

## A FACE DETECTION AND RECOGNITION PROCESSING WITH LIGHTING INVARIANCE CONDITION

Jaya Sachan<sup>1\*</sup>, Keshav Dev Gupta<sup>2</sup>

<sup>1</sup>M. Tech. Research Scholar, Jayoti Vidyapeeth Women's University, Jaipur, Rajasthan, India

<sup>2</sup>Assistant Professor, Jayoti Vidyapeeth Women's University, Jaipur, Rajasthan, India

### ABSTRACT

Very rarely will a face recognition system be presented with perfect lighting conditions with ambient lighting not causing distinct irregular shadows on a subject's face. If a face recognition system be to be used in real-world environments, under varying light conditions, it must be able to overcome irregular lighting [1]. Therefore the following image processing techniques were used during the author's research to provide a degree of lighting invariance mechanism.

**Key Word:** Invariant, Lighting, Image, Processing, Scenario, Recognition, Visual.

### 1. INTRODUCTION:

Face detection is an important division of face recognition as the first step of automatic face recognition. However, face detection is not simple because it has a lot of variations of image appearance, such as pose variation such as front, non-front, occlusion, image orientation, illuminating condition and facial expression. Very rarely will a face recognition system be presented with perfect lighting conditions with ambient lighting not causing distinct irregular shadows on a subject's face [2]. The worst case scenario is when there is a single directional light source on one side of the subject's face. Human face vertical differences in lighting do not seem to affect the frontal face image a great deal. Vary the lighting as much as possible in the environment which the images were gathered to test the systems robustness.

### 2. Normalizing Process of Face Detection and Recognition:

The following image is captured under lighting conditions which to a human's visual system do not seem that adverse for face recognition.



Figure 1.1: Frontal view face captured under real-world lighting conditions.

However by examining this image under a suitably scaled color map it is evident that there is extremely irregular lighting prevalent (Figure 1.2) these conditions would adversely affect the performance of the whole face recognition and detection system and therefore must be adjusted.

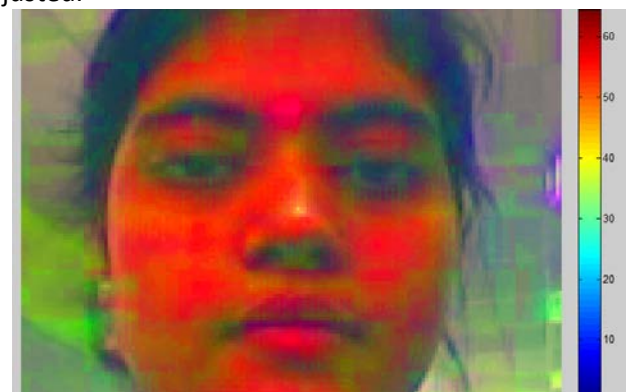


Figure 1.2 Face with a suitably scaled color map

The worst case scenario is when there is a single directional light source on one side of the subject's face, similar to the above figure. Furthermore, most lighting irregularities in the real world are with a light source on either side of the subject. Because of the inherent contours of a human face vertical differences in lighting do not seem to affect the frontal face image a great deal [3]. After examining many image processing techniques it was found that normalizing the columns of the image matrix (normalizing the image in the vertical direction) was an effective method of overcoming irregular lighting shown in blow figure 1.3.

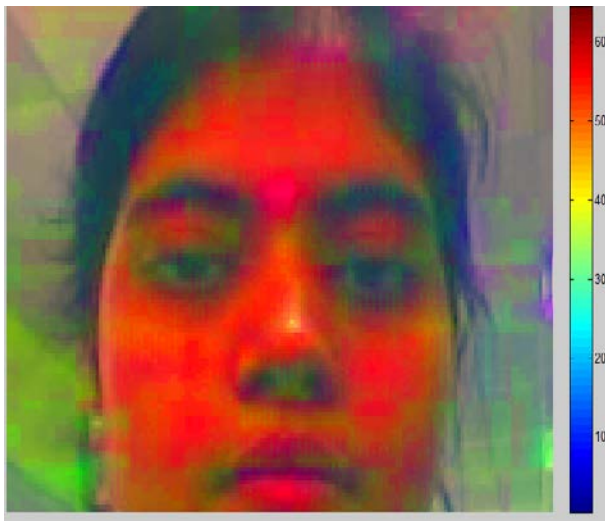


Figure 1.3: Face after normalizing vertically

Normalizing horizontally and even normalizing horizontally after normalizing in the vertical direction was found to give unsatisfactory results (Figures 1.4 and 1.5)

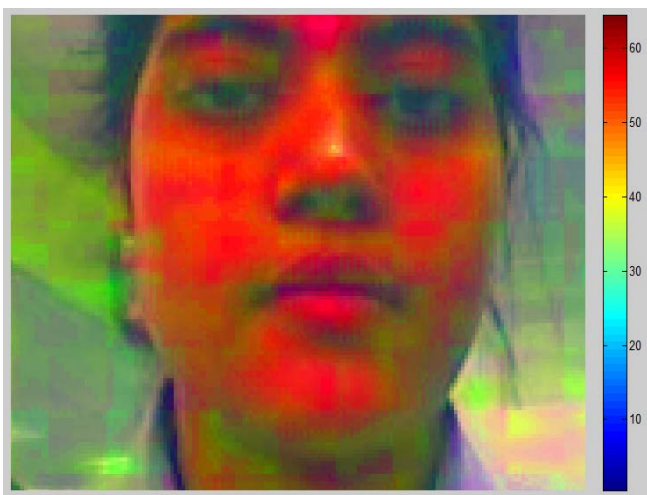


Figure 1.4: Face after normalizing horizontally

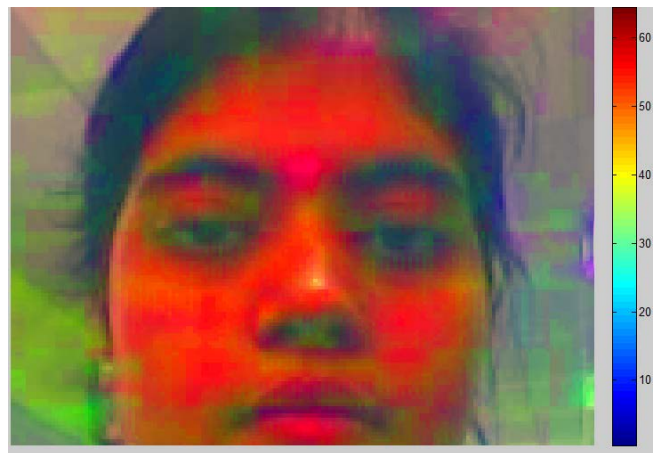


Figure 1.5: Face after normalizing vertically

Then normalizing horizontally. Notice the horizontal bands that appear along rows with high intensity areas. Horizontal normalization should not be used in similar computer vision problems.



Figure 1.6 Face under real-world lighting



Figure 1.7: Face after vertical normalization

The original and vertically normalized images are shown above using the normal grey scale color map. Although they both look similar to the human visual system the image on the right is far superior for reasoning using computer vision and for face recognition purposes.

### 3. Histogram Equalization Method for Image Processing:

The digital camera, which the author used to assemble the face database, had an automatic exposure, which unfortunately adversely affected the face images. Many of the images were too dark and not suitable for face recognition [4]. Histogram equalization equitably spreads the pixels of an image among the grey-level intensities thereby increasing the contrast of the image.

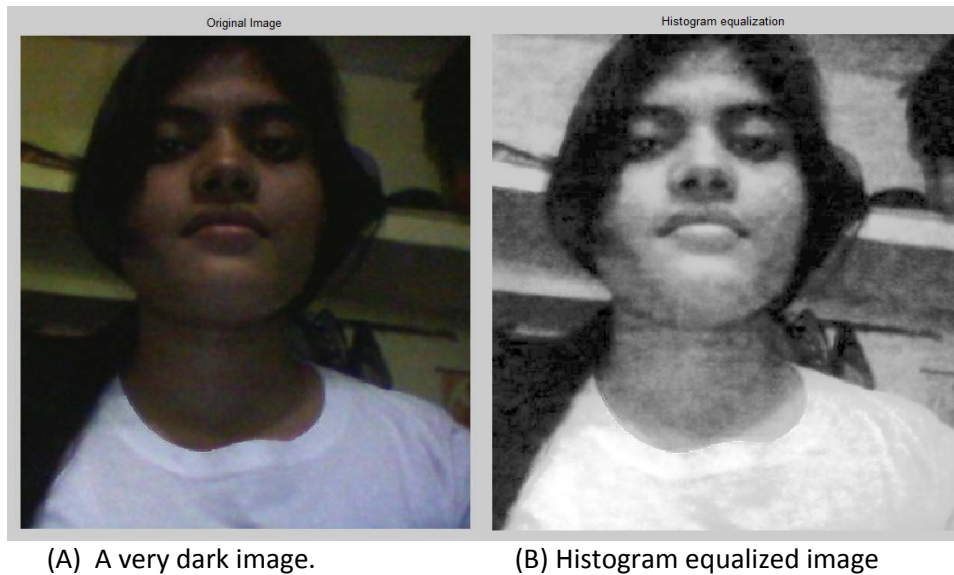


Figure 1.8: Histogram equalization

### 4. Order-Statistic Filtering:

A serious error was made by the author when assembling the main face database. While the images in part VII were captured without a flash, the author used digital camera with a flash when photographing subjects for this project's main face database. Using the flash frequently caused highlights in the subject's eyes which affected the vertical normalization pre-processing as described in the

previous section and also adversely affected face recognition accuracy [5]. Since over 450 photographs were taken in the main face database, retaking the whole database was not an option. Also, the author did not want to manually alter the face images since this would detract from the value of the overall system. An image processing technique was needed to isolate and remove the highlights.



Figure 1.9: Highlights from camera flash



Figure 1.10: After order-statistic filtering

A 2 dimensional order statistic filter, which replaces each element in a 3x3 neighborhood with the minimum element in the neighborhood, was found to provide satisfactory results. Order-statistic filtering encompasses many useful image processing techniques including the popular median filter.

**5. System Testing for Images:**

The following systems were implemented using Mat lab 7.0 and tested on an Intel Pentium 4, with 1GB of RAM running Windows XP. This platform should be considered as the minimum hardware requirement since the face detection and recognition algorithms could have been modified for increased accuracy on a more powerful testing platform.

- 1) Fully automated face detection with verification
- 2) Fully automated face detection without verification
- 3) Manual face detection and automated face recognition
- 4) Fully automated face detection and recognition
- 6) Pose invariant face recognition

450 images from 30 test subjects were obtained to test the above systems. The data for testing the fully automated face detection system, manual face detection and automated face recognition system and the fully automated face detection and recognition consists of 4 frontal view images per test subject. The first image was taken under 'good' conditions with relatively constant lighting conditions on a white background. This would be used as the known frontal view face image in the face recognition system [6]. The environment condition of the image was categorized by the researcher as 'A'. The other three frontal view images were taken under worsening conditions with adverse lighting conditions and sometimes with a black background. These would be used as test images for the frontal view face recognition system. An effort was made to vary the lighting as much as possible in the environment which the images were gathered to test the systems' robustness [7] [8]. The environment condition of the image was categorized as 'B'. Data for the pose invariant face recognition was gathered as follows. Nine known images from each individual were collected and three (unknown) images taken when the subject was posing in intermediate angles between the nine known images. The nine known images were taken with the test subject posing. Since pose invariant face recognition is not as robust as frontal view face recognition this data was gathered under very controlled conditions. The images from three test subjects had to be rejected since many of these had been

very adversely affected by the automatic exposure of the digital camera used to obtain the face images [9].

**6. Fully Automated Face Detection Process:**

The output of the face detection system (segmented face area) is subjectively evaluated to fall into the following categories:



Figure 1.10: Successful detection, excellent face segment



Figure 1.11: Successful detection, Good face segment



Figure 1.12: Failure face image

**7. Fully Automated Face Detection Testing Without Verification:**

First, the fully automated frontal view face detection system was tested without verifying its results (without using reconstruction or correlation with the average face). The following table contains the testing results shown in the following table:

Table 1:

Condition of images	Total tested	Successful detection		Failures
		Excellent	Good	
A	15	10 (62%)	8 (29%)	1 (7%)
	15	15 (92%)		2 (7%)
B	50	15 (45%)	12 (40%)	4 (15%)
	50	25 (85%)		4 (15%)

Condition A refers to frontal view images taken with a plain white background under relatively controlled lighting conditions, while condition B images are those randomly taken from the set of images that were taken under worsening lighting conditions and sometimes with a black background. When considering all the trade-offs that were made, the adverse environment conditions and the degradation to the images caused by the digital camera's automatic exposure, the successful detection rate is quite high [10]. While the successful detections with a good segment area will probably require modest alterations in the face window location to be done by the face recognition system, the excellent face segments will need little adjustment. The PCA recognition is extremely sensitive to scale and position variations so small adjustments to the face detection output will always be needed. Unfortunately the segmented areas from the face detection failures are totally useless for face recognition [11]. These errors occurred when the best faceness heuristic did not coincide with the actual best face location.

**8. Conclusion:**

After examining many image processing techniques it was found that normalizing the columns of the image matrix be an effective method of overcoming irregular lighting process. Histogram equalization equitably spreads the pixels of an image among the grey-level intensities thereby increasing the contrast of the image.

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