Facial Images Improvement in the LBPH Algorithm using the Histogram Equalization Method

Aditya Salman[1], Mardhiya Hayaty[2], Ika Nur Fajri[3]

[1,2,3]Faculty of Computer Science, Universitas Amikom Yogyakarta,Indonesia

[1]aditya.salman@students.amikom.ac.id,[2]mardhiya_hayati@amikom.ac.id,[3]fajri@amikom.ac.id

Abstract - In face recognition research, detecting several parts of the face becomes a necessary part of the study. The main factor in this work is lighting; some obstacles emerge when the low light's intensity falls in the process of face detection because of some conditions, such as weather, season, and sunlight. This study focuses on detecting faces in dim lighting using the Local Binary Pattern Histogram (LBPH) algorithm assisted by the Classifier Method, which is often used in face detection, namely the Haar Cascade Classifier. Furthermore, It will employ the image enhancement method, namely Histogram Equalization (HE), to improve the image source from the webcam. In the evaluation, different light intensities and various head poses affect the accuracy of the method. As a result, The research reaches 88% accuracy for successful face detection. Some factors such as head accessories, hair covering the face, and several parts of the face, like the eye, mouth, and nose that are invisible, should not be extreme.

Keywords: LBPH, Histogram Equalization

I. INTRODUCTION

Humans use faces to exchange information and share emotions through expressions [1] with the development of technology in artificial intelligence, especially in face detection, it is widely used to provide security solutions or track attendance. Face detection aims to determine the presence and identity in the form of a particular digital image or video on an area [2]. When face detection takes place, some parts of the face must be visible, but the lighting factor in a room or placed outside the room can cause some parts of the face to have little light, which causes the face to not be read clearly.

Face recognition uses several algorithms like eigenfaces, fisherfaces, and local binary pattern histogram (LBPH). Previously, the study combines a local binary pattern histogram algorithm with sound output. The system will identify faces through the camera. The output is a voice with the help of a Text-to-Discourse synthesizer application. The accuracy is about 85% and requires a long computational time because the calculations on the GPU are pretty complicated [3]. The local binary pattern histogram algorithm has a minor noise disturbance than the eigenfaces and fisher face algorithms. Using the OpenCV library's help, the local binary pattern histogram algorithm is authentic and competent[4]. In another study, the local binary pattern histogram algorithm worked well for face identification by having three main parts: face representation, feature extraction, and classification[5]

However, the grey image with the minimum light intensity causes some parts of a face to be undetected. In this study, image improvement uses Histogram Equalization on the LBPH algorithm to handle face detection in low light conditions. The Histogram Equalization method will increase the brightness of the image evenly so that later the accuracy of the local binary pattern histogram algorithm can be seen.

The study of face recognition uses The local binary pattern histogram (LBPH) algorithm. In other studies, compare three algorithms, namely: eigenface, fisherface. LBPH outperformed the other two algorithms with an accuracy rate of 96%[6]. Combine of Local Binary Patterns with Histogram of Oriented Gradient (HOG), it can significantly improve detection performance on multiple datasets[7].

Histogram Equalization research performed image detection for the maritime field (Pan et al., 2020), which used Sub histograms Brightness Preserving Bi-Histogram Equalization (BBHE) to improve images and prevent excessive enhancement. Histogram Equalization was tested together with ten other image enhancement methods[8]. The development of histogram equalization has a sample of 500 images with a faster computation time of 0.151 seconds, the highest contrast, and a minor color level compared to 10 other methods.

II. METHOD

A. Haar Cascade Classifier

The face detection process uses haar cascade algorithm. Haar Cascade is one of the few object detection methods to detect faces[9]. In general, detecting objects in digital images used haar-like features (Kamarudin et al., 2019), wavelet-based features that describe the image. The word "haar" refers to a mathematical function that is rectangular. A Haar wavelet is a single rectangular wave (one high and one low). For two dimensions (2D), it has one light side and one dark side. The function of cascade classification is to combine features more efficiently[9]. Haar cascade divides the two images based on red, green, blue (RGB), which varies from 0 to 255[10]. Detect an object of images uses a machine learning model like as Haar cascade algorithm. Calculation of feature values based on integral images to get object detection values. This integral can calculate the value accurately and relatively quickly, displaying a new image according to the value of the previously scanned area (1):

$$s(x,y) = i(x,y) + s(x,y-1) + s(x-1,y) + s(x-1,y-1) \quad (1)$$

(x, y) is the value of the number of areas in (x, y) while i (x, y) is the intensity of the original image matrix. s (x, y- 1) is the neighbour pixel value of y, while s (x-1, y) is the neighbour pixel value of x, and s(x-1, y- 1) is the sum of the neighbouring diagonal pixel values. The Haar cascade algorithm implements a cascade function to perform image training in four main stages: determination of Haar features, obtaining an integral image, AdaBoost Training, and classification using a cascading classifier.

B. Local Binary Pattern Histogram

LBPH is usually the preferred method in computer vision, image processing, and pattern recognition, and it is suitable for feature extraction because it describes the texture and structure of the image well. LBPH represents facial images and extracts image textures by dividing the image into several local regions and extracting binary patterns for each region 11). The features of the region merge into a single feature histogram representing the image. The images can than be compared by measuring their histograms' similarity (distance) [11]. The Local Binary Pattern operator obtains a binary pattern, called an LBP pattern whose value is between 0 and 1 [12]. Local Binary Patterns can be used to describe the texture features of an image. It has great advantages in grey and rotational invariance and has strong resistance to illumination[13].

LBPH is the binary ratio of the pixel intensities in a central pixel of about eight pixels. Surrounded by eight pixels, it is handy for defining facial features. In the face matrix on Fig. 1, features are extracted from the image to compare with the centre pixel value to finally produce a binary code[14].

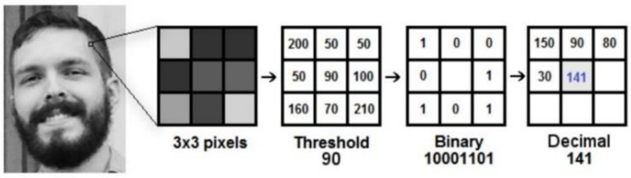

Fig 1. Image extraction on LBPH

The LBPH algorithm also has several limitations, including extreme changes in head position, facial expressions, occlusion, or other objects in the facial area[15].

C. Histogram Equalization

Image enhancement is one of the important tools in digital image processing in order to improve the visual appearance or to provide better analytical results in the future[16]. Image enhancement has been widely used to improve quality or reduce noise in digital images, in this study, using an image enhancement method, namely Histogram Equalization. A histogram is one of the most widely used methods in image enhancement, which has advantages in computation and easy implementation[17]. Histogram equalization (HE) is the most common contrast enhancement method due to its simplicity and easy application[18].

Histogram equalization increases the contrast in the image evenly. However, it has a drawback, namely if the image produced by the camera is bright enough, using this method will change the contrast of the resulting image significantly, which means that the area of the pixel value on the average image surface is close to zero. Histogram Equalization is an effective method to improve the image[19]. The principle is to map the original uneven gray level histogram to the dynamic range of the entire grey scale evenly by remapping the grey scale according to the probability distribution of the original grey-level histogram. Traditional histogram equalization algorithms can sometimes cause substantial grayscale combinations, resulting in loss of image detail.

Histogram equalization is the most well-known image processing procedure in the spatial domain based on intensity transformation[20]. Histogram Equalization can be divided into global histogram equalization (GHE) and local histogram equalization (LHE)[21]. What histogram equalization does is stretch the light intensity at each pixel; see the image below. The green circle shows a lack of intensity; after applying histogram equalization, will get a histogram like the image in the middle, after the image is increased the intensity can be seen for example like the image on the right, shown in Fig. 2.

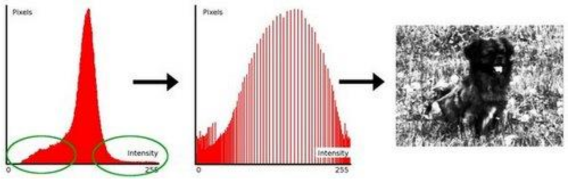

Fig 2. Image extraction process with histogram equalization

Histogram Equalization (HE) is widely used to enhance digital images 8). However, HE produces an increasing effect and excessive intensity in most cases. Histogram Equalization (HE) is a simple and effective technique for image contrast enhancement. HE distributes the intensity level of the input histogram uniformly throughout the range, the overall brightness of the image is also significantly altered by this method[22].

There have been many developments in the field of image enhancement using histogram equalization, one of which is Global HE (GHE). Global HE (GHE) is one of the most frequently used techniques in Contrast Enhancement (CE) because it has maximum efficiency. Increasing image contrast is an essential goal in digital image processing. HE-based CE is achieved by redistributing intensity values, and minimum contrast can be seen in the shade and on a supportive background[23].

D. Research Flow

Research flow shown Fig. 3. The stages and flow of this research include preparing datasets, training data, capturing faces from webcams, preprocessing images with histogram equalization methods, face detection, displaying rectangle frames on faces.

At the initial stage, determine the data source to be used and set several parameters of the LBPH algorithm including radius, neighbours, number of grids x number of grids y, threshold values. Facial images that have been captured via a webcam are extracted to be grayscale (grayscale image). The Haar Cascade Classifier creates an initial null rectangle. Increase the exposure of the extracted image to grayscale. The next stage is extracting the image with the LBPH algorithm and mapping the rectangle starting from the top of the forehead to the chin. Furthermore, the evaluation of several test scenarios and drawing conclusions.

E. Research Tools & Materials

All these experiments were carried out on a computer with Intel(R) Celeron (R) 2957U specifications, 1.40 GHz processor clock with 8.00Gb ram, running on Windows 10 operating system. Using C# language for program testing and OpenCV 2.4.9 library assistance. For storage of training data, the SQL Server Management Studio 2012 database was used, the image was taken using a webcam camera with a resolution of 1920x1080 (1080p). The dataset used in this study was sourced from a modified kaggle whose brightness level was reduced from 10 – 90%[24].

F. Experimental Methodology

In this study, 120 images were used from the face dataset taken from Kaggle[24], where each image has reduced its exposure level by 10 - 90% resulting in 1800 face datasets. As shown in the research flow diagram (figure 3.1), it will first retrieve the dataset stored in a database, namely SQL Server as many as 1080 training images, the next step is to set several LBPH algorithm parameters including: radius is 1, neighbor value is 8, many grid x is 8, many grids y is 8, the threshold is 70.

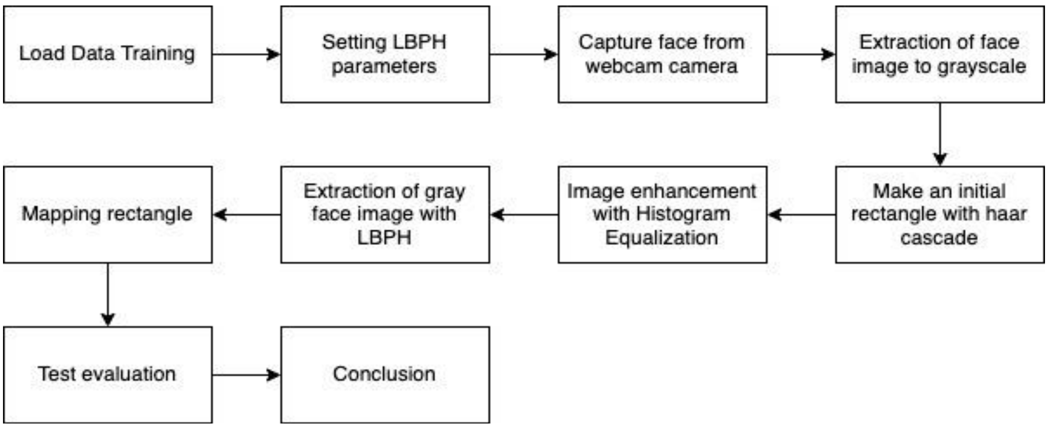

Fig 3. Research flow

The face is captured with a webcam camera and the face image will be extracted to a gray scale (grayscale image), the haar cascade classifier first creates an initial null rectangle , followed by the extraction of gray scale facial images with the LBPH algorithm.

Local Binary Patterns can be used to describe the texture features of an image. It has great advantages in gray invariance and rotational invariance, and has strong resistance to illumination[13]. After extracting the face image with LBPH, it is continued with image enhancement using a histogram, where histogram equalization gives an even brightness increase effect for all image pixels, the final result will map a rectangle from the forehead to the chin if the face is detected successfully.

The test required 35 images of faces with various criteria including 8 people with a tilted head position and 4 people using glasses, this test was to be able to detect faces in low light conditions.

III. RESULTS AND DISCUSSION

A. Testing Result

Local Binary Patterns can be used to describe the texture features of an image. It has great advantages in gray invariance and rotational invariance, and has strong resistance to illumination 13). In this test, it was carried out with a webcam camera with a resolution of 1920x1080 (1080p) requiring 35 images of faces with various criteria including 8 people with tilted heads and 4 people wearing glasses (Table I).

Table I there are 27 images of faces that have been detected and 8 images that are not detected as faces, resulting in an accuracy of 77% before using the Histogram Equalization image enhancement method, while when using the Histogram Equalization image enhancement method, 31 images were successfully detected and 4 images were not detected as faces, resulting in an accuracy of 88%.

B. Face Detection at Different Intensities

Contrast enhancement has an important role in image processing applications[25].In the testing phase, which was carried out with 35 images of faces from each individual at different lighting intensities, an increase in accuracy results was obtained after using the image enhancement method with Histogram Equalization. In Fig. 4, faces at bright light intensity can be detected well by the LBPH algorithm and after being increased by the Histogram

TABLE I
TESTING RESULTS

Information	Amount	
	Before	**After**
Successfuilly Detected	27Pictures	8 Pictures
Fail Detected	31Pictures	4 Pictures

Equalization method there is an increase in the white area more than the dark or gray area, this will produce a binary value of 1 with a threshold value of 70 it will be easy to detect it as a face.

Tests on other objects were also carried out at 80% light intensity on the face, in Fig. 5, the faces were successfully detected because facial features such as eyes, cheeks, nose and mouth were still clearly visible. The facial image is enhanced by the Histogram Equalization image enhancement method, the more clearly visible facial features such as eyes, cheeks, nose and mouth, resulting in a binary value of 1 with a threshold value of 70 which will easily detect it as a face.

Tests at 60% lighting intensity were also carried out, in Fig. 6, the face was not detected before using the Histogaram Equalization image enhancement method because the face area was dominated by dark gray. However, a significant change occurred when the image was enhanced with Histogram Equalization, the face was successfully detected and some parts of the face could still be seen such as the nose, cheeks and mouth area while other parts looked darker.

Fig 4. Image bright light, before using histogram equalization, after using histogram equalization (left to right)

Fig 5. Image 80% light intensity, before using histogram equalization, after using histogram equalization (left to right)

Fig 6. Image 60% light intensity, before using histogram equalization, after using histogram equalization (left to right)

C. Face Detection at Different Positions

The LBPH algorithm also has several limitations, including: extreme head pose changes, facial expressions, occlusion or the presence of other objects in the facial area[15]. At this stage, facial testing is carried out in different poses, for example right and left tilted poses, although extreme head poses are one of the limitations of the LBPH algorithm, but in the tests carried out the face can still be detected properly. In Fig. 7 (left), the faces were successfully detected even though the head is tilted to the right and there is a smile expression, this is because the light intensity on the face is still bright enough so that facial features such as the nose, cheeks and mouth areas can still be detected clearly, especially if it is increased by this method. Histogram image enhancement Equalization of the face area is dominated by white, resulting in a binary value of 1 for a threshold of 70.However, in testing an object with an extreme head pose, the face cannot be detected, in Figure 7 (right) the face is not facing the camera directly which causes the face to be difficult to detect, although some parts of the face such as the nose, cheeks and mouth can still be seen clearly.

D. Face Detection With Accessories

Tests on one of the other LBPH boundaries were also carried out, namely occlusion or there were other objects in the facial area. In Fig. 8, the face has been detected properly because there are no hairs that cover part of the face, so even though there are accessories in the form of glasses on the face, even though the light intensity is quite bright, some parts of the face such as the nose, cheeks and mouth can still be seen clearly.

Fig 7. Image with head tilted, extreme head pose (left to right)

Fig 8. image with accessories

However, in other cases the face is not detected successfully, in Fig. 8 (right), part of the face is covered by hair which causes the detection to fail, this will cause a high dense gray area on the left side of the face which makes one of the facial factors undetectable.

E. Face Detection With Noise

Tests were also carried out on objects that contained noise in the form of blurry images, faces were successfully detected even without using the Histogram Equalization image enhancement method. In this experiment, faces can still be detected even though there is noise blur because some parts of the face such as the nose, cheeks and mouth can still be seen quite clearly.

F. Testing With LBPH Parameter Values

In this test, the threshold value was reduced to 50, the result was that faces at 60% light intensity could not be detected, faces are very difficult to detect if the threshold value is set at 50 with training data of 1080 faces from 120 different individuals, based on The test carried out with a threshold value of 70 is very suitable for that much training data. The test image as shown in Fig. 9.

From several testing schemes carried out with 35 facial data from different individuals (Table II),

- A = Testing at different light intensities without Histogram Equalization.
- B = Testing at different light intensities using Histogram Equalization.
- C = Testing on different poses.
- D = Testing the use of accessories, veils or other objects on the face.
- E = Test for noise blur face image.
- F = LBPH parameter test.

Fig 9. Image for testing

TABLE II
AVERAGE ACCURACY RESULT OF FACE DETECTION SYSTEM

A	B	C	D	E	F	Average
77%	88%	87%	86%	100%	77%	85.83%

The results in Table II show the Local Binary Pattern Histogram algorithm when combined with the Histogram Equalization image enhancement method give a pretty good accuracy result in the range of 86%, when compared to the results of previous studies. The model is made specifically for detecting the faces of many people in a room, in contrast to this study which only detects one object. The results of the study [2] show that the Haar algorithm has a lower detection error rate than the Local Binary Pattern, but when the detection is carried out at low light intensity, the accuracy decreases quite drastically compared to the Local Binary Pattern.

The results of the accuracy of face detection using the LBPH algorithm are also not much different from other studies[3] which produce an accuracy of 85%, the LBPH algorithm is combined with voice output using the help of a Text-to-Discse synthesizer application so that it requires a long computational time due to calculations on the GPU quite complicated.

In this study, it was also tested when face detection contained noise that was detected well, this is also the same as other studies 4) which said that the LBPH algorithm has less noise disturbance compared to the eigenfaces and fisherface algorithms, this is very useful in detecting faces automatically. realtime because in some cases the frame rate of the camera cannot spontaneously follow the movement of the head.

IV. CONCLUSION

The image enhancement method with Histogram Equalization on the LBPH algorithm gives a significant improvement result, the face image is evenly enhanced by Histogram Equalization which can increase the light intensity in an image on the entire image surface, with the LBPH algorithm which is resistant to illumination makes face detection at intensity low light can be handled properly resulting in 88% accuracy, tested on 35 different individuals with different poses and different light intensities.

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