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Analytical Analysis on Illumination Invariant Face Recognition

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***Abstract*: The illumination variation problem is one of the well-known issues in face recognition in uncontrolled surroundings. In this paper, an in depth and up-to-date survey of the prevailing techniques to handle this problem is given. This survey reviews various illumination processing techniques such as Self Quotient image,Logarithmic Total Variation, Log DCT, Gradient Face ,Weber Face,a hybrid of Local Phase Quantisation and multi-scale Local binary pattern etc.**
***Keywords*: Illumination, singular value decomposition, recognition rate, self quotient image,LTV.**

I. INTRODUCTION

Person identification has become one of the foremost important issues within the current situation of globalisation. Amongst various forms of Person identification that includes passwords, keys, etc, biometric is considered to be one of the distinct, measurable and robust physiological traits of an individual. Thus, various forms of biometrics are being utilized to verify the claimed identity of person. Every individual carries one's own personal identification in the type of one's face, which is extremely hard to be falsified. Face biometric is gaining popularity than others techniques such as fingerprint, iris, voice, gait, etc due to its very nature of being non-intrusive[9]

Face recognition is a process of matching a given face image against set of face images stored in the image database. However, this process is not a simple task as stated in its definition. This is because of internal and external factors that influence the appearance of an individual [13]. Researchers developed various new approaches for solving these challenges like variations caused due to illumination, pose, occlusion, aging, race difference and is continuing to progress at a faster pace. This paper analyses different approaches for recognizing a face under different illuminations with small variations in expressions and pose. It is based on the underlying assumption that between two samples of same subject even if changes do occur, it is relative at least in some dominant positions. This factor is used for encoding images which are then used in decision making.

A. Face recognition concept

Face recognition usually consists of two stages namely training stage and recognition stage as shown in Fig.1. The training stage starts with preprocessing of training images to extract face from a complicated background.The next step is to apply an algorithm on the preprocessed images to generate feature vectors. At the end,the feature vectors are saved in a proper format to compare with test images during recognition stage[16].

Recognition stage usually involves three steps. First step is the detection of the face area in a complicated background and localization of its exact position. Following step is to extract the facial features followed by normalization to align the face with the saved face images in training stage. Finally, classification happens on the basis of the criteria that the comparison of the database images and test images crosses a threshold.

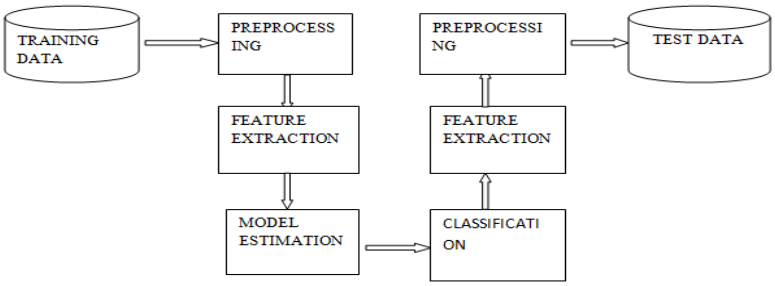

Fig. 1 Training and recognition phases[9]

The following flowchart in Fig. 2, illustrates the procedure of face Recognition. The face images are represented in face space and

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their reconstruction will be similar to the original face image resulting in very low reconstruction errors. The unknown face images will result in reconstruction error which is larger than the threshold level.With respect to known face image,the distance measure is used to determine its closeness to the original image.

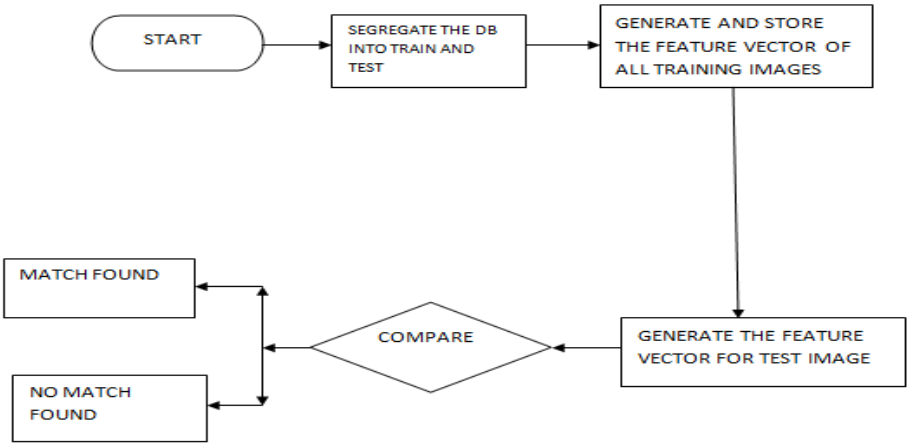

Fig. 2 Flowchart[9]

B. Illumination

Illumination is a standoutt amongst the biggest factors impacting the performance of face identification system. It is outstanding that, for face identification, image modifications because of illumination changes are generally more critical than that because of unique individual details.[2]

Fig. 3 Face images under varying illumination

Illumination normallization is a key task in an comprehensive variety of image handling areas. Changing illumination in encountered faces frequently encourages unwanted issues, e.g., unwarranted sides from dark areas are inclined to perplexity with authentic boundaries of the face elements like mouth and eyes. To take care of this issue, the prevalent thought is to model an image I as a result of the reflectance R and illumination L elements (i.e., I=RL) [1].

One of its most crucial programs has got to be face identification under varying illumination environments. Its concept application areas integrate law execution ,security, voter check, and physical accessibility control of building areas, entrances, vehicles or net accessibility. Considering the review on face identification techniques acknowledging faces under different illumination environments can be categorized as Self Quotient image[SQI],Logarithmic Total Variation[LTV],small scale and large scale features[S&L_LTV], Log DCT, Gradient Face ,Weber Face ,LBP,LTPetc. [9]

II. RELATED WORK

The quotient image (QI) was considered one of illumination insensitive measure. Shashua et al. [7] first provided QI, which was the image ratio between a test image and the linear combination of three non-coplanar illuminated images. QI relied on the infirmation of the face reflectance. Wang et al. [15] prolonged the QI concept to the non-point light quotient image (NPL_QI) and the self-quotient image (SQI), where NPL_QI was described as the ratio between the input image and its estimating illumination and SQI

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was described as the ratio between the input image and its smooth version.

Chen et al. [4] suggested the logarithmic total variation (LTV) model to draw out the small-scale featuress (i.e. high-frequency components) of a face image, which reduced the well known notorious halo artifacts and preserved only the small-scale face components. The LTV design had more power to keep sharp edges in low-frequency illumination areas with simple parameter selection than the total variation (TV) design. Xie et al. [12] designed an illumination normalization method based on small-and large-scale features (S & L_LTV), which was inspired by the fact that the large-scale features (i.e. lowfrequency components) also included useful information for identification. The LTV design was used to break down the face image into small-and, large-scale features for S & L_LTV. The illumination normalization centered on DCT [9] conducted on the large-scale features and only a small modification was made on the small-scale features, then a normalized face image was obtaineded by combiniing the processed small-and large-scale features. However, these high-frequency facial features can attain expected performace under moderate illumination variations but perform unsatisfactorily under severe illumination variations.

Weilong Chen et al., presented a novel illumination normalization strategy for face recognition under different illumination environments. In the recommended strategy, a discrete cosine transform (DCT) was employed to make up for illumination changes in the logarithm domain. Since illumination variations mainly lie in the low-frequency band, an appropriate number of DCT coefficients were cut down to reduce variations under different illumination environments[21] Experimental were performed on the Yale B database and CMU PIE database which showed that the proposed approach improves the performance significantly for the images with large variations in illumination. Moreover this does not require any modeling steps and can be easily implemented in a real-time face recognition system**.**

Taiping Zhang et al. recommended a novel strategy to extract illumination insensitive features for face recognition under different illumination known as the Gradient faces. Theoretical research revealed Gradient face was an illumination insensitive measure, and robust to different illumination, such as uncontrolled and natural illumination. In addition, Gradient faces was derived from the image gradient domain such that it could discover underlying inherent structure of face images since the gradient domain explicitly considered the relationships between neighboring pixel points[5]

Georgios Tzimiropoulos, Stefanos Zafeiriou introduced the concept of subspace learning from image gradient orientations for appearance-based face recognition. As image data were typically noisy and noise was substantially different from Gaussian, traditional subspace learning from pixel intensities very often fails to estimate reliably the low-dimensional subspace of a given data population.They showed that replacing pixel intensities with gradient orientations and the ‘2 norm with a cosine-based distance measure offers, to some extent, a remedy to this problem. Within this framework, which they coin Image Gradient Orientations (IGO) subspace learning, they first formulated and studied the properties of Principal Component Analysis of image gradient orientations (IGO-PCA). They then showed its connection to previously proposed robust PCA techniques both theoretically and experimentally. Finally, they derived a number of other popular subspace learning techniques, namely, Linear Discriminant Analysis (LDA), Locally Linear Embedding (LLE), and Laplacian Eigenmaps (LE).

Biao Wang et al. recommended an illumination normalization strategy based on Weber’s law which suggests that for a stimulus, the ratio between the smallest perceptual change and the background is a constant, which implies stimuli are perceived not in absolute terms but in relative terms**..** Inspired from that, they utilized and analyzed a novel lighting insensitive representation of face images under different illuminations via a ratio image, known as “Weber-face,” where a ratio between local intensity differences and the background was measured[11]

Ping-Han Lee,Szu-Wei Wu and Yi-Ping Hung proposed the orientated local histogram equalization (OLHE) which compensates illumination while encoding rich information on the edge orientations. They claimed that edge orientation was useful for face recognition. Three OLHE feature combination schemes were proposed for face recognition: 1) encoded most edge orientations; 2) more compact with good edge-preserving capability; and 3) performed exceptionally well when extreme lighting conditions occurred .The proposed algorithm yielded state-of-the-art performance on AR, CMU PIE, and extended Yale B using standard protocols. The further evaluated the average performance of the proposed algorithm when the images lighted differently were observed, and the proposed algorithm yielded the promising results[23].

Soodeh Nikan, Majid Ahmadi proposed a local-based illumination insensitive face recognition algorithm which was the combination of image normalisation and illumination invariant descriptors. Illumination insensitive representation of image was obtained based on the ratio of gradient amplitude to the original image intensity and partitioned into smaller sub-blocks. Local phase quantization and multi-scale local binary pattern, extract the sub-regions characteristics. Distance measurements of local nearest neighbor classifiers were fused at the score level to find the best match and decision-level fusion combines the results of two

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matching techniques. Entropy, class posterior probability and mutual information were utilised as the weights of fusion components. Simulation results on the YaleB, Extended YaleB, AR, Multi-PIE and FRGC databases showed the improved performance of the proposed algorithm under severe illumination with low computational complexity and no reconstruction or training requirement[19]

III. COMPARISION OF RECOGNITION RATES

TABLE I
RECOGNITION RATES OF VARIOUS TECHNIQUES

METHOD	YALE B	CMU PIE
SQI[7,15]	93.33	93.14
LTV[4]	89.05	91.05
S&L_LTV[4]	93.17	94.05
Log DCT[21]	93.81	94.30
Gradient Face[5]	94.29	93.84
Weber Face[11]	97.46	95.72
MSLDE[9]	96.19	95.39
Multiscale LBP+LPQ[19]	99.17	98.7

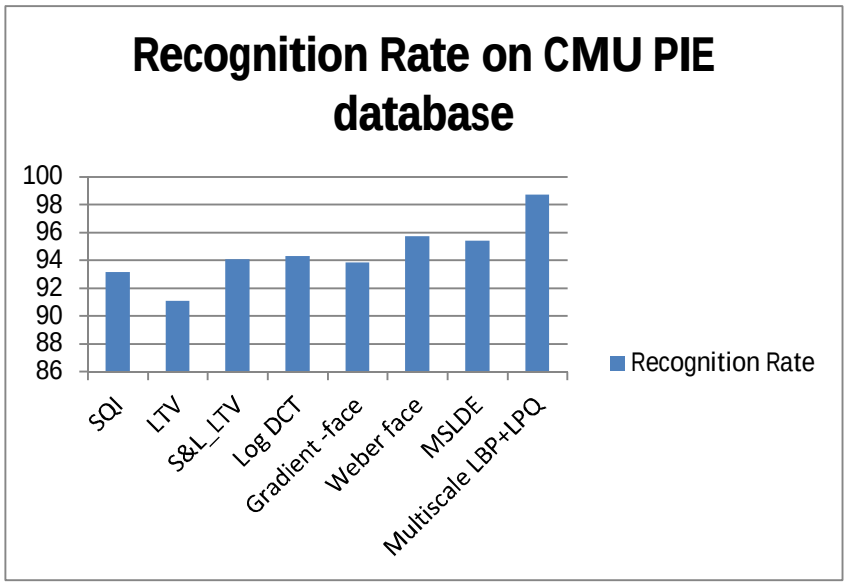

Fig. 4 Recognition rate on CMU PIE database

IV. CONCLUSION

Face Recognition under different illumination is one of the greatest problem in face identification. Illumination normalization is a very complicated process to get an illumination invariant image. An in depth overview of most latest improvements of face identification methods has been given in this document to deal with illumination issue. According to the evaluation,the hybrid technique of multiscale LBP and LPQ outperforms several other methods under serious illumination variations such as on the CMU PIE face database.

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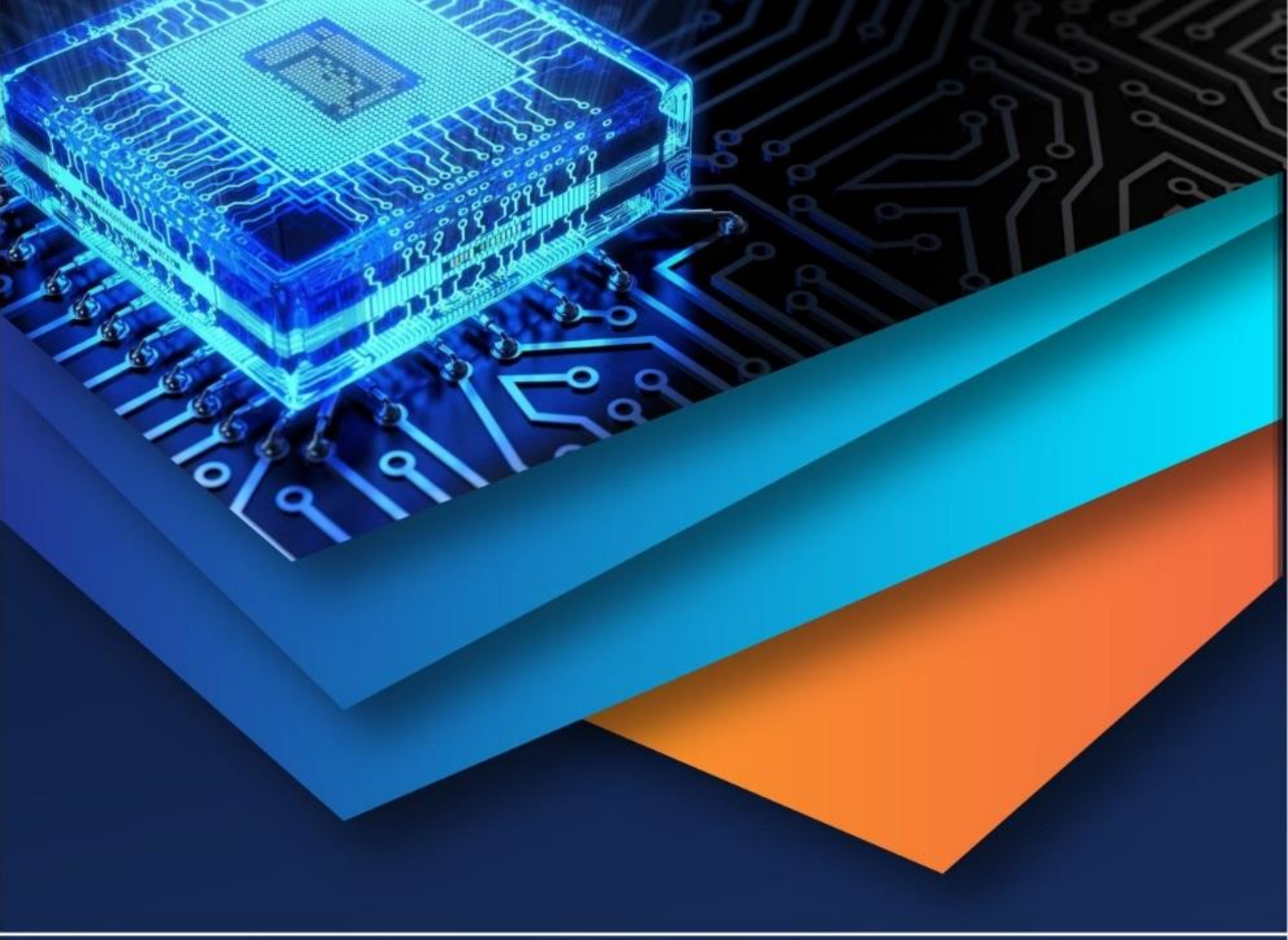

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