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HUMAN RECOGNITION FROM MULTI ANGULAR IMAGES

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Abstract

Face recognition is still complicated task because to envision human actions might not realizable in each incident. Intention of face recognition is to identify human based on face that is similar from available dataset face images. Human face has multidimensional structure so it requires efficient technique for face harmonization and verification.

Proposed work aim for developing efficient human face recognition method that deals with front as well as side view face in normal face expression. Using Viola–Jones face detection algorithm it accumulate only face region. Face features like eyes, nose and lip are extracted from whole face region using canny edge detection and harris corner detection method. To match individual face features, it compares position of edge boundary of features between images. Authors' uses Euclidian distance method to retrieves maximum match value among all store face images. Based on threshold value it decides whether human face is recognized or not. Authors have evaluated performance of proposed method with DCT, DWD, PCA and LFL method on public free database like FEI, CVL and MIT-CBCL.

1 Introduction

Face recognition has appeared as one of the most broadly studied research topics in computer vision because security is major concern nowadays. Major issue related to face recognition is frequently change human face orientation. Numerous security solutions available for front face recognition and side view face recognition up to 25 angles [1] with certain constraints and limitations. Due to face orientation foremost issue in face recognition is face expression, cross-face, face up down, more side view [2] etc. Face recognition task may be very valuable in human-machine interactions, identifying smart cards, surveillance, object tracking, siblings identification [3, 4] etc.

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Aim of face recognition is to identify people from still images or video. Basic step of face recognition is i) Face Detection in region of interest, ii) Face Feature Extraction and iii) Human Identification by Classifier that identifies person from face features. In this paper, authors focus on side view face up to 30 angles in both directions. Issue of cross face is solved by face rotation. Using both eyes coordinate it is possible to rotate whole face.

In Face Detection step remove background region from image except face or faces. So in ROI, it gives only single face or all faces area. In feature extraction step, need to identify face feature's region by its size and position on face. Then its boundary coordinated is extracted. At end of feature extraction it preserve coordinate of left eye, right eye, nose and mouth features of both images. In final step of human identification same feature of dataset and runtime scene images are compared. It chose a dataset face image who gives maximum matching value towards scene image face. Finally if this maximum match value is higher than threshold value then considered as human recognize. Threshold value is an identifier which decides recognition result.

We have evaluated result of proposed face recognition method on local database as well as on standard public free database FEI, CVL, MIT-CBCL. We have compared proposed method result of front face and side view face up to 30 angles with exiting face recognition method evaluated on same database.

2 Related Work

To develop generalize face recognition method that manage with front and side view face in uncontrolled environment is not possible [2]. In side view face recognition face angle is major issue [9]; particular angle can have different methodology. Therefore to achieve higher success rate is still challenging task [4, 5]. Following are the conventional methods that are habitually used for front and side view face recognition in restrict.

2.1 DISCRETE COSINE TRANSFORM (DCT)

DCT is admired because of its energy compaction ability. Majority of the signal information lean to be concentrated in a low-frequency component of the DCT [14]. DCT convert input into a linear combination of weighted basis functions. DCT function is very like to be discrete Fourier transform (DFT) in signal transformation of image. DCT transform uses simple cosine-based basis functions whereas the DFT is a complex transform and therefore insist on both image magnitude and phase information be encoded.

2.2 DISCRETE WAVELET TRANSFORM (DWT)

It starts feature extraction from edge detection of upper and lower part of face (upper forehead to lower jaw). It offer a side view face verification method which requires more number of training face data that allows subsets to preserve global details [15]. Photometric method use eye coordinates and nose curve for face recognition. It works only when face must more side angle view. It will not work with front face.

2.3 PRINCIPAL COMPONENT ANALYSIS (PCA)

PCA is used to minimize the features required to represent face in image. So PCA reduces the computational complexity of the method [16]. Purpose of PCA is using eigen face it keeps smaller dataset in size. Majority it use to recognize face from crowd. Execution speed of method is good but its accuracy is fair [10]. So it is not advisable for strict recognition.

2.4 LOCAL FEATURE LEARNING (LFL)

LFL method for face recognition deal with varying head poses using gray scale images [6]. In ROI, LFL extracts the subject related part from a local feature by removing pose related part. LFL shows a significant recognition improvement under varying poses over general local feature approaches and break or similar with related modern pose invariant face recognition approaches [12].

2.5 LBP and FACE WARPING

It starts with preprocessing where it remove unwanted background and apply warping to achieve shape-free texture images [11]. It is feature description method that is used for describing local spatial structure of an image. It is widely used in face recognition applications due to its invariance against illumination changes and its computational simplicity [13]. Its result with side view face recognition is good but biggest limitation is method require manual face feature selection for feature labeling landmarks. Following is summary table of existing face recognition methods.

Methods	Feature type	Face Occlusion Result	Side view Recognition	Require Image Quality	Database Size
DCT) [14]	Eigen face, Edge Detection	Poor	Good	Normal	Large
DWT[15]	Wavelet features from side-face curves	Poor	Good	Normal	Large
PCA [16]	Local Spatial Structure	Poor	Good	Normal	Less
LFL [12]	Face localization and key point detection from eyes, nose etc.	Good	Poor	High	Large
LBP [11]	Texture features from face region	Poor	Poor	Normal	Less
Proposed Method	Corner key points from face components like eye, nose, lips, nose etc	Good	Good	Normal	Less

Table 1: Existing Face Recognition Methods Summary

Authors have developed proposed face recognition method that recognize front and 30 angle side view face with normal face expression in regular quality image. Basic step of any face recognition is it requires face region only. Many techniques available like viola-jones face detection, template based, color-based face detection etc. Authors choose viola-jones face detection technique because its result accuracy with very low false detection rate [19]. Only limitation of viola-jones is it don't detect partial or occlude face and not work in lower visibility where faces is not properly shown [18]. In face recognition, proposed method expects proper visibility in scene along with full face in region of interest.

After face extraction proposed method required face feature extraction which requires edge detection and segmentation. There are many techniques available for segmentation such as threshold technique, edge detection technique and region-based technique. Threshold and region-based technique works when environment is very controlled with fix surrounding [21]. So authors can't use these approaches in proposed method. Edge is a coordinate where image brightness changes sharply or formally for identifying corners and curves. Admired methods for edge detection is gradient based technique, gaussian based technique (laplacian of gaussian), canny edge detection [20]. Gradient based technique is simple, easy and quick to compute but it detects edges with its orientation too, another limitation is quite sensitive to noise so this method is less reliable. Gaussian based techniques works

with fix dimension in control environment, so there is possibility of malfunctioning at corners, curves where the gray level intensity value varies. Canny edge detection improve signal to noise ratio which cause higher accuracy, so it's better in noise condition too [20]. Canny edge detection is time consuming but gives high accuracy compare to other methods, so authors choose canny edge detection because of its accuracy and robustness [21].

To determine starting and ending we required corner detection method. A corner can be defined as points for which there are two dominant and different edge directions connect in a local neighborhood of the point. Harris corner detector, susan corner detectors, moravec corner detection algorithm, förstner corner detector are popular methods used as corner detection. Among authors have chosen harris corner detector because it efficiently works on both gray and color images using RGB information [22]. Its result might be slow but its accuracy is prominent [23]. Another advantage is harris corner detector is invariant to translation, rotation and illumination change [24]. Lastly proposed method match features of target image face with all dataset faces.

3 PROPOSED FACE RECOGNITION METHOD

Human faces are recorded in a dataset which used in future to verify with current face is face recognition process. In proposed face recognition method, input image can be front or side view face so authors use geometric method that requires minimum two face images,

1. Dataset image (Single person face image/images),
2. Target image (Single person or group image).

Following are implementation steps of proposed face recognition method.

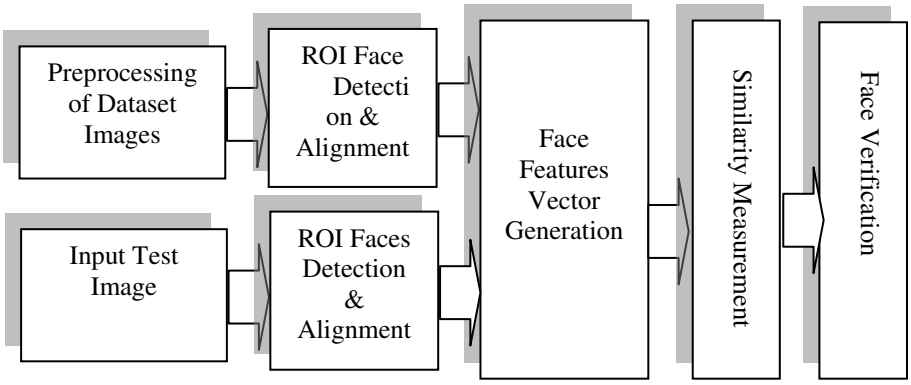

Figure 1: Steps of Face Recognition Method

3.1 Preprocessing for Dataset & Target Images

In dataset for preprocessing authors anticipate keeping single person's multiple angle specific images. Purpose of keeping multiple images of same person is to match with manifold images for producing firm recognition result. So we manage individual person folder that contain maximum number of images. Then apply basic filter for smoothing image edge value. Target image can be single person photo or group photo.

3.2 ROI Face Detection & Alignment

It entail only face region from datasets and target image. These images can have human body component like neck, solder, cloth, cap or any other things that is not required for recognition. Using viola-jones face detection technique authors extract only face region. Viola-jones face detection technique has three vital steps: i) feature extraction, ii) boosting iii) multi-scale detection. Detected face region may have minor cross face as of normal human behavior. It save face region as feature vector for further investigation.

3.3 Face Features Vector Generation

Target images may have other background objects too, so using viola-jones face detection technique proposed method extract available faces from target image scene. At the end of this phase all faces are extracted and store it properly for future verification operation. In normal environment human face may not be straight always, so in recognition method position of face feature landmark is changed, and as a result it gives less matching value so face recognition might be unsuccessful. For solution of this issue, we can rotate whole face by calculating distance from X and Y axis of both eyes.

y = left eye from Y axis − right eye from Y axis
x = left eye from X axis – right eye from X axis

Rotation angle = arctan (y/x) [7, 8]

Using above equation we have rotate whole face to prepare it straight then send for further steps. End of this step all faces are extracted and store it in form of feature vector for feature extraction.

3.4 Similarity Measurement

After face detection and preparing straight face, in next step requires extraction of face's features like eyes, nose and mouth part. Target image face features' will be compared with all dataset face features. To accomplish this task, we can split human face in three rows and five columns. In Figure 2, we can see basic of human face. This might not suitable for all human orientation like i) different side angle face, ii) up down face etc. Each face position has its own template. But as overall structure with increasing height-width of feature region authors use for face feature extraction.

In fig. 2, there are two red points for whole face region. We consider top left coordinate as (0, 0). If we closely observed then eyes part can be extracted in second row, to separate both eye we can see left eye in second column and right eye in fourth column. Likewise we can find nose and mouth region too.

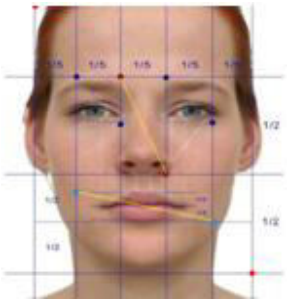

Figure 2: Face Template

After face feature region extraction, proposed method requires to match individual face features value. Face features are focused on high frequency areas so need to get the edges from each facial patch. So, proposed method requires using edge detection technique. Authors apply canny edge detection for selecting high frequency edges because it is better in noisy condition with result accuracy and robustness. Canny operator starts performing after applying gaussian filter for smooth image then reduce the effects of noise on the edge detector. Canny edge detection use filters to detect horizontal, vertical and diagonal edges on blurred image that help to improves feature extraction result. For face feature region extraction, along with edge detection it required corner detection technique. Authors have chosen harris corner detector because it efficiently works on both gray and color images using RGB information irrespective with execution speed. Harris corner detection algorithm can be used to find relevant key points in each patch. The algorithm returns the coordinates of each key point.

3.5 Face Verification

Verification require to compare corresponding feature points of left eye, right eye, lips, nose of input face image with all dataset face image one by one. This is done by finding the Euclidian distance between same feature points. The feature comparison task is followed by accomplish using the similarity measures including structure similarity index measure (SSIM), root mean square (RMS), and similarity assessment value (SAV) [20]. Among authors choose RMS because it works on pixel value so its result accuracy is high irrespective with execution time in surrounding manner [17]. In fig. 3 we can see two images dataset (front face) and target image (30 angle side face). Face recognition method find nearest key points in target image face and dataset image. If distance between two key points is less than a particular threshold, it can be considered as a matched key point. The overall match between two images will depends on the total number of matched key-points. We can see match key points and using similarity measurement we have evaluate matching value too.

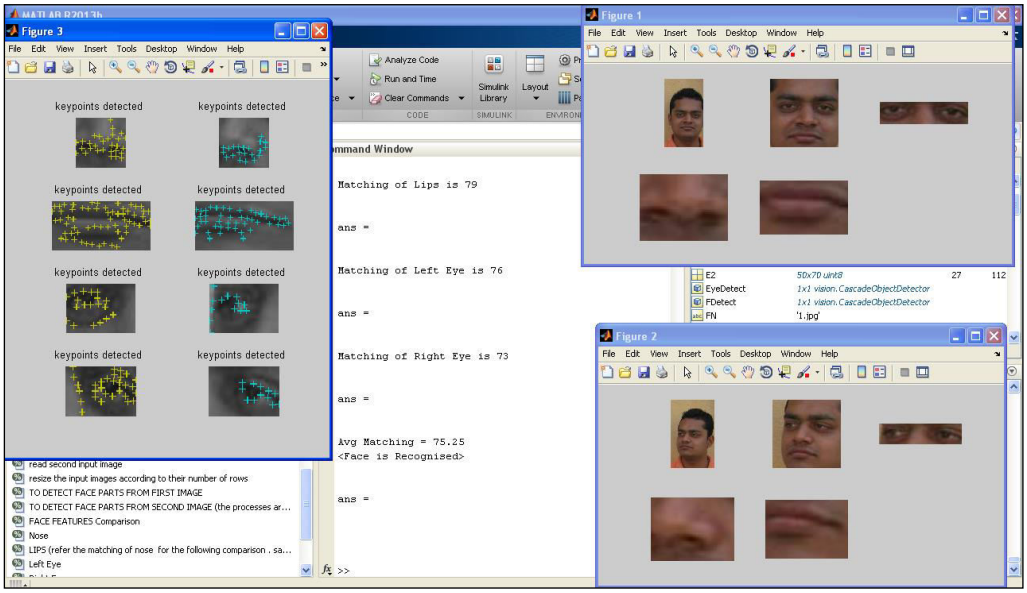

Figure 3: Face Recognition Result in Matlab

Following is basic algorithm of face feature matching.

1. Firstly we store the locations of key points from two images.
2. Consider each point from first image one by one and check for the key points in other image.
3. Distance between the key point locations is calculated using Euclidian distance.
4. If the distance is less than a particular threshold, such case considered as the matches ones and the same process repeated for the entire key points.
5. Finally we compute matching percentage by finding the ratio of matched key points and total key points

For single face profile, proposed method match lips, nose and eyes with all dataset face images. Proposed method finds average matching value of single face's all features. Among all dataset images it retrieves maximum match value. After doing more than 1000 tests in control environment of 30 people authors decide if threshold value is higher than 71 it consider as human face recognized. In fig. 3 we can see matching value between images if lip 79, left eye 76, right eye 73 and mouth 73. Average matching value is 75.25.

4 Result

We have evaluated proposed method result with existing face recognition method on FEI, CVL and MIT-CBCL database. It has 2800 images of 200 people. We have compared with existing face recognition method like,

1. Discrete Cosine Transform (DCT) [19]
2. Discrete Wavelet Transform (DWT) [20]
3. Principal Component Analysis (PCA) [14]
4. LOCAL FEATURE LEARNING using Scale Invariant Feature Transform (SIFT) [6]
5. LOCAL FEATURE LEARNING using Local Binary Patterns (LBP) [6]
6. Gabor-EBGM and HOG-EBGM [21]
7. Neuro Biologically [22]
8. Original C2 Features [23]
9. MPCALDA [24]

Existing Face Recognition Method	Front Face	Right view (15 angle)	Left view (15 angle)	Right view (30 angle)	Left view (30 angle)
DCT		90.00	92.00	82.50	81.50
DWT		85.00	82.00	76.00	77.50
PCA		75.00	75.00	70.00	70.00
LFL using LBP	77.00			78.70	76.50
LFL using SIFT	84.30			85.30	84.20
Proposed Method	94.50	91.75	92.25	86.50	85.75

Table 2: Face Recognition Result Comparison of Proposed Method with Existing Methods on FEI

In Table 2, Face Recognition methods are tested on standard FEI database. Among certain method tested on only front face or with specific side angle.

Database		Front Face	Right view (15 angle)	Left view (15 angle)	Right view (30 angle)	Left view (30 angle)
FEI	No of Images	200	100	100	100	100
	Threshold	82	79	79	76	76
	Result	94.50	91.75	92.25	86.50	85.75
CVL	No of Images	100	100	100	100	100
	Threshold	83	79	79	75	75
	Result	97.35	92.50	91.75	85.5	86

Table 3: Face Recognition Result with Minimum Matching value on FEI, CVL

In Table 3 we can see minimum matching value in different head position on FEI and CVL. Here minimum matching value is higher than my local database because in standard dataset it has very control image with lighting condition and facial expression. In FEI, it also has +-10% variation in side angle as well it has face expression change. But more over it has control images.

All below face recognition proposed method results are tested on our local database because standard face recognition database has only single face in image. We have capture more than 1500 images in indoor and outdoor surveillance with distance up to 5 ft in different head pose with normal face expression behavior. In many local database face has cross face orientation that can be solved by face rotation. Following Table 4 is display result of cross face and after face rotation result.

Scene Image		Matching Value	Matching after Face Rotation	Difference
Front Face		69	82.25	13.25
Side View Face Angle	10	67.5	79.75	12.25
	20	65	77.25	12.25
	30	61.75	72.5	10.75

Table 4: Face Rotation Process

In Table 4 there can see matching value of front and side view face. In next column it displays matching value of same image after face rotation. In last column it displays difference of both this matching value. From these results we can says matching value increase up to 20% in face rotation of front and side view face images.

In Table 5 we can observe that if distance between camera and human face increase then matching value will be decrease because visibility of face feature might be lesser.

Distance wise Face Recognition Result									
Distance in ft		Total Image Sample	Front Face	Right view (10 angle)	Left view (10 angle)	Right view (20 angle)	Right view (20 angle)	Right view (30 angle)	Left view (30 angle)
Up to 3′	Threshold	200	80	78	78	76	76	74	74
	Avg Match Value		84.4	80.80	81.00	77.60	78.00	75.90	76.30
Up to 4′	Threshold	200	78	76	76	74	74	72	72
	Avg Match Value		83.1	79.10	79.20	76.25	76.45	74.70	75.00
Up to 5′	Threshold	150	76	74	74	72	72	71	71
	Avg Match Value		81.8	77.80	78.00	74.90	75.30	73.50	73.70

Table 5: Face Recognition Result Distance wise in Group Photo on local database

We have evaluated proposed method's front face recognition performance on CVL Database too. Here we tested 114 people.

	Sample Images	Gabor-EBGM	HOG-EBGM	Proposed Method
CVL	114	96.5%	99.1%	97.35

Table 6: Front Face Recognition Comparison of Proposed Method with Existing Methods on CVL

In Table 6 we can see that HOG-EBGM method produce higher matching value but it doesn't support side view face recognition. For side view recognition result we have tested proposed method on MIT-CBCL Dataset display in Table 7.

	Neuro Biologically	Original C	MPCALDA	Proposed Method
MIT-CBCL	95.40%	87.05	88.53	95.75

Table 7: Side view Face Recognition Comparison with Existing Methods on MIT-CBCL

In Table 7 we can observe that proposed method produce higher matching value compare to other methods tested on MIT-CBCL database.

5 Conclusion

Current approach produces good result when object is captured within 5 feet distance in normal face expression and side view face up to 30 angle in both directions. Face is accurately detected by Viola Jones method. Many face images can have cross face orientation that can be resolved by face rotation using eye coordinate. Face features are extracted by human template skeleton where features are situated at defined position and size. Exact feature boundary is accumulating by canny edge detection followed by harris corner detector. Feature matching is performed by RMS method; it helps to choose face with maximum matching value. This matching value is compared by threshold value as recognition result. We have evaluated result with many existing front and side view face recognition tested on standard database like FEI, CVL and MIT-CBCL.

6 Future Work

In uncontrolled environment if human wear optical or can have light glass or eye occlusion then it failed to locate eyes coordinate and produce less matching value so might be false recognition so we are working on it as we have individual face feature matching value. We are also working on improving face expression revolutionize with improving recognition result using combination of PCA and this method.

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