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Comparative Analysis of Facial Recognition involving Feature Extraction Techniques

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Abstract: Facial Recognition is a primary branch of Pattern Recognition used to distinguish faces based on feature variation. All the objects in the universe has a proper arrangement termed as "pattern", thus every human face has a unique pattern. Those patterns are identified or verified by Recognition process. Especially Facial Recognition done manually is a trouble-free process whereas recognizing a face using computers is a knotty task because of illumination, occlusions, facial expression and pose. The input for the recognition face can be in any digital sources such as image or video from the face database. Therefore the key features of the face such as brows, eyes, nose and mouth serves as input. In order to achieve utmost accuracy in facial recognition in digital images different feature extraction techniques are used in Facial Recognition. Feature based and Appearance based complexities like feature extraction and illumination for automated computer vision recognition is discussed. This paper evaluates feature extraction techniques in a broad perspective.

Keywords- *Facial Recognition, Feature Extraction, Illumination, Appearance Based, Recognition Rate*

I. INTRODUCTION

Pattern Recognition plasters many subdivisions such as Facial, Iris, Text, Image, Object, Speech, Handwriting, Ariel, Fingerprint, Sound wave and Barcode Recognition. The process of extracting data and producing the solution using the given resource such as image, text, audio, etc is called as Pattern Recognition. Among, Facial Recognition is an emerging area, several new technologies using facial recognition is developed but still some tough situations evolved in it such as illumination, facial expression, posture, occlusions, etc. not all images contains same illuminations also every time the face cannot be found exactly in the same posture and the mood swings in humans may change facial expressions like sad, happy, etc., finally partial occlusion akin wearing sunglasses, scarf's, hair, even hands, etc., By overcoming these obstacles preprocessing is performed to mine the valid data labeled as feature extraction. Usually, Preprocessing does the feature extraction is the preliminary process in pattern recognition. Facial recognition involves the steps described in the fig 1 [12].

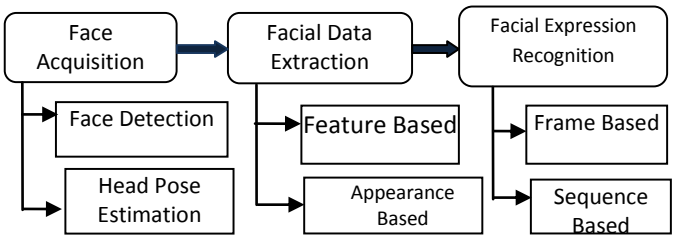

Figure 1: Steps of Facial Recognition

Therefore this paper discusses the feature extraction techniques pacts with the Facial feature/data extraction. So far we have seen the introduction in Section 1. Section 2 describes the Facial Data Extraction, popular Feature Extraction Techniques depicted in Section 3, Comparative Analysis on Feature Extraction Technique in dealt in Section 4 and the Conclusion in Section 5.

II. FACIAL DATA EXTRACTION

Feature extraction techniques serving facial analysis for automated facial recognition. Hence this auxiliary advance with taxonomy: *feature based and appearance based*. Feature based invoke with fractal based extraction, the chief features of the face is extracted as valid data and Appearance based identify the illumination of an image, pixel density and light variations.

Feature based yet again sort out into *Geometric feature* recognize a face principal features like eyes, brows, nose and mouth in geometrical shapes and *Appearance feature* refers skin texture, wrinkles and furrows is illustrated in fig 2.

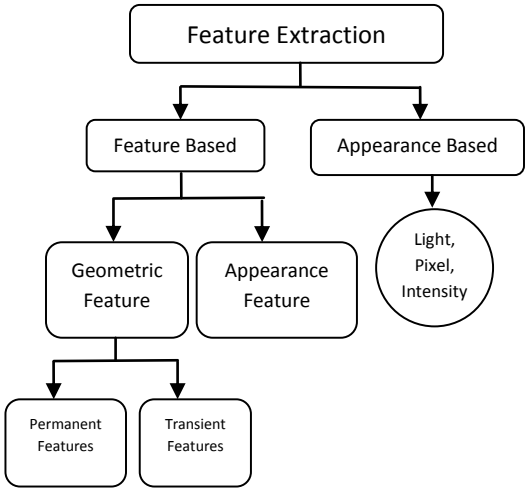

Figure 2: Classifications of Feature Extractions

Tian et al. widen multi-state models geometric facial features extraction. Lip state: open, closed, tightly closed lip models. Eye: open or closed model. Cheek and brow has a one-state model. Appearance features furrows and wrinkles using two states: present and absent [2]. Geometric feature can be distinguished into *Permanent feature* covers key features and *Transient features* with nasal root, nasolabial furrows. The method that comprise of geometric and appearance feature is Hybrid approach. These are extensive classification beneath feature extraction; subsequently diverse techniques are established to extract data is conferred below.

III. FEATURE EXTRACTION TECHNIQUES

Extraction techniques consider the prime features of the face like eyes, brows, nose and mouth in the initial step then capsules the skin texture, wrinkles, illumination and pixel intensity. Hence all the feature extraction techniques shown in fig 3 are elucidated further.

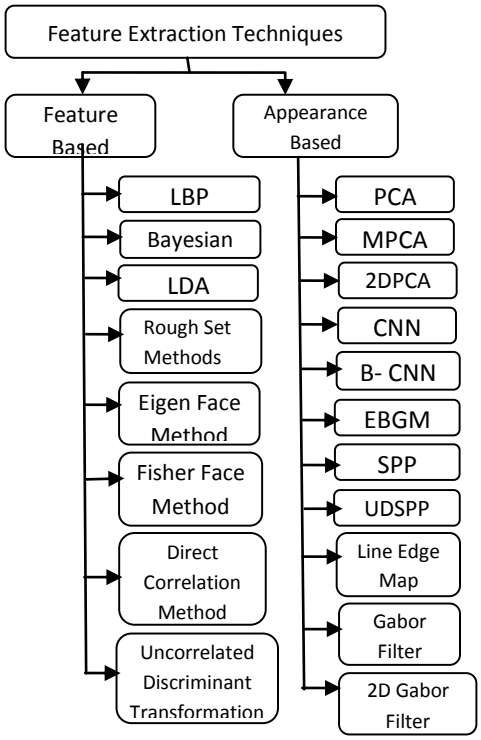

Figure 3: Feature Extraction Techniques

3.1 Local Binary Pattern (LBP)

The most common and widely followed technique: Local Binary Patterns (LBP), it worn for geometric information and surface intensity efficient in 2D face recognition. Li and Zhang [1] put forward recognized geometrical attributes such as angles, curvatures and geodesic distances. It is a texture operator resulting in binary number pixels labeled and threshold with the neighboring pixel. LBP effectively grade texture and matching in computer vision, acknowledged for its robustness. Threshold converts coordinate values into binary numbers in LBP.

3.2 Principal Component Analysis (PCA)

The next often used technique is PCA. To reduce feature aspect Principal Component analysis (PCA) is an ample used in facial recognition for the intention to explore and visualize variation minutely by generating long vectors.

3.3 Modular PCA

Feature extraction is done with points on key features is which later correlated to fabricate the sketch of the face, but the traditional PCA method botched to generate accurate upshot whilst light fields contrast, to resolve it Modular PCA has been widen where the face segmented into smaller regions and weighted, despite the fact that if the illumination or pose fluctuate only in few regions will not affect the optimal recognition of a face.

3.4 Two-dimensional Principal Component analysis (2DPCA)

The two-dimensional Principal Component analysis (2DPCA) advance with 2D matrices instead of 1D vector, no necessity for compulsory vector rather original image transforms into image covariance matrix which is tiny mass enhanced with better computational time for feature extraction [3]. It depends on Eigen vector for extraction.

3.5 Bayesian Method

Bayesian face recognition, it has core conception for direct visual matching and retrieval of images, by comparable measuring of pictures [4]. It is a non Euclidean similarity measure matching has storage and computational benefits [4]. Bayesian recognition progress with Eigen values to figure out Eigen vectors.

3.6 Linear Discriminant Analysis (LDA)

Priyanka et al defined, Linear Discriminant Analysis (LDA) simplified from Fisher's Linear Discriminant utilized for feature extraction and dimensionality reduction with more data classification [5] were Preprocessing is a former step of recognition project class-separability to avoid overfiting and computational cost.

3.7 Uncorrelated Discriminant Transformation

To extract optimal Discriminant feature of face, Uncorrelated Discriminant Transformation technique is exercised, the features boost by increase in statistical pattern classifiers and it is huge when decreases [6]. Thus fresh extraction method derived uncorrelated discriminant feature extraction with KL expansion as m x n resolution then original space is N = mn with K no of training samples and L known face classes [6].

3.8 Direct correlation method and Eigenface & Fisherface

There is another system entitled as Direct correlation method compute face vectors Euclidean distance d by converting 65 bitmap images into 82 pixel, 5330 vectors & dimensions, it examine illumination variations [11]. Subsequently, the Eigen face construct face keys using Euclidean distance with direct correlation [11], Were Fisherface method exploits LDA and PCA for subspace projection matrix outcome, benefits each class has maximum class separation and minimum variation [11].

3.9 Convolutional Neural Network (CNN)

In Convolutional Neural Network (CNN) is a multilayered neural network works for the 2D image recognition, m x m size of input to the CNN with r channels. Measures of equivalent colors are wrapped into single weights for pixel intensity.

3.10 Bilinear CNNs

Bilinear CNNs (B-CNN) has pooled with multiple CNNs which pastes the texture models and part-based models [7].Even if the feature extraction partially detected then it effect in part-based model, bear a resemblance to Fisher vector, symmetric B-CNN frequently used with SVM, focal lead without ground truth part-annotations only image labels used [7].

3.11 Rough Set Theory

In Appearance based feature Rough Set Theory reducts the vectors and project with two steps : Boolean reasoning, from the given data table mines the relevant reducts in the prime step, then approximations pull out from parameter tuning reduct in the second step [8].

3.12 Sparse Preserving Projection (SPP) & Uncorrelated Discriminant SPP (UDSPP)

Sparse Preserving Projection (SPP) by design selects neighborhood number, weights with no computation and determination using sparse representation [9]. Recognition usually needs discrimination information it has been promoted as Uncorrelated Discriminant SPP (UDSPP) to reduce eigenvectors for Redundancy-free approach, Euclidean distance measured by selected k neighbor aware of data noise [9]. Feature extraction can directly affect recognition result, thus UDSPP produce better result when compared with SPP and LDA achieved by statistical uncorrelated constraints. Gabor filter construct a few techniques for the defy dilemma of illumination in feature extraction for face recognition, analysis texture in linear filter.

3.13 Gabor Filter and 2D Gabor

Gabor filter extract feature extraction using neural network, when evaluating with PCA and LDA, Gabor filter ensue with optimal recognition [10]. 2-D Gabor filters perform matching, recognize and verify pedestal threshold [10]. To portray face via average distance classifier in face graph corresponds matching [10].

3.14 Elastic Bunch Matching Graph (EBMG)

Elastic Bunch Matching Graph (EBMG) broaden form EBGM is Extended Bunch Graph recognize objects using graph points in computer vision, it uses Gabor filters to extract local features, in the initial stage is normalization locate eye coordinates manually and description based on statistical evaluation and FBC [10].

*3.15 Line Edge Map (LEM)*Line Edge Map (LEM) is a new technique to accomplish line matching encoded into binary edge map using Sobel edge detection, LEM deals with physiologic features renovate into gray-scale even in dim light fields analogous to human beings preservation and able to vary human faces manually [12].

IV.COMPARATIVE ANALYSIS OF FEATURE EXTRACTION TECHNIQUES

The evaluation of the feature extraction techniques delivers the optimal recognition rate (RR) in LEM with 96.43% and 2DPCA with 96.0% in automated computer vision in facial recognition. Although few other techniques also compete and serves the better RR like UDSPP in FERET database 91.67% RR, LDA with 90.56% RR and B-CNN with 89.5% RR. Few other techniques consider Minimal Error Rate instead of RR, thus in Uncorrelated Discriminant Transformation with KL-Expansion is 2.5% Minimal Error Rate in ORL and 1.2% in NUST603 when compared with other techniques. LBP and PCA are the primary technique in facial Recognition and all the enhancements are made by its base. Techniques can be performed for real time applications like surveillance, Face ID verification, Auto-scanning digital recognition, etc., Modular PCA and 2DPCA segments the image to extract chief features in various illuminations to produce High accuracy in recognition. The Table 1 describes the brief analysis of various techniques in facial recognition. Almost all the extended techniques are analyzed with PCA and Eigen face to check whether the extended technique superior the existing techniques.

Table 1: Comparison of feature extraction techniques

Optimal Resulting Method	Key Feature	Resulting Rate	DB Used	Feature / Appearance Based	Compared with Techniques
LBP [13]	Computational Efficiency	0.79% for illumination	FERET	Both	PCA, LDA, 2DPCA
Modular PCA [15]	Segmented into regions & compared	False Rejection Rate 0.36%	UMIST, Yale	Appearance Based	PCA
2DPCA [3]	Accuracy, Computational Efficiency & less time	96.0% Recognition Rate	ORL, AR, Yale	Appearance Based	ICA, KPCA, PCA
Bayesian [4]	Computational Efficiency & Storage advantage in Large DB	Only 2% misclassification, No clear recognition rate defined	FERET	Feature Based	Eigenface Matching, Dual Eigenface, LDA, Fisherface
Uncorrelated Discriminant Transformation with KL Expansion [6]	Real time Matching with surveillance	Just 2.5% Error rate in ORL 1.2% in NUST603	ORL, NUST 603	Feature Based	Eigenface, CNN, Foley Sammon
LDA [14]	More data Classification	90.56% of Recognition Rate	128 person classes	Feature Based	PCA
BCNN [7]	Fine grained Recognition	89.5% of Recognition Rate	FaceScrub,	Feature Based	CNN

			VGG-Face		
Rough Set Theory [8]	High quality classification on selected features	75% accuracy	ORL	Feature Based	PCA
UDSPP [9]	shrink redundancy in Eigen vectors	91.67% RR in FERET, 82.63% RR in YaleB	FERET YaleB	Appearance Based	DSPP, SPP
Weighted LBP [10]	Needs only scanning without complex analysis	Highest recognition rate when compared with other techniques	FERET	Feature Based	Gabor, 2D Gabor, Optimal EBGM
Direct Correlation Method, Eigenface [17]	High accuracy	Only 18% Error in DCM, 20.4% in Eigenface	Face DB	Appearance Based	Fisherface Method, PCA
LEM [12]	Accurate detection in light field variations	96.43% of Recognition Rate	Yale	Appearance Based	Eigenface, Edge Map

V.CONCLUSION

Comparative analysis of all popular Feature Extraction Techniques employed in facial recognition having feature extraction complexity. This paper evaluates all popular *feature based and appearance based* feature extraction and its subdivisions in detailed manner. Notably the facial recognition techniques that deal with 2D images gives superior result in Line Edge Map (LEM) and Two-Dimensional PCA, also it performs efficiently in producing accuracy in recognition under the varying illumination conditions. After all the popular techniques review, it has been found that the feature extraction concentrated mainly on fractal based area rather than the illumination complexity. In few techniques, performance analyzed on minimal Error Rate with optimal solutions is Uncorrelated Discriminant transformation with KL-Expansion, while the other techniques performance is average.

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