the database. From the overall trial error test results, the best threshold is 0.5 & 0.6 because this value can represent all testing data.

The testing results of suspect face identification by taking the first frame for the duration of the video (S_1) will be compared with the testing results of the suspect faces identification with the original frame rate (S_2).



Figure 7. The results example of the search test suspect A in the first room.



Figure 8. Search results for suspect A in the second room.



Figure 9. Search results for suspect A in the third room.

Table 1. System test results of identification suspect faces with the best threshold (> 0.5 & < 0.7) for two scenarios.

Test Data	Face recognized		Processing time (sec)	
	S_1	S_2	S_1	S_2
1	√	√	2.81	71.84
2	√	√	2.73	54.48
3	√	√	2.69	42.51
4	√	√	2.65	42.07
5	√	√	2.70	39.94
S_4 6	√	√	1.72	6.86
7	√	√	1.67	5.02
8	√	√	1.61	3.79
9	√	√	1.66	3.17
10	√	√	1.61	4.21
11	√	√	7.66	76.76

	12	√	√	7.63	72.66
	13	√	√	7.63	71.66
	14	√	√	7.66	71.77
	15	√	√	7.63	72.49
S_B	1	√	√	1.70	3.29
	2	√	√	1.70	3.21
	3	√	√	1.66	3.19
	4	√	√	1.64	3.43
	5	√	√	1.64	4.14
	6	×	×	2.95	3.16
	7	×	×	3.02	3.05
	8	×	×	3.01	2.95
	9	×	×	2.97	2.91
	10	×	×	2.98	2.94
	11	√	√	1.90	3.25
	12	√	√	1.84	6.43
	13	√	√	1.82	4.10
	14	√	√	1.80	3.36
	15	√	√	1.80	3.15
S_C	1	√	√	1.71	13.74
	2	√	√	1.68	4.18
	3	√	√	1.75	5.89
	4	√	√	1.67	6.25
	5	√	√	1.68	3.22
	6	√	√	1.64	3.31
	7	√	√	1.71	3.41
	8	√	√	1.66	3.93
	9	√	√	1.61	3.51
	10	√	√	1.63	3.40
	11	√	√	1.75	3.31
	12	√	√	1.79	3.43
	13	√	√	1.76	3.23
	14	√	√	1.79	3.17
	15	√	√	1.80	3.15
	Average		2.62	16.86	

From Table 1, the accuracy of the suspect detection system based on face recognition according to equation (2) is:

$$A_c = \frac{40}{45} \times 100 = 88.88\%$$

The results in Table 1 shows that the S2 requires 14.24 seconds longer in time processing compared to the S1.

The test data uses 9 videos with 15 times testing for each suspect. The processing time of each test data is different because the position of the suspect is bent or reversed so that it takes longer time. From all test data videos, there was an identification error in the test data from SB, because the same probability score was generated on the test data and other faces which were 0.6403. Mistakes in recognizing faces are suspected to be caused by several factors such as facial features and skin color that is somewhat similar to other people's faces.

4. Conclusion

This research uses the cascade classifier method with features of LBP descriptors to detect faces, the HOG method for feature extraction, the SVM method with multi-class one-versus-all coding models and linear kernel parameters for face classification. System that uses the first frame of every second during the duration of the video shows faster processing time than the system using the original frame rate (30 fps). The threshold value between 0.5 and 0.7 is the best threshold value for classifying face suspect and the results of system testing of face recognition achieved the accuracy of 88.88%. For further research, it is still necessary to analyse other parameters so that the face recognition process can be maximized.

Acknowledgements

This research is funded by JICA-CBEST Program 2018-2019.

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