CHAPTER 3
OVERVIEW OF CONTRAST ENHANCEMENT
METHODOLOGIES BASED ON MODIFIED HISTOGRAM EQUALIZATION TECHNIQUE

3.1 INTRODUCTION

In real life scenario, under surveillance systems and access control systems it is a challenge to have controlled illumination conditions. Necessity demands to recognize face images captured in both indoor and outdoor environments where intensity and direction of illumination are likely to vary. Illumination variation has extremely complex effects on the acquired face image[76, 77]. It is a challenging task for Face Recognition (FR) systems to recognize face image with a change in the direction and intensity of illumination. Illumination variation impairs the accuracy of Face Recognition systems due to the following conditions:

- Change in the direction of illumination may cause shadows or shift in the location of shadows or results in the change of shape of the shadows on the face images [5, 78].
- Change in the direction of illumination can result in a half-lit image [5].
- Change in the intensity of illumination may cause the acquired image to be a dark-lit image [5].
- When the face image is captured in bright illumination condition, it may cause the acquired image to be an overexposed image [5].

When any of the above conditions prevails the clarity in the facial features essential for recognition does not exist. Hence, Face Recognition systems struggle to recognize face images with illumination variation. For any Face Recognition systems illumination pre-processing or illumination enhancement is an essential step before the system proceeds with the
recognition process. This is a vital step for any real time Face Recognition systems. In literature, various methods are available to overcome the challenges caused by illumination variation.

3.2 CONTRIBUTION OF THE THESIS

Face recognition has become a popular area of research in computer vision. Some of the most popular applications of face recognition are fraudulent detection, and restricted entry (access control)[79]. The problem statement in face recognition can be formulated as, given a frontal face image captured under real-time environments, face recognition system has to recognize the person as known/unknown by comparing with the repository of face images stored in the facial database.

When a face image is captured in real time environment, it could be acquired with an expression (smile, anger, or surprise) or illumination variation in comparison with the face images already acquired and stored in the database. The major challenge of face recognition system is to recognize face images with variation in pose, expression and illumination variation[79].

The main contribution of this thesis lies in recognizing face images acquired with illumination variation. Face images captured with illumination variation may contain shadows, or it could be half-lit face image or dark-lit face image, which does not reveal the identity of a person. Therefore, it is essential to enhance the contrast of the face images before trying to recognize them. Contrast enhancement is a task that makes the image features striking more evidently by making optimal use of the colours available for displaying the image. Figure 3.1 shows the overview of the proposed contrast enhancement methodologies for improving the face recognition accuracy.
The contribution of this thesis for contrast enhancement has evolved in three different phases:

- Localization of the global technique
- Using Neighbourhood Metric
- Localization coupled with Neighbourhood Metric

### 3.2.1 Localization of the Global Technique

Any global or holistic technique used for contrast enhancement of an image takes the whole image as input. When taking the whole image as input, the overall contrast of the image improves, but it fails to operate on local areas of the image. Shadows and annoying artifacts still exist in the face image even after pre-processing the image using the holistic technique.

Therefore, there exists a necessity to localize the global technique for removal of shadows and annoying artifacts. To overcome this drawback
the first method, namely Completely Overlapped Uniformly Decrementing Histogram Equalization (COUDSHE) has been proposed for localizing the global technique. It provides a unique framework for localizing the global technique, which helps in the removal of shadows from the face image. COUDSHE framework has been proposed and implemented using MATLAB on the Yale Face Database B and shows that there is a decrease in the mean squared error rate by 0.3 %, 9.85% and 2.55% on heavily shadowed images, half-lit and dark-lit images respectively. Also, the proposed method COUDSHE shows 48.65% of the decrease in the Histogram Flatness Measure for a heavily shadowed image. The decrease in Histogram Flatness measure indicates that there is an increase in the contrast ratio of the face image. However, for half-lit and dark-lit image COUDSHE increases the flatness ratio.

3.2.2 Using Neighbourhood Metric

Contrast is a significant aspect for the subjective evaluation of image's quality. The bedrock of Contrast Enhancement lies in improving the contrast of an image to make features of the face image distinguishable or easily perceivable. The contrast of an image is determined by the use of the dynamic range of all possible gray levels available for displaying an image. The contrast of an image improves by maximizing the usage of gray levels (increasing the spread of the intensity value within the dynamic range).

To increase the spread of the gray level value in illumination affected image the second method, namely Histogram Equalization using fuzzy approach on the neighbourhood metric has been proposed. This method has been implemented using MATLAB and tested on the Yale Face Database B. Histogram Equalization using Fuzzy approach increases spread of the intensity values in the image, which subsequently increases the contrast of the image. The proposed method shows 13.57% decrease in Histogram Flatness measure on heavily shadowed images. As mentioned earlier decrease in Histogram Flatness measure indicates that there is an increase in the contrast ratio of the face image.
3.2.3 Localization coupled with Contrast Enhancement

A face image captured in the real-time scenario may be low contrast image with shadows. The third method, namely COUDSHE coupled with Neighbourhood metric (hybrid approach) has been proposed for removal of shadows and to enhance the contrast of the face image. COUDSHE has been coupled with three neighbourhood metrics, namely voting metric, distinction metric and fuzzy approach on the neighbourhood metric. This hybrid approach has shown significant improvement in enhancing shadowed, half-lit and dark lit face images. The proposed method shows 7.4%, 1.97%, 13.41% of decrease in Histogram Flatness measure for heavily shadowed, half-lit and dark-lit images respectively. This reveals that the proposed hybrid approach considerably increases the contrast of the illumination affected images.

3.3 SUMMARY

In this chapter, contrast enhancement methods and their hierarchy of the evolution have been discussed. This chapter also brings to light the need behind the proposal of each technique and the effect of the same on the face images in the Yale Face Database B. Hence, this chapter gives a birds-eye view of the proposed techniques and their effect on illumination affected images.