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Human face detection in excessive dark image by using contrast stretching, histogram equalization and adaptive equalization

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Abstract

Darkness is the inverse state of the brightness, is obtained as an absence of noticeable light and illumination. Generally, face detection applications cannot detect any human face in a dark image, where the image has captured from the dark environment or dark night. In this manuscript, we demonstrate our experiment, where we use Contrast Stretching, Histogram Equalization and Adaptive Equalization techniques for detecting any human face in any dark image. In this paper, we also illustrate our proposed algorithm, working procedure and differentiate the pixel intensity of different stage of image processing. We essentially do this research from an application perspective, where a software application detects the human face from a dark photo or a very low-contrast image and the photo has been captured from an excessive dark environment.

Keywords: *Image Processing; Dark Image; Face Detection; Low-Contrast Image; Computer Vision.*

1. Introduction

Detection and recognition of any human face are currently important topics in the area of image processing and computer vision. For the most part, if any photo receives from the high dark environment, most of the software application cannot detect any human face. Here, high dark environment means that a circumstance where we have very low light and the photo of this situation which contains very low intensity. An issue happens when the picture is caught in the night with no flash or light. In this situation, the software applications cannot detect any human face in dark image [1], [2].
In addition, in recent years, some research papers have been published, where researchers have shown how to identify or recognize people's face in the shadowy night using the concept of "Night Vision", "Thermography" and "Infrared Vision" [3]–[6]. Using these three methods are really expensive and require specific device and camera. Moreover, those manuscripts are not exhibited how to track a human face from the dark image without using these three methods. Moreover, another three recent experiments have revealed. Two discussions have expressed for detecting partial imperceptible objects from a dark and foggy image [7], [8]. Another method that solves a similar problem but this method has utilized for identifying the human body organs [9]. Besides, these previous researches have not disclosed any approach for detecting any human face from a dark image, where contrast is immensely low.
According to this research gap, an approach for detecting a human face from a dark image is proposed. For developing our experiment, we have utilized Contrast Stretching, Histogram Equalization and Adaptive Equalization methods. We have developed a model from application perspective using Contrast Stretching, Histogram Equalization and Adaptive Equalization methods. Then changed the intensity of the dark image and finally, detect the face.
The main contributions of this research paper are three areas- (1) Detection of a human face in the excessive dark environment; (2) Usage of Contrast Stretching, Histogram Equalization and Adaptive Equalization methods for detecting the face from the dark image; (3) Performance of these three techniques for human face detection in dark image.
The rest of this paper is organized as follows. Section 2 describes the proposed model and process. Section 3 presents the experimental methods of different image processing techniques for detection face in dark image. Section 4 demonstrates the proposed algorithm. Section 4 presents the experimental result with the discussion. Finally, the paper is included in Section 5 with a brief conclusion and our future work.

2. Proposed model and process

Our research showed an application based model which have displayed, how a computer program can detect a human face from a dark photo. At first, a photo was taken from a dark environment or night and we have measured the pixel intensity. Then, this image was sent to Contrast Stretching, Histogram Equalization and Adaptive Equalization processes. Contrast stretching is also called Image Normalization which improves the dark image by expanding the range of intensity values of the image [10]–[12]. Histogram equalization adjusts the image intensity to enhance contrast [13]. In the image processing field, Adaptive Equalization also knew as Adaptive Histogram Equalization (AHE) which is

used for improving the contrast of images by changing the intensity [14].
By using these three techniques or methods, the dark image was enhanced by particular contrast and again measured the pixel intensity. If any technique detects the face, then an updated image is displayed, where we tracked the human face by a rectangular shape in a dark image. In Fig. 1 we have illustrated an algorithmic flowchart of our experiment and in Fig. 2 we have displayed our experimental visualization.

Step 1: Captured dark image from dark environment by a camera.

↓

Step 2: Use Contrast Stretching, Histogram Equalization and Adaptive Equalization on Dark Image for enhancing contrast.

↓

Step 3: After applying previous step's three techniques, get three processing images.

↓

Step 4: Try for detecting human face among the processing images by a rectangle shape.

↓

Step 5: After detecting face, set the same coordination of rectangle shape in dark image.

↓

Step 6: Show the result of human face detection in dark image.

Fig. 1: Steps of our proposed model.

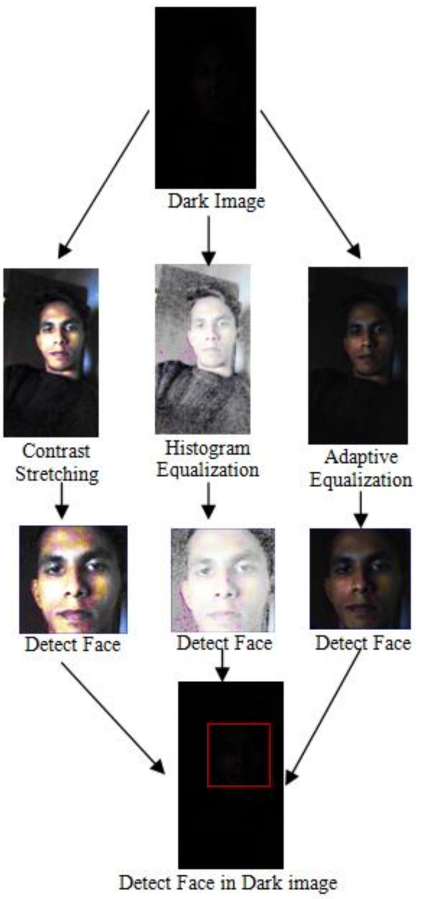


Fig. 2: Image processing and visualization of our experiment.

3. Dark image processing

There are some techniques for enhancing the contrast of the dark image. A study has been described as a dynamic stochastic resonance for improving the contrast of the dark and low-contrast image [15-16]. The noise-induced technique takes a topical adaptive image processing and importantly increases the contrast and colour fact [17]. The content-aware algorithm increases dark photo, sharpens sides in the textured area, and maintains the softness of flat area [18]. For Auto-focusing at the low-contrast image, a robust focus approach has used where the approach is based on the energy [19]. On the other hand, for decreasing the sticking in dark image, the driving waveform works very effectively [20]. In our experiment, we used Contrast Stretching, Histogram and Adaptive Equalization approach for increasing the contrast and pixel intensity of the dark image.

3.1. Contrast stretching or image normalization

Contrast stretching is an activity that applied to images, where promotes the contrast of the image so that the image can be seen clean. Sometimes Contrast stretching is also called image normalization. The formula of contrast stretching [21] was used in our experiment which given below:

$$I_o = \left(I_i - Min_i \right) * \left(\frac{Max_o - Min_o}{Max_o - Min_o} + Min_o \right) \qquad (1)$$

Here, I_o is the output of pixel, I_i is an input of pixel, Min_i is the minimum pixel of an input image, Max_i is the maximum pixel of an input image, Min_o is minimum pixel of output image and Max_o is the maximum pixel of an output image. Here, the input is dark image and output is the image of contrast stretching method. This is displayed in Fig 2. After using this formula we got a new image, where the pixel intensity is higher than the dark image's pixel intensity.

3.2. Histogram equalization

Commonly, a histogram is a probability estimation of a particular type of data. An image histogram is a kind of histogram which offers a graphical statement of the total format of the *Gray* values in an image. Generally, histogram equalization is a method for adjusting or synthesizing image intensities to increases contrast. The procedure of histogram equalization relies on the usage of the Cumulative Probability Function (cdf).
Suppose think an image which is represented as *f*. Pixel intensities ranging is 0 to $L - 1$. L is the values of probable intensity. Normalized histogram denoted by p. From initial steps of Histogram equalization [22], we get,

$$p_n = \frac{\text{Number of pixels with intensity } n}{\text{Total number of pixels}} \qquad (2)$$

Where $n = 0, 1, ..., L - 1$. The final stage of histogram equalization is as per as following,

$$p_Y(y) = p_X((T^{-1})y)\ \frac{d}{dy}((T^{-1})y) \qquad (3)$$

Here, the intensities of image contain random values X, Y. p_X is the possible f density function. T refers the cumulative distributive function of X. In histogram equalization, T is differentiable and invertible. Y defined by $T(X)$, where T is distributed on $[0, L - 1]$. By using histogram equalization approach we get an update which is illustrated in Fig 2.

3.3. Adaptive equalization

Adaptive histogram equalization (AHE) is also known as adaptive equalization. It is different from traditional histogram equalization in the favour that the adaptive technique calculates various histograms. In this method an individual section of the photo, and conducts them to redistribute the lightness of the image. It is a suitable process for enhancing the topical contrast and improving the edges in each of an image.

If the (x, y) is a pixel mapped location and i is the intensity of an image. The mapping $m_{+,-}$ at the grid pixel (x_+, y_-) to the upper right $x_{+,-}$. Similarly the mapping $m_{+,+}$ of right lower $x_{+,+}$. The mapping $m_{-,+}$ of left lower $x_{-,+}$. The mapping $m_{-,-}$ of left lower $x_{-,-}$. So the formula of the adaptive equation,

$$m(i)=a[bm_{-,-}(i)+(1-b)m_{+,-}(i)]+[1-a]\,[bm_{-,+}(i)+(1-b)\,m_{+,+}(i)] \tag{4}$$

Where,

$$a=\frac{y-y_-}{y_+-y_-};\; b=\frac{x-x_-}{x_+-x_-}$$

After using the equation [23], [24] of adaptive equalization which have demonstrated in equation 4, than we get an update image which is illustrated in Fig. 2.

4. Proposed algorithm

In this segment, we expressed the programming idea and structure of our algorithm. The algorithm was implemented by Python programming language and also used Open Source Computer Vision Library (OpenCV) [25], [26]. The idea of the algorithm (See Algorithm 1) in programming perspective is as follows:

The idea of the algorithm (See Algorithm 1) in programming perspective is as follows:

- At first read a dark image and set this image into *darkImg*.
- For identifying the images of contrast stretching, histogram and adaptive equalization, *testImg[ ]* array have declared, which contains *testImg1*, *testImg2* and *testImg3*. By using these three techniques three new images are accordingly set in *testImg1, testImg2, testImg3*.
- Another array *detectFace[ ]* have declared for collecting the detected face image where contains *detectFace1, detectFace2, detectFace3*. Array *detectImg[ ]* was declared for showing output of face detection in dark image. *detectImg[ ]* contains face *detectImg1, detectImg2, detectImg3* variable.
- For recognising human front face, Haar Cascade feature [27] is used. Then set it into *face_cascade*.
- Some rectangular points (x, y, w and h) are declared for colouring or marking the face detection in dark image.
- Variable i which is initially zero but every while loop section the value of i is increased (i++), until the *testImg[ ].length( )* is not complete.
- The *readImg* temporary variable that contains the particular *testImg[ ]*. Then load the test image (*readImg*) in grayscale mode and use “RGB ↔ GRAY” flag [28] by *cvtColor( )* function of OpenCV library [29]. This function have used for converting color-space to another.
- *detectMultiScale( )* function [30] used for detecting face by using Haar Cascade Classifier in the *gray* image [31].
- An “inner for loop” works there, for detecting face in the images (*testImg1*, *testImg2* and *testImg3*) of *testImg[ ]*. In OpenCV library of Python there have *rectangle( )* function [32] for drawing rectangle at *face* in dark image (*img*) and detect image (*testImg1, testImg2, testImg3*).
- Region of Interest (ROI) concept was created for the apply face detection [33] in *readImg*.
- By *imwrite( )* function, detect face in *readImg* then detect face in dark image (*darkImg*) and save these images in the folder. Lastly show the result of particular *detectImg*, where face detect in dark image.

Based on the above discussion, the formation of the purpose algorithm for the programming standpoint [34], [35] is according to algorithm 1:

Algorithm 1: Dark Image Face Detection Algorithm.

```
import OpenCV library cv2;
darkImg ← read raw dark image;
testImg[ testImg1, testImg2, testImg3 ];
testImg1 ← ContrastStraching(darkImg);
testImg2 ← HistogramEqualization(darkImg);
testImg3 ← AdaptiveEqualization(darkImg);
detectFace[ detectFace1, detectFace2, detectFace3 ];
detectImg[ detectImg1, detectImg2, detectImg3 ];
face_cascade ←Identify face by Haar Cascade Classifier XML file;
Rectangular Area Pont: x; y; w; h;
i = 0;
while ( testImg[ ].length( ) not complete )
   readImg ← testImg[ i ];
   gray ← cv2.cvtColor( readImg, RGB ↔ GRAY flag ) ;
   face ← face_cascade.detectMultiScale( gray,1.1, 5 ) ;
   for ( complete x, y ,w, h in face )
        cv2.rectangle(readImg,(x,y), (x+w, y+h) ,(255,0,0), 2) ;
        cv2.rectangle(darkImg,(x,y), (x+w,y+h), (255,0,0), 2);
        ROI_gray ← gray[ y : y + h, x : x + w];
        ROI_color ← readImg[ y : y + h, x : x + w];
        cv2.imwrite(detectFace[ i ], ROI_color);
        cv2.imwrite(detectImg[ i ], darkImg);
        showResult(detectImg[ i ]);
   end for
   i++;
end while
```

5. Result and analysis

The proposed technique was developed in the Spyder IDE and Anaconda application [36]. We had measured the mean intensity of different image. Fig 3 has been shown the percentage rate of face detection in dark image by using Contrast Stretching, Histogram Equalization and Adaptive Equalization methods. After applying these three techniques we have found that Contrast Stretching showed better performance for detecting the face in dark image. Here, Contrast Stretching 90%, Histogram Equalization 83%, Adaptive Histogram Equalization 84% have been detected the human face in the dark images. Some image is visualized only one or two processes.

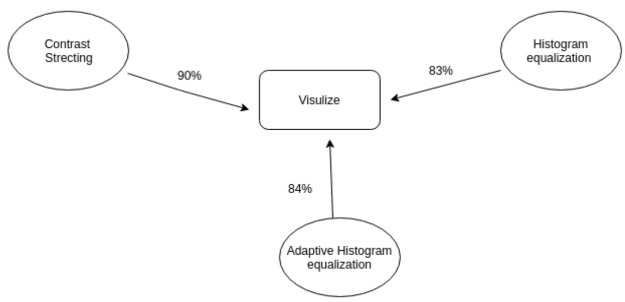


Fig. 3: Percentage of Dark Image Face Detection in Utilized Three Approaches.

Histogram equalization technique had been increased the image intensity more than another two techniques. It makes a big problem. The original image intensity is very low. When the image processed and increased the intensity so much that time, it is making noise in the image, and then the image is not well visible. Another two techniques Contrast Stretching and Adaptive

Histogram Equalization were increasing the intensity; maintain a range and making less noise. Contrast Stretching and Adaptive Histogram Equalization had been increased the image intensity nearly. For that reason, their visualization rate in dark environment is little high than Histogram Equalization.

Fig. 4, Fig. 5 and Fig. 6 have represented the graphs and dark images, contrast stretching, histogram equalization and adaptive equalization processes, where we can understand the intensity differentiation among the steps.

In Fig. 4, section (a) has been displayed a dark image and its intensity range and pixel numbers. The pixel intensity of dark image is very low. Section (b) have shown different outputs of three techniques which has been applied in our experiment and their graphs. In contrast stretching the pixel intensity has been enhancing and in histogram equalization the pixel intensity has been enhancing excessively, but in adaptive equalization the pixel intensity cannot increase. For that reason, here, face detection in dark image by using only contrast stretching method which has shown in section (c).

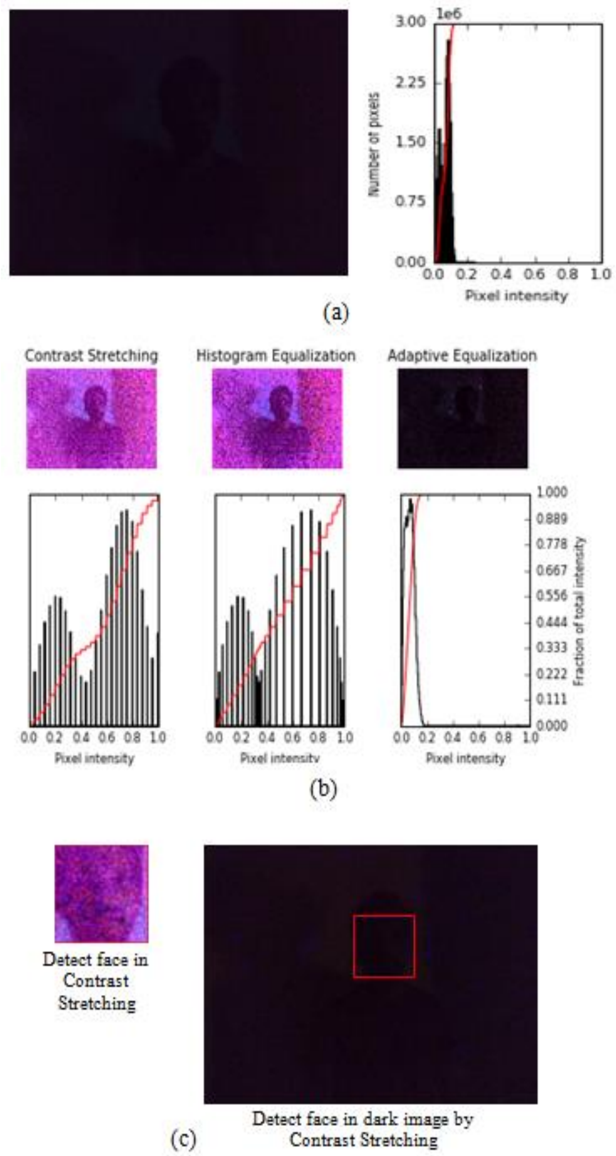


Fig. 4: Experiment Results of Face Detection in Dark Image.

In Fig. 5, section (a) has been shown a dark image with its pixel numbers and intensity, where the pixel intensity of dark image is obsessive low. Section (b) has displayed different outputs of three techniques. In contrast stretching and histogram equalization, the pixel intensity has been enhancing, but in adaptive equalization the pixel intensity cannot increase. Therefore, here, by using contrast stretching and histogram equalization, face can be detected in dark image which has been shown in section (c). In this case face cannot detect in adaptive equalization techniques cause at this process pixel intensity cannot increasing.

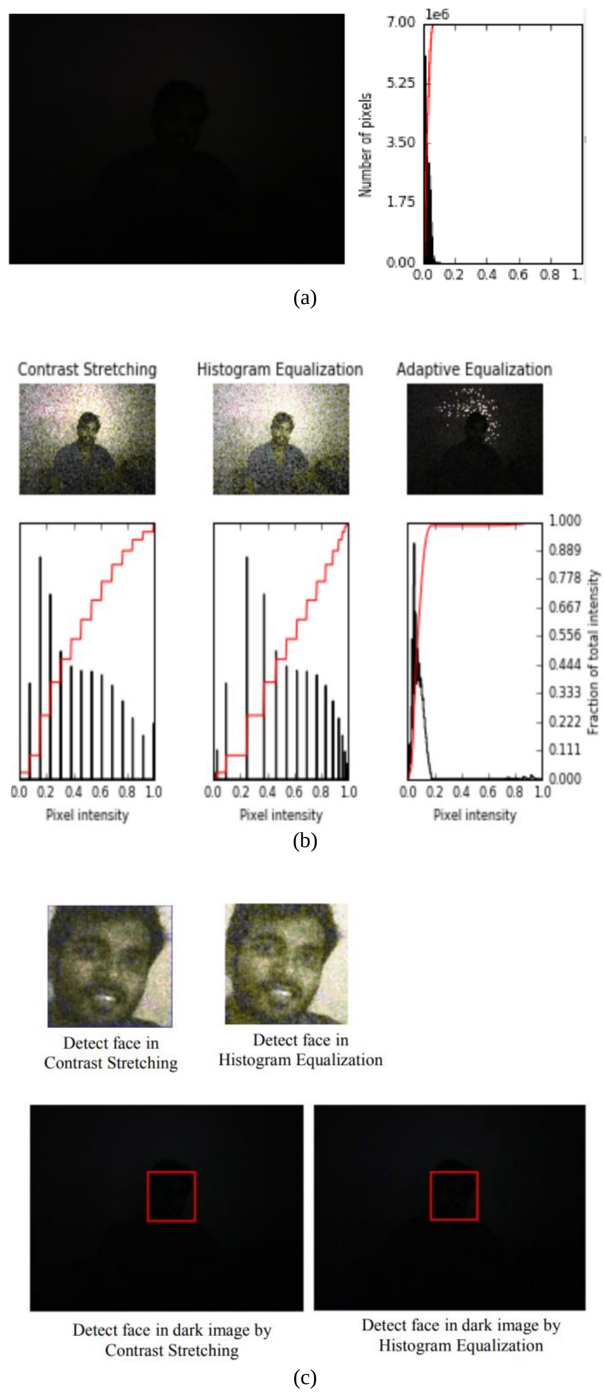
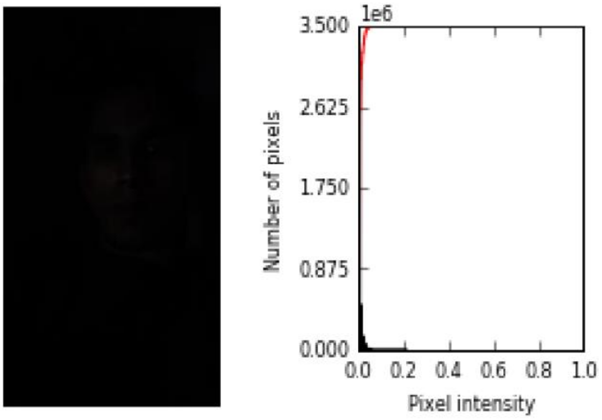


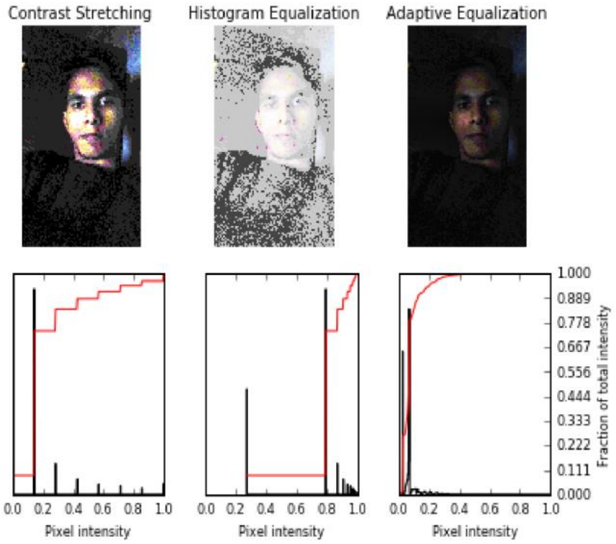
Fig. 5: Another Experiment Result of Face Detection in Dark Image.

In Fig. 6, section (a) has displayed a low contrast dark image and its pixel numbers with intensity. Section (b) has shown three different images by using the Contrast Stretching, Histogram Equalization and Adaptive Equalization and their graphs. In contrast stretching and histogram equalization, the pixel intensity has been enhancing, but in adaptive equalization the pixel intensity also has been increased but not too much. In this case, face detected at all techniques. Then set the rectangular co-ordination of detect face images to dark images which has been shown in section (c).

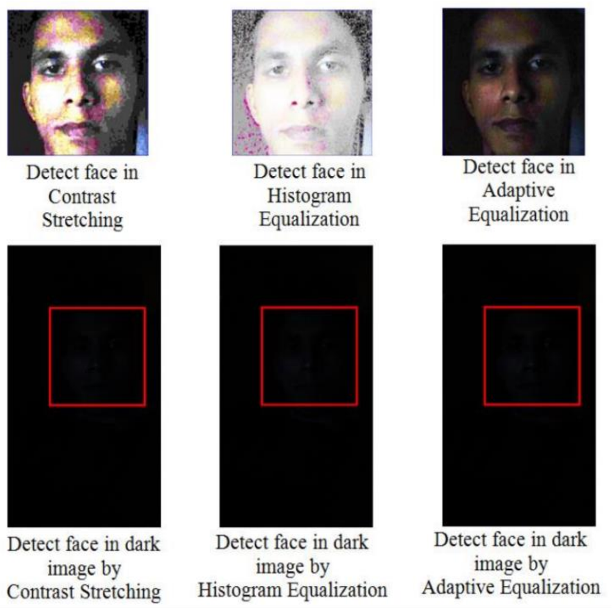
In the detection part of the dark Image, we can see that a rectangular shape is shown in the image. This rectangular shape has detected the face in the dark image. After processing our proposed Algorithm 1, the program had made four points in images of Contrast Stretching, Histogram Equalization and Adaptive Equalization methods. Then the rectangular shape coordinates in the dark image.



(a)



(b)



(c)

Fig. 6: An Experiment Results of Face Detection in Dark Image By Using Contrast Stretching, Histogram Equalization and Adaptive Equalization.

6. Future works and conclusion

The experimental research illustrates an approach to face detection in dark image where represents how a computer application can detect any human face from dark image by using contrast stretching, histogram equalization and adaptive equalization techniques. The application is currently under development in the perspective of artificial intelligence (AI) and Machine Learning. These are key examination for better proximity about face detection in dark image in our future exercises. The entire dark environments concept can be changed into a scholarly model by various learning calculations (Deep Learning, and Neural Networks). In our fourth coming exploration, we are hopeful to complete real-time face detection in dark environment with Machine Learning and Computer Vision based our own deployed software.

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