Performance Comparison of Min-Max Normalisation on Frontal Face Detection Using Haar Classifiers

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ABSTRACT

Face detection and analysis is an important area in computer vision. Furthermore, face detection has been an active research field in the recent years following the advancement in digital image processing. The visualisation of visual entities or sub-pattern composition may become complex to visualise due to the high frequency of noise and light effect during examination. This study focuses on evaluating the ability of Haar classifier in detecting faces from three paired Min-Max values used on histogram stretching. Min-Max histogram stretching was the selected method for implementation given that it appears to be the appropriate technique from the observation carried out. Experimental results show that, 60-240 Min-Max values, Haar classifier can accurately detect faces compared to the two values.

Keywords: Face detection; Haar classifier; Normalisation

INTRODUCTION

Face detection is an active research interest area in computer vision due to the advancement in digital image processing techniques and algorithms. Patterns and entity composition of medical images and other standard images can be complex to visualize or interpret due to the high frequency of noise or light effect in the images during examination process. Face detection is a dynamic research field that relates to visual informatics as well as computer vision encompassing locations, position, and sizes of human faces in digital images.

Face detection is significant for the success of any face related application processing system especially where there is a

need to further process or detect facial features correctly such as in security and surveillance systems. However, images are used in various fields to help monitoring process. For example, computer-aided diagnosis (CAD) is a rapidly growing research area that focuses on designing alternatives for the radiologist to interpret and evaluate results of cancer tests (Michael & Malik, 2007). Histogram Equalization (HE), local binary patterns (LBP), and modified census transform (MCT) techniques have been proposed to generate features that are robust to illumination variation (Fröba & Ernst, 2004; Lahdenoja, Laiho & Paasio, 2004; Yang, Kriegman, & Ahuja, 2004). This paper demonstrates Haar classifier to detect faces and compared min-max normalisation. Face recognition applications uses a database of collated data of images, comparing them with other images to discover similarities that may exist. One of the important roles within machine learning is a subdivision of computer science which is concerned with designing systems that can learn and predict from provided input data and automatically recognize complex patterns, to distinguish between the different patterns and to also make intelligent decisions (Nu, 2012; Zhang & Zhang, 2010).

Face detection was implemented using the Viola-Jones face detector (Amaro, 2012) which is implemented on OpenCV (Bradski & Kaehler, 2008). Faces are detected by the use of Haar Classifier Cascade. By reading the input data frame by frame, uniqueness can be detected. Histogram Equalization is important in face detection to enhance the global contrast, increasing accuracy. For a given image, overall methodology of face detection is concerned to find if there exists face or not, if present then the methodology will return face location and contents of the each face. The most important role in face detection is to detect the 'face' character. Through an application, face detection process has environmental setups, which are; illumination, instrument, light and conditions. In 2008, Hu, Zhang and Wang (2008) proposed a colour image based face detection that is based on the theory of rough sets and applying condition attribution. To extract the regions of the skin colour, foreground was segmented using two different types of skin colour model; HSV and YCrCb colour spaces. Open and close the morphological process are applied in order to eliminate the insignificant regions. de Magalhaes and Lima (2014) present a new method, based on the approach of Pavani and colleagues, by assigning weights to the Haar-like features in which PCA is used to find a vector of weights that detects the positive training instances. These two methods were set to verify the distribution of each key point generated from negative instances which can be same distribution to the features. However, the negative instances may spread from each other since it cannot be modelled.

MATERIALS AND METHODS

Pre-processing

The images are initially in JPG file format of RGB colour scheme; pre-processing was done by reserving the RGB colour schemes because converting to greyscale is not requirement for face detection. 14 pictures were selected from 435 pictures contained in the dataset. Dataset consists of 20 persons where each person has 15 training images. There is no visible noise in the images i.e. salt and pepper. However, the brightness in some of the images are not same. Dimension of the images in the datasets are different.

Flowchart for Face Detection

Figure 1 shows the flowchart for face detection. The pre-processing of the images is initiated by starting the methodology, then loading the first image from the images dataset followed by RGB values calculation. The min-max value is set by the user. Based on equalize histogram, the image in buffer is stretched using the value entered by the user. After a successful stretching of the image in the buffer, the next image from the path is loaded and is executed just as the previous image. This process is continued until all images in the dataset are executed or processed in the same way. However, for every image that is loaded into the buffer for execution, the value for RGB pixels is printed for the processed image. The histogram stretching computation of the min-max histogram stretching was conducted using Java programming language to implement the detection methodology illustrated in Figure 1.
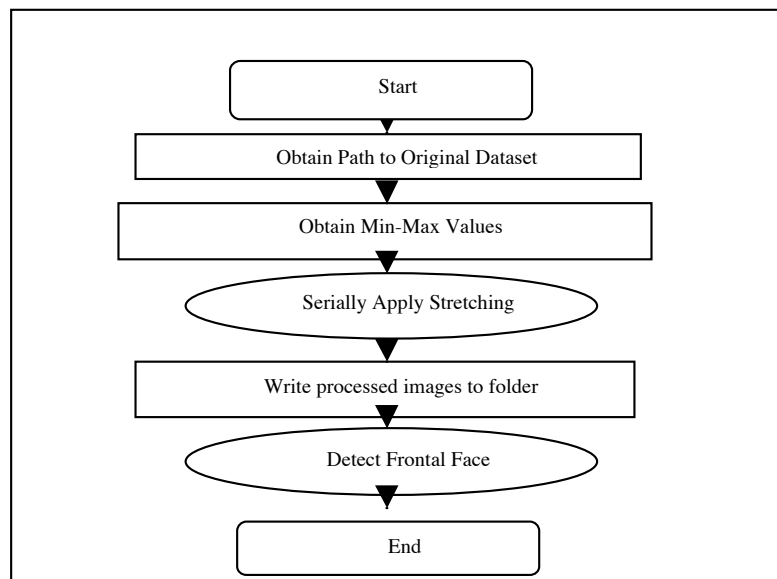

Figure 1. Flowchart for face detection

Face Detection. The face detection algorithm implemented in this research is Haar Cascade Face Detector. Haar Cascade Face Detector is contained in OpenCV (Open Computer Vision) developed by Viola and Jones in 2001. It combines four approaches in detecting faces, which are:

1. Haar features which are rectangular-like features.

2. An Integral Image for rapid feature detection.

3. The AdaBoost machine-learning method.

4. A cascaded classifier to combine many features efficiently.

Haar Features with Integral Image. Haar features are based on wavelets which are squared waves combining high and low intervals. The squared waves are pairs of adjacent rectangles (i.e. dark and light waves). The different features used by Amaro (2012) in Haar classifier are shown in Figure 2. The integral image as posited by (Amaro, 2012) is an array that contains sum of pixels' intensity values located directly to the left of a pixel and directly above the pixel location (x, y) inclusive.
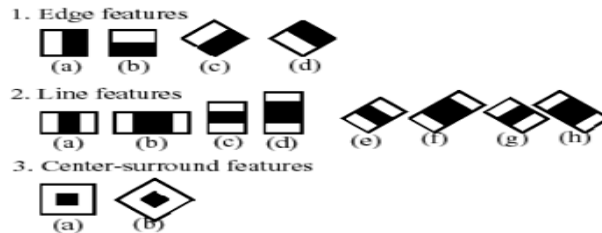
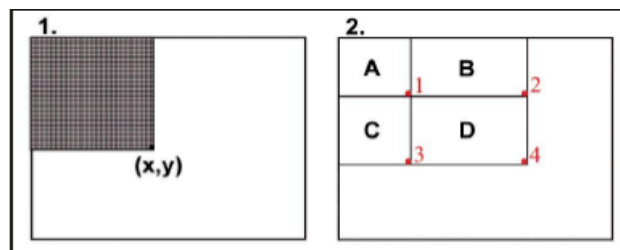

Figure 2. Features of Haar: Robin H. [11]

Figure 3. Image Integration: Robin H [11]

Following integration, the value at the location of each pixel (x, y) contains the summation of the entire pixel values contained in a rectangular region that has one corner at the top left of the image and the other at location (x, y). To compute the average pixel value in this rectangle, the value at (x, y) is divided by the area of the rectangle e.g. to find (x, y) sum of pixels at rectangle 'D', computed as D = (x4, y4) – (x2, y2) – (x3, y3) + (x1, y1).

Implementation Using Machine learning. The Machine learning algorithm used in training the Haar classifier is AdaBoost. It is an ensemble learning method that combines weak classifiers to generate a strong committee. The pseudocode for AdaBoosting as introduced by (Freund, Schapire, & Abe, 1999) is shown in Figure 4.

- **Train weak learner using distribution D_t.**
- **Get weak hypothesis $h_t : X \rightarrow \{-1, +1\}$ with error**

$$\epsilon_t = \Pr_{i \sim D_t}\left[h_t(x_i) \neq y_i\right].$$

- **Choose $\alpha_t = \frac{1}{2}\ln\left(\frac{1 - \epsilon_t}{\epsilon_t}\right)$.**
- **Update:**

$$D_{t+1}(i) = \frac{D_t(i)}{Z_t} \times \begin{cases} e^{-\alpha_t} & \text{if } h_t(x_i) = y_i \\ e^{\alpha_t} & \text{if } h_t(x_i) \neq y_i \end{cases}$$

$$= \frac{D_t(i)\exp(-\alpha_t y_i h_t(x_i))}{Z_t}$$

where Z_t is a normalization factor (chosen so that D_{t+1} will be a distribution).

Output the final hypothesis:

$$H(x) = \text{sign}\left(\sum_{t=1}^{T}\alpha_t h_t(x)\right).$$

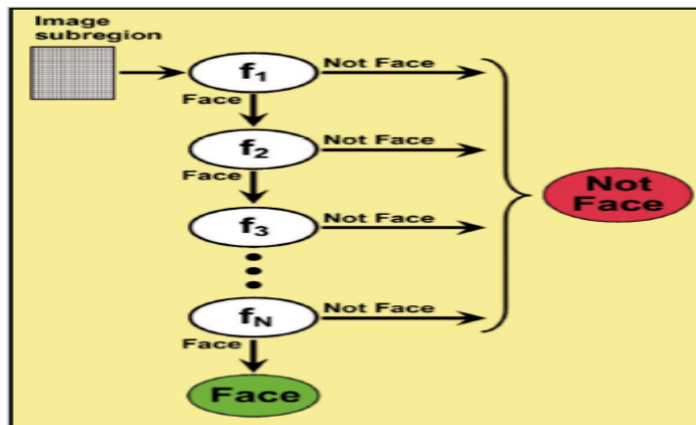*Figure 4.* Boosting Algorithm: Freund et al.

Figure 5. Cascade Classification: H. Robin

Image Features Cascade. The cascade in the classifier works as different level filters that are applied to each image where the sub-regions from the face make it through each level which are classified as face images.

RESULTS AND DISCUSSION

Experimentation was done based on three values to measure the impact and analyse the value pair that produces the best result. The value pairs represent the min-max values that were applied during the histogram stretching, which are:

Pair one – min (10) max (50)

Pair two – min (50) max (200)

Pair three – min (60) max (240)

The results obtained are as follows:

Pair One

The values for min-max (i.e. 10 and 50) were selected after loading the images into a sequence by setting the file path as shown in Figure 6. The individual RGB values were adjusted, and the outcome is shown in Figure 6. However, the visual effect is also shown in Figure 7.

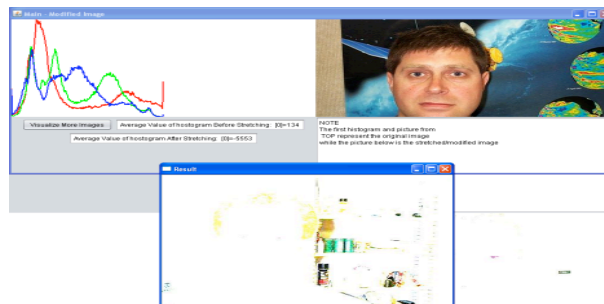*Figure 6.* Individual RGB values of pair one

Figure 7. Histogram stretching before and after

It can be clearly seen from Figure 7, that the results are showing distortedly to the image. The result of the stretching is a distorted image where no face could be detected using the Haar algorithm. Therefore, we experiment Pair-2 (min (50) max (200)) and Pair-3 (min (60) max (240)) is the better outcome.

Pair Two

The values for min-max (i.e. 50 and 200) were selected after loading the images into a sequence by setting the file path as shown in Figure 8. The individual RGB values were adjusted, and the outcome is shown in Figure 8. The visual effect is shown in Figure. 9.

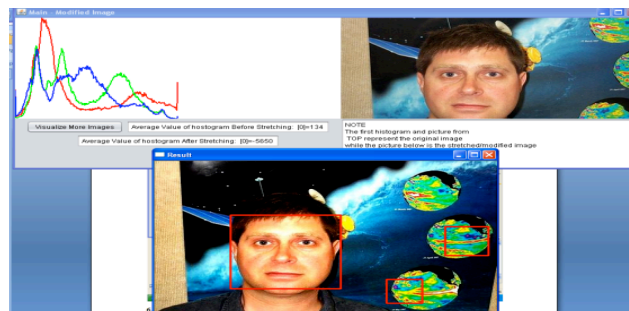*Figure 8.* Individual RGB values of pair two

Figure 9. Result before and after detections

It can be clearly seen from Figure10, that the values applied, result in a better image compared to the result from Figure 7. However, the result of implementing the Haar frontal face detection algorithm detects three faces of which only one is real and the other two are elliptical or circular shapes. Therefore, experimentation of Pair-3 (min (60) max (400)) results a better outcome.

Pair Three

The values for min-max (i.e. 60 and 240) were selected after loading the images into a sequence by setting the file path from the program. The individual RGB values were adjusted, and the outcome is shown in figure 10. The visual effect that 60 – 240 (min-max values) had is shown in Figure 11.
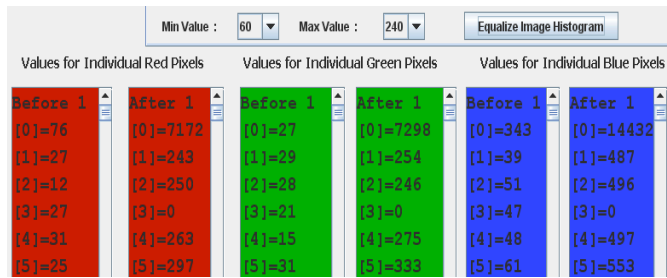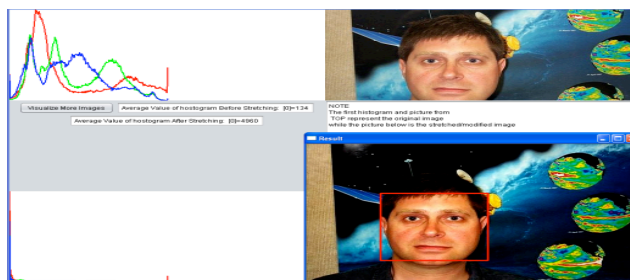
Figure 10. Individual RGB values of pair three

Figure 11. Before and after detecting only the face

Before and after detecting only the face. Figure 11 shows that the values (60 – 240 min – max) applied, resulted in a better image compared to the previous (10 – 20 min-max) and (50 – 200 min-max) values. Also, it is a relatively better result due to the fact that only this paired min-max value detects the only face from the experimented image.

Evaluation

Table 1
Over roll performances of the three pair

	Pair-1	Pair-2	Pair-3
Recall	0	100	100
Precision	0	77.78	87.5
F1	0	87.5	93.33

Based on the F1 figure from the graph in Figure 12, the Min-Max Pair 3 (60 – 240), score the highest values. Pair-3 has a surplus of 5.83% F-Measure (F1) accuracy in comparison to Pair-2. Pair-1 is the worst in terms of recall, precision, and F1, because it could not detect a single face from the set of faces used in the experiment.

CONCLUSION

This research analysed three min-max paired values for histogram stretching as a pre-processing technique and implemented Haar frontal face detection on the pre-processed images. Accuracy in face detection is important, however, to achieve high accuracy, pre-processing is relevant especially where the images are not clear, not balanced, or noisy. This study shows the impact of different min-max paired values for histogram stretching in detecting frontal human face.

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