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# Face Recognition of Low-Resolution Video Using Gabor Filter & Adaptive Histogram Equalization

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***Abstract*— The increasing of CCTV usage for handling security's problems has prompted the demand for face recognition system. Therefore, face recognition with low-resolution data from CCTV is needed. In this study, Viola Jones, Gabor filter and Support Vector Machine (SVM) is used for face detection, feature extraction, and classification, respectively. Adaptive Histogram Equalization (AHE) is applied in the preprocessing stage to increase the recognition accuracy. With the implementation of AHE, the accuracy is increased from 82.85% to 97.14% for class (person) 1. The data in this study consist of 11 classes (people) where each of them has 50 training data and 70 testing data with the image size of 32x32 pixel.**

***Keywords*—*face recognition, gabor filter, adaptive histogram equalization***

## I. Introduction

Face recognition is one of the famous biometric identification. In the last few years, within the increasing of CCTV (Closed Circuit Television) to handle security problems has prompted the demand for facial recognition systems. However, the CCTV captured usually comes with low-resolution, lightning, and uncontrollable distance make recognizing faces is one challenging task to do.

In face recognition, there are three important phases, i.e. face detection, face extraction, and face classification. In face detection, the commonly used method is Viola Jones [1][2]. Face extraction is used for collecting face's important features by Gabor filter, and the feature extraction result is classified using Support Vector Machine (SVM) [3][4]. This study also adds Adaptive Histogram Equalization (AHE) method, one of brightness enhancement techniques, in the preprocessing to make lighting improvements to improve the accuracy of face recognition as did in Ref. [5].

Lim Song Li et. al. conducted the research using Gabor filter and Singular Value Decomposition (SVD) for face recognition and gained accuracy of 92%. The training and testing data is an image [6]. Banker and Pise proposed two effective color local texture features, i.e. Color Local Gabor Wavelet (CLGWs) and Color Local Binary Pattern (CLBP) for face recognition. Those methods codes discriminatory features by combining both color and texture information as a combined approach [7]. Jun Qin et. al. have completed research using Gabor on feature extraction and SVM for classification. This research study uses images that not come from a video frame and gained an accuracy of 97% [8].

In this study, the training and testing data from the video with frame image size of 32x32 pixels.

## II. Proposed Method

Low-resolution face recognition in this study used two scenarios, i.e without Adaptive Histogram Equalization (AHE) and with AHE in preprocessing as shown in Figure 1.

### A. Data Description

The data used is from a video that recorded using 2 megapixel IP camera with the resolution of 1280 x 720 pixels and frame rate of 30 fps. Video recording is done with a camera angle of 70 degrees and a camera height of 2 meters and distance of 5 meters. In this study, the samples of people are described as a class, where each class will have to walk in a 5 meters straight line towards the camera. The first video is for the training data while the second is for the testing data. The illustration of the recording data is shown in Figure 2.

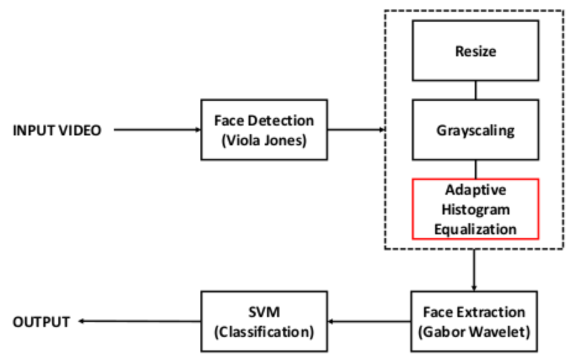


Fig. 1. Flow Diagram Face Recognition With Adaptive Histogram Equalization


Fig. 2. Video Capture Illustration



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Fig. 3. Training data samples from left to right from class 1 to class 11

Fig. 4. Testing data samples from left to right from class 1 to class 11

Fig. 5. Training data with AHE samples from left to right from class 1 to class 11

Fig. 6. Testing data with samples from left to right from class 1 to class 11

The training and testing data consist of 50 frames and 70 frames per class, respectively. Figure 3 shows the samples of training data from each class and Figure 4 shows the samples of testing data from each class. Figure 5 and 6 shows the samples of training and testing data with AHE applied on the preprocessing phase, respectively.

### *B. Preprocessing*

This study uses several preprocessing methods such as resize, grayscaling and adaptive histogram equalization.

- Resize is a way to change an image size by using resampling method. Where image will be added by new pixels within the resized pixel mathematically and the color and new pixel will be predicted to be added within the pixels colors nearby. This process is called interpolation.

- Grayscaling is a method to change an RGB image into a grayscale image by using the following equation:

$$Gray = \frac{R+G+B}{3} \quad (1)$$

  where $R$ is the value of red, $G$ is the value of green, and $B$ is the value of blue.

- Adaptive Histogram Equalization (AHE) is an image processing method that used for increasing an image contrast [9][10]. The difference between an image with and without AHE can be seen in Figure 7. In the preprocessing phase, The used parameter of AHE by using Matlab is Number of tile is [3,3], Contrast enhancement limit of 0.01, NBins of 256, Range: Full, Distribution: uniform, and Alpha 0.4.

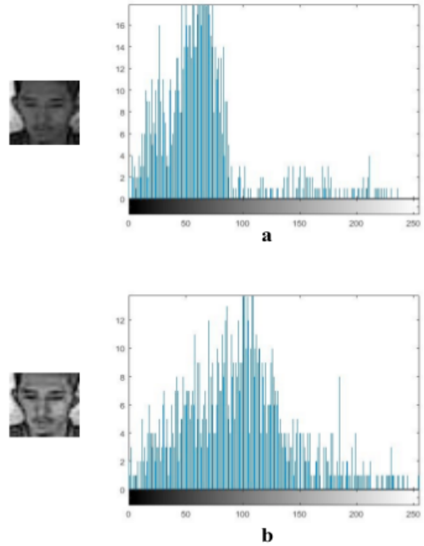


Fig. 7. Histogram graphs examples: a. with AHE, b. without AHE

Images with AHE look brighter and evenly illuminated.

### *C. Extraction Feature*

Wavelet Gabor is very important for the EBGM algorithm, which is the two-dimensional form of wavelet Gabor. Wavelet, like Fourier Transformation (FT), is used for analyzing frequency room properties of an image. The wavelet is operating on image patch while Fourier is changing the entire image. Every wavelet is consists of planar sinusoidal multiply by two-dimensional Gaussian distribution. A Sine wave is activated by image frequency information, while Gaussian makes sure that convolution result is dominated by region nearby the wavelet center. Wavelet specification is using the following equation[11]:

$$W(x,y,\theta,\gamma,\lambda,\sigma,\emptyset) = e^{-\frac{x'^2+\gamma y'^2}{2\sigma^2}} \times \cos\left(2\pi\frac{x'}{\lambda}+\emptyset\right) \quad (2)$$

$$x' = x\cos\theta + y\sin\theta$$

$$y' = -x\sin\theta + y\cos\theta \quad (3)$$

where $\theta$ is the orientation of the wavelet where in this case, there are 8 orientations. $\lambda$ is the length of a wave. $\emptyset$ is a phase of a sine wave. Usually, Gabor has an odd or even value. An even sine wave fits with cosine function, while odd sine wave fits with a sine function. The even wavelet is considered as a real part of the wavelet and the odd wavelet is considered as the imaginary part. Therefore, convolution with two phases generates a complex coefficient. $\sigma$ is a Gaussian radius. This parameter is usually proportional with the wavelength so wavelet from different size and frequency is actually the scale version of one another $\sigma = \lambda$. $\gamma$ is the spatial aspect ratio that determines ellipse of the Gabor function. The calculation of Gabor features steps is shown in Figure 8.

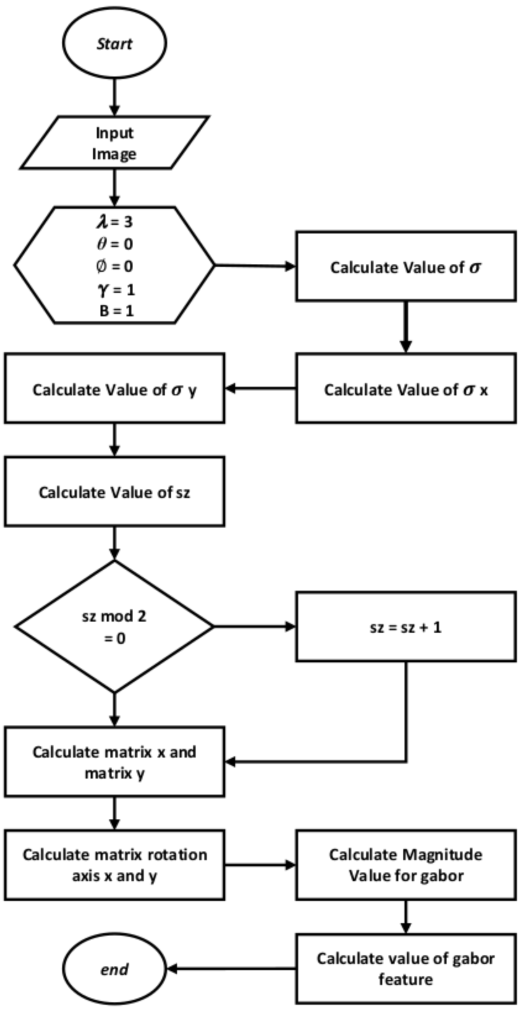


Fig. 8. The Flowchart of the Gabor feature calculation

### D. *Classification*

In this study, the classification method used is Support Vector Machine (SVM). SVM itself is a prediction method that can be used in classification and regression. SVM uses basic linear classifier principal but has been developed to works on non-linear problems by inserting kernel concept in the high dimensional workspace. The basic idea from this technique is to find the best hyperplane by maximizing hyperplane margin that works as a separator of two data classes in the input room. Hyperplane with maximum margin will give a better generalization on classification, which brings more accurate results.

$$P(s_a) = \begin{cases} 0; s < \max\limits_{y_{k=-1}} s_k \\ \pi; \max\limits_{y_{k=-1}} s_k \le s_j \le \min\limits_{y_{k=+1}} s_k \\ 1; s_a > \min\limits_{y_{k=+1}} s_k \end{cases} \tag{3}$$

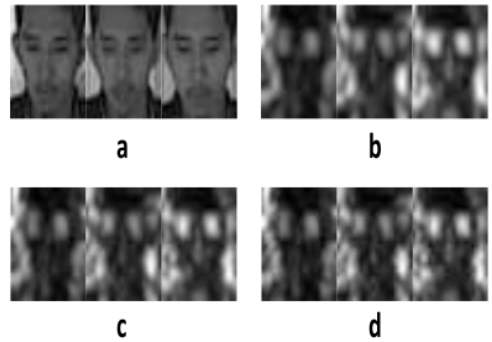


Fig. 9. The result example of Gabor feature extraction (class 1) : a.input image, b. $\gamma = 1$, c. $\gamma = 1.5$, d. $\gamma = 2$.

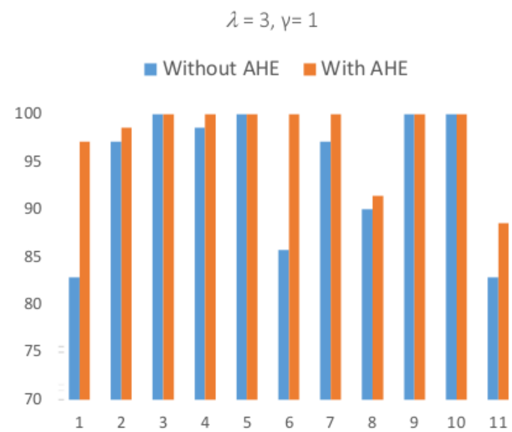


Fig. 10. Graph comparison of class and accuracy with parameter $\lambda = 3$, γ= 1

This study uses multiclass SVM where P($s\_a$) is the score probability on the testing data $a$, $k$ is class = {-1,1}.

## III. Result and Discussion

The testing process is fixed with two different scenarios, i.e. with and without AHE implemented. There are 7 classes that had been tested with image size of 32x32. The testing parameters of Gabor are $\lambda = 3$, $\gamma = 1$ to 3. The Gabor extraction result example is shown in Figure 9.

On testing with AHE implemented, the accuracy of every class is increased. The lowest accuracy is on class 8 and 11. In class 8, the Gabor result is similar to class 4 that can be seen in Figure 13. The same thing occurs in class 11 Gabor result that looks similar to class 5 that can be seen in Figure 13.

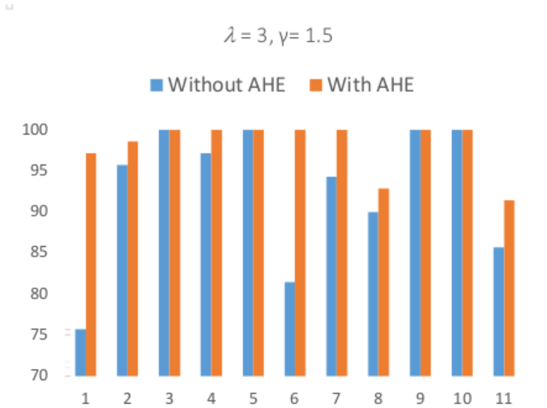


Fig. 11. Graph comparison of class and accuracy with parameter $\lambda$ = 3, $\gamma$= 1.5

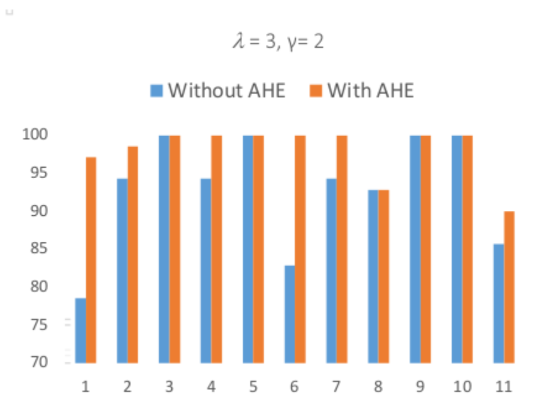


Fig. 12. Graph comparison of class and accuracy with parameter $\lambda$ = 3, $\gamma$= 2

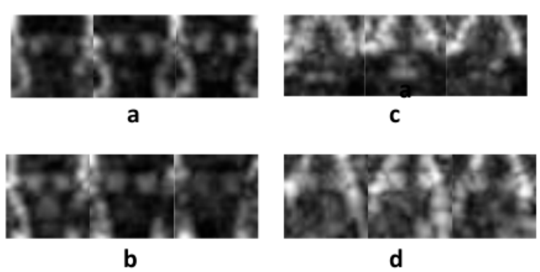


Fig. 13. The result example of Gabor extraction: a. class 4, b. class 9, c. class 5, d. class 11

## IV. CONCLUSIONS

Low resolution face recognition by using AHE preprocessing, gabor feature extraction, and SVM classification has been done. The data used are 550 training data, which is 50 data for 11 classes and 770 testing data, which is 70 data for 11 classes. AHE is proved to increase image quality so it can increase every class accuracy where 7 from 11 classes gained 100% accuracy.

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