A Comprehensive Literature Review on Face Recognition Approaches

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Abstract: Face Recognition is a prominent biometric system and also it has been widely used basic strategy that human use in their visual contacts. Numerous biometric verification frameworks like Iris, Deoxyribonucleic Acid (DNA), Vein, Finger Print endures the issues of data acquisition. Face Recognition (FR) plays very important role in biometric systems. The recognition rate of Face biometric primarily relies upon choosing the features. This study presents a survey on FR techniques. The majority of the current techniques are extensively described in Five steps, Face Image Acquisition, Preprocessing, Feature Extraction, Feature Classification and Recognition. According to the available literature work, the real time Face Recognition biometrics needs still better performance, resistant to be spoofing attack and needs better recognition accuracy. The recognition accuracy can be increased by advanced methods such as Neural Networks and by using Feature Extraction algorithms.

Keywords: Face Recognition, Preprocessing, Feature Extraction, Pattern Recognition, Recognition Rate, Accuracy.

1. INTRODUCTION

As there is a rapid growth in internet technology, every location in the society is more and more interconnected with a digital network. Every day communication between each user and between several organizations is rapidly increasing through the digital devices. Since there is a huge, massive communication network or transactions, each person or user is identified through unique Personal Identification Number (PIN) in order to establish a reliable communication. Though Personal Identification Number acts like an ID card for each individual for authentication, fails to satisfy the security requirements as there is a chance of hacking the card details. Biometric, the term got from Greek word Bio implies life and metrikos means measure, meaning estimation of life [1]. It authenticates the person based on their behavioral or physiological characteristics can be considered for biometric authentication until it obeys the following requirements; Circumvention, Distinctiveness, Universality, Performance, Acceptability, Permanence and Collectability. But, practically, no single biometric system satisfies all the requirements because of noisy data, spoof attack etc.

This problem can be overcome by fusing more than one biometric system. In view of the quantity of Biometric attributes., the Biometric system is classified as Unimodal Biometric System and Multi Modal Biometric System.

Face biometric system is one of the successful applications of image processing. Person recognition using face is the challenging task since it involves identifying the 3D object from 2D object. Basically there are two approaches to identify a person through his/her face; First approach involves extraction of different types of features (Spatial, Shape, Location etc.) between facial attributes and Second approach treats the whole image as the weighted combination of canonical face. For instance, in case of Iris Recognition framework, the concerned individual should obtain his/her iris layout by utilizing a unique costly gadget called opthalmoscope and in the event of unique finger impression the concerned individual should keep his/her finger in appropriate position and direction. But, the Face Recognition overcomes these problems, since the face acquisition is non-intrusive and less expensive. Face Recognition system has become very important because of its potential capability in solving other complex applications like Object Recognition.
Generally, Face Recognition or any biometric system including Finger Print, Palm Veins, DNA, Palm, Hand, Iris, Retina and Voice is classified into two modes; Training Phase and Testing Phase. In Training Phase, the Preprocessing and Feature Extraction are performed for all images present in the database and created a feature space. Where as in Testing Phase, the Feature Space is obtained during Training and is used to recognize with unknown query face. Face recognition is an optical Pattern Recognition challenging area of research. Face is a 3D object and subjected to vary in Pose, Illumination and Expressions and so on and has to be recognized based on its 2D image. Generally, Face Recognition mechanism can be implemented by making use of Four modules; Image (Face) Acquisition, Preprocessing, Feature Extraction and Matching. Face Detection involves segmenting the area of concern (i.e. Face) in the background images which contributes significantly in Face Recognition system. If there is an occurrence of video sequence, the identified faces need to be monitored by using Face Tracking Element. Preprocessing is performed on the identified face. The Preprocessing step involves Image Resizing, Noise Elimination and Image Restoration etc., for better Recognition Rate. Further, Feature Extraction is carried out which provides a valuable data using which it is very easy to discriminate faces of dissimilar people irrespective of geometrical differences. Face matching is performed by comparing the trained set of features present in the database with Test Feature. Figure 1 shows the FR Process Flow involves the following steps; Image Acquisition, Preprocessing, Feature Extraction, Feature Matching and Database of Enrolled Users.

A. Image Acquisition
Two primary methods are available for acquiring the image (Face) Recognition. The First one is the Offline Method (Non Real-Time) and the Second one is the Online Method (Real Time). Typically the Offline Method requires static image obtained from the standard face database like FERET, YALE, NIR, etc. In [2] the Face Recognition system is proposed by using NIR database which includes different Pose, Illumination, Scale and Blurring combinations. A Face Recognition system which uses color images from FERET Database is proposed in [3]. In the other hand the Online Method acquires face images in a real time environment from the image sensor typically a web camera. A Face Recognition system proposed in a real time which uses web camera as image acquisition is presented in [4]. However, the use of web camera suffers several problems like Illumination, Color Change, Lighting Variations, Spoof Attack etc., while acquiring in a real time environment. To overcome these problems, a real time Face Recognition system to avoid Spoof Attack is presented in [5] by using polarized light during acquisition. Further, a thermal camera for image acquisition is proposed in [6] to avoid illumination change. A portable high resolution mobile web camera is used for face image acquisition in [7] to avoid blurring effect. A Near Infrared Rays (NIR) based camera is utilized in [8] to capture the face image in the absence of ambient light for the implementation of efficient face recognition system.

B. Preprocessing
Preprocessing method is one of the significant steps in Biometric recognition system, since it improves the recognition accuracy by enhancing the input image. In [9] illumination normalization is performed on face images by using Histogram Equalization technique. This technique minimizes the contrast in the image. In [9] illumination normalization performed by diving the image into Four Non Overlapping Region and calculating the probability density function for each region. Various types of noises like Impulse Noise, Salt and Pepper Noise and Gaussian Noise etc, can influence on the quality of the image.

A Median Filter is applied for the face image to remove the Salt and Pepper Noise in [10]. Edge Detection is a very important technique used in preprocessing to enhance the edge region. A linear Gabor Filter has been used for enhancing the boundaries in the input image (face) are performed in [10]. Face identification plays very important role in Face Recognition system. Face detection enables the extraction of Region of Interest (Face) and eliminates the unwanted background. Face region can be detected by different techniques. In [11] a Viola Jones method for efficient face recognition is used. A combination of Locally
Assembled Binary (LAB) feature and Ada-Boost technique is used in [12] for face detection. Skin color based face detection system is used in [13] which involve converting the input RGB image into different color space like YCbCr and HSV.

C. Feature Extraction
Feature Extraction is a process of extracting numerical features from the preprocessed image or a signal to remove Redundancy. The extracted test template features are compared with train data features for authentication. Various Feature Extraction techniques for face biometric system have been proposed from past decades. Principal Component Analysis (PCA) based Eigenface Feature Extraction is implemented in [14]. In [23] local features are obtained from the face image by making use of Extended Local Binary Pattern (ELBP) technique. The PCA method was used to proportionally minimize the extracted features. Feature Vectors which are obtained after Feature Extraction stage are compared with Faces of enrolled users in the database and comparison of Feature Matching has been carried out and the corresponding Face ID is generated.

D. Classification
Classification is a very important step in the biometric system. There are several methods to classify the Test and Train features; Neural Network Based Method, Fuzzy Rule Based Method, Statistical Based Method, Weighted Distance Based Method, Multi-Classifier Based Method and Structure Based Method. The widely used classifiers for Face biometric are the Distance and Similarity measuring methods Based Classifiers in Machine Learning are Euclidean Distance (ED), Hamming Distance (HD), Mahalanobis Distance and Manhattan Distance (MD) etc. Facial features are classified using both ED and MD and we compared the recognition results of both the classifiers. City Block Distance and Mahalanobis Distance are used in [61] for Face Recognition system. Several multi class classifiers are used for classifying the facial features; K Nearest Neighbor Classifier (KNN) [62], Support Vector Machine (SVM) [63] and Fuzzy Logic [64] etc.

2. LITERATURE REVIEW
The Face Recognition is prominent research area because of the extensive applications in the fields of Industries, Manufacturing, Commercial, Construction, Healthcare, to protect law enforcement, Forensic Investigations and Social Media Platforms etc. This section gives the overview of various approaches and techniques along with their Recognition Rate, Accuracy and Database used etc. Local Ternary pattern (LTP) is used in [34] to extract the feature vectors from the Face image. Feature Extraction is transform domain can also provide better performance. A Discrete Wavelet Transform based PCA Feature Extraction is proposed in [35]. PCA features are extracted by first converting the image from spatial domain to frequency domain using DWT. The Combination of Fast Walsh Hadamard Transform (FWHT) which was used to resolve illumination problem, Chiral Image Superimposition (CIS) which was used to resolve pose variation and Discrete Wavelet Transform (DWT) which was used for transformation has been proposed in [46]. A Binary Particle Swarm Optimization (BPSO) method is used to obtain the features from the transformed face image. Real-time feature extraction Discrete Cosine Transform (DCT) was performed in [47]. The dominant frequency components present in the image (face) are obtained using DCT and local features are obtained using zone DCT. Automatic Face Recognition system is proposed in [48] using Singular Value Decomposition (SVD). The obtained SVD features are classified using Hidden Markov Model (HMM). A combination of Local Binary Pattern (LBP) and Gabor Features are extracted in [49] for better recognition. Recognition Accuracy can be increased by extracting multiple feature extraction techniques. A Face Recognition system using Eigenface is proposed in [50], which involves extraction of facial features using PCA and the features are classified using Naïve Bayes Classifier. Fusion of LBP and Zernike features to extract Local and Global features are proposed in [60], authors reveals that fusion of these features provides reliable Face Recognition system. Recognition Rate of the face biometric can be increased by merging or fusing the features. In future fusion, the acquired biometric trait coming from different channels are preprocessed first, then the feature extraction technique is performed for each channel using different algorithms and finally combine the obtained features to form composite feature vector. In this paper we tried to cover different Face Recognition comparison approaches such as Databases and Techniques use, Accuracy and Recognition Rate obtained on the basis of Eigenfaces, Gabor Wavelet, Hidden Markov Model (HMM), Neural Network (NN) and Support Vector Machine (SVM). [72] S. Misra et al. have described the performance of Extreme Learning Machine (ELM) as a classifier for face recognition problem. Viola Jones algorithm was used for detecting and extracting the faces from the dataset. Histogram of Oriented Gradients (HOG) technique was used to extract the feature wherein authors have combined the Viola-Jones Algorithm for object identification, HOG for feature selection and Extreme Learning Machine (ELM) for pattern classification for better recognition rate particularly for YALE dataset. The proposed scheme was tested on standard face recognition datasets from AT&T and YALE.

The AT&T database contains 400 grayscale images of 40 persons. Each person has 10 images. The UMIST face database is a multi-view DB, consisting of 575 gray-scale images of 20 people. ORL database has images of 40 people, 10 images of each person. FERET database, which is a standard test-bed for face recognition technologies. 600 frontal face images corresponding to 200 subjects are extracted from the database for the experiments - each subject has three images of size 256x384 with 256 gray levels. The BANCA database consists of images from 52
subjects captured in 12 sessions. The FRAV2D facial database, containing 1000 frontal face images corresponding to 100 subjects, which are acquired under variable illumination and facial expression. XM2VTS database, comprises 2360 facial images that correspond to 295 distinct subjects. YaleB face DB, contains images of only 10 subjects. The database comprises a total of 5760 grey-scale facial images which were taken under 576 different viewing conditions (9 poses × 64 illumination conditions). CASIA database captured images of 123 subjects, with each individual having about 37 or 38 3D point clouds. The total number of range images is 4 625, including the variations in expressions, poses, occlusions and illumination, for each one also combined with other variations. The FRGC database is more recent. Based on the time of acquisition, the database can be divided into Spring 2003, Fall 2003 and Spring 2004, with over 4 900 range images from 557 people. 2,432 images of 38 individual subjects are considered from the Extended Yale Face Database B YALE DB contains grayscale images of 15 subjects in GIF format. In this experiment, we chose 5 individual subjects and considered 64 images per each subject (total 320 images). The BioID Face DB consists of 1521 gray level images. Each one shows the frontal view of a face of one out of 23 different test persons. IIT Delhi dataset contains 681 images of 75 subjects with different kinds of disguise variations. Task DB contains 21 subjects. For each subject we collected 2 sequences, where one has 322 frames and is used for training; the other has around 400 frames and is used for testing. In Mobo DB, there are 24 subjects. Each subject has 4 sequences captured in different walking situations Each sequence has 300 frames. The Yale face database contains 165 images of fifteen subjects.

Table 1: Face Recognition Comparison Approaches on the Basis of Eigenfaces.

<table>
<thead>
<tr>
<th>Database</th>
<th>Methods/Year Techniques</th>
<th>Accuracy</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>AT&amp;T, UMIST Face DB</td>
<td>[17] 2008 PCA RBF NN</td>
<td>Randomly partitioning DB: Best avg RR (93.05%) is achieved when 60, 70, 90 and 100 PCs are used. The max and min RR among 10 experimental runs (for PCs = 10-100) are found to be 95.50% and 85%. N-fold cross validation test: Best avg RR (97.00%) is achieved when 50 and 60 PCs are used in the system. Max and min RR among the ten-folds experimental runs (for PCs = 20-60) are found to be 100% and 85%, respectively. Best avg RR of 94.10% is achieved using 140 hidden layer neurons and 60 PCs. Max and min RR over 10 experimental runs are 95.90% and 92.05%..</td>
<td>AT&amp;T DB is used under the condition of minor variations of rotation and scaling, UMIST DB is used when the angle of rotation of the facial images is quite large.</td>
</tr>
<tr>
<td>RICE Face DB</td>
<td>[19] 2010 Multiple Eigenface Subspaces</td>
<td>Best avg RR of 94.8% is achieved. 960 bitmap images of 120 individuals (60 male, 60 female), extracted from the RICE database is used. The training set, containing 60 images of different people of various gender, race and age taken under natural lighting conditions with neutral expression; test set containing 900 images (15 images of 60 people of various gender, race and age).</td>
<td>In terms of computational time, this method takes less training time than the generalized algorithm in all tested instances. Eigenface algorithm promise much for the field of facial image recognition but not before some technical refinement.</td>
</tr>
<tr>
<td>Olivetti, ORL Face DB</td>
<td>[21] 2010 PCA FFBPNN</td>
<td>97.018%</td>
<td>The eigenface method is very sensitive to head orientations, and most of the mismatches occur for the images with large head orientations.</td>
</tr>
<tr>
<td>Face94</td>
<td>[18] 2012 PCA</td>
<td>100% i.e. 0% FAR, Increasing the number of images for each person in the training set to get best RR causes long computational time which increased exponentially with the database size.</td>
<td>The enhanced algorithm gives the same performance results in less time of recognition as 35% of the recognition time of the original algorithm.</td>
</tr>
<tr>
<td>ORL Face DB</td>
<td>[22] 2010 Eigenface</td>
<td>Highest recognition rate of 97% is achieved when 15% of eigenfaces are taken with threshold value equal to 0.8 times of the maximum value of minimum Euclidian distances.</td>
<td>As the number of eigen faces are increasing, recognition rate goes on increasing.</td>
</tr>
<tr>
<td></td>
<td>[20] 2006 EF, RBF NN</td>
<td>The recognition performance is decreased dramatically if only one image per class used in learning phase.</td>
<td>When face images with different pose are added in learning step, RR increase.</td>
</tr>
<tr>
<td></td>
<td>[14] 2012 PCA EF</td>
<td></td>
<td>190 images of 38 different persons (5 images per person) of ORL DB is used. It can be concluded that, for recognition, it is sufficient to take about 10% eigenfaces with the highest eigenvalues.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of Principal Components</td>
<td>Euclidean Distance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>77.5%</td>
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<tr>
<td></td>
<td></td>
<td>20</td>
<td>97.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>190</td>
<td>97.5%</td>
</tr>
<tr>
<td>FRAV Face DB</td>
<td>[16] 2013 Eigenface</td>
<td>96%</td>
<td>Total 510 face images of 51 different individual are selected to test the experimental results.</td>
</tr>
<tr>
<td></td>
<td>[15] 2014 PCA Eigenfaces</td>
<td>79%</td>
<td>From the test conducted, 21 face images were successfully recognized, while 3 faces were not detected, and 6 faces could be detected but not recognized by the system. In the original and testing images, it can be seen that the students have different postures and facial expressions therefore the system failed to successfully match both images.</td>
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</table>

Table 1 describes the Face Recognition Comparison Approaches on the Basis of Eigenfaces.

Table 2: Face Recognition Comparison Approaches on the Basis of Gabor Wavelet

<table>
<thead>
<tr>
<th>Database</th>
<th>Methods/Year Techniques</th>
<th>Accuracy</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>FERET Face DB</td>
<td>[27] 2005 5GF, Improved AdaBoost Learning</td>
<td>When only 140 features are used, the selected features achieve as high as 95.5% accuracy, which is about 2.5% higher than that of features selected by AdaBoost.</td>
<td>Training time of the proposed algorithm is only about 0.1 times longer than that of AdaBoost.</td>
</tr>
<tr>
<td></td>
<td>[28] 2007 GT-LDA</td>
<td>GT-LDA</td>
<td>Huge number of features of Gabor face representation often brings about the problem of curse of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>98.24%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>89.18%</td>
<td></td>
</tr>
<tr>
<td>Database</td>
<td>Methods Year Techniques</td>
<td>Recognition Rate %</td>
<td>Remarks</td>
</tr>
<tr>
<td>--------------------------</td>
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<td>----------------------------------------------</td>
</tr>
<tr>
<td><strong>Japanese Face DB</strong></td>
<td>[37] 2003 RAN-LTM, ILA</td>
<td>99%</td>
<td>The face detection method introduced here is still rather immature in terms of the computation costs and accuracy. We evaluate the recognition performance using another set of 331 images, which consists of 1748 nonface images and 1536 non-registered faces.</td>
</tr>
<tr>
<td></td>
<td>[36] 2007 HE, HF, NC, PCA, LDA, ASN, ED</td>
<td>FE Classifier RR</td>
<td>The database consists of face images from twenty (20) individuals, each with ten (10) face images. The face detection method introduced here is still rather immature in terms of the computation costs and accuracy. We evaluate the recognition performance using another set of 331 images, which consists of 1748 nonface images and 1536 non-registered faces.</td>
</tr>
<tr>
<td></td>
<td>[38] 2007 ILDA, APCA</td>
<td>At the end of experiment we get the normalized errors equal to 0.121, 0.232 and 0.305 for the first, second and third LDA significant features.</td>
<td>Low resolution images generate huge dimensional feature space.</td>
</tr>
<tr>
<td><strong>Yale Face DB</strong></td>
<td>[40] 2008 2D-DCT, SOM</td>
<td>81.36%</td>
<td>DB of 25 face images, containing 5 subjects and each subject having 5 images with different facial expressions. Best RR achieved with the least amount of processing time is for the case of 850 training epochs.</td>
</tr>
<tr>
<td></td>
<td>[41] 2011 PCA, FFNN</td>
<td>92.40%</td>
<td>Low resolution images generate huge dimensional feature space.</td>
</tr>
</tbody>
</table>
Table 3 shows Face Recognition Comparison Approaches on the Basis of Neural Network.

### Table 4: Face Recognition Comparison Approaches on the Basis of Hidden Markov Model

<table>
<thead>
<tr>
<th>Database</th>
<th>Methods Year Techniques</th>
<th>Recognition Rate %</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORL Face DB</td>
<td>[54] 2003 HMM, WC</td>
<td>100%</td>
<td>Yale DB: Train time per image (second)=0.53 to 0.54, Recognition time per image (second): 0.15. ORL DB: Train time per image (second)=0.46 to 0.63, Recognition time per image (second)=0.15 to 0.28</td>
</tr>
<tr>
<td>ORL, FERET Face DB</td>
<td>[55] 2008 MC HMM</td>
<td>95.5 % Recognition Rate</td>
<td>Using ORL DB, randomly selected 5 images as training images and the other 5 images as test images. FERET DB containing sufficient facial variations was adopted for evaluation. 153 human classes selected with at most eight images provided for each class. Recognition time using FERET DB for dimensions 10, 12, 14, 16, 18 and 36 is 0.25, 0.30, 0.38, 0.43, 0.55, 1.67 (in sec) respectively.</td>
</tr>
<tr>
<td>BANCA Face DB</td>
<td>[52] 2011 2D-DWT, HMM</td>
<td>97% Recognition Rate</td>
<td>BANCA DB contains 52 subjects (26 female and 26 male). For each subject, 12 different sessions.</td>
</tr>
<tr>
<td>ORL, Yale Face DB</td>
<td>[55] 2008 MC HMM</td>
<td>92%</td>
<td>Essex Faces95 DB contains 20 color images each of 72 individuals. For the FERET database, 4 images per individual were used for training, with the remaining image being used for testing.</td>
</tr>
</tbody>
</table>

Table 4 shows FR Comparison Approaches on the Basis of Hidden Markov Model.

### Table 5: Face Recognition Comparison Approaches on the Basis of Support Vector Machine

<table>
<thead>
<tr>
<th>Database</th>
<th>Methods Year Techniques</th>
<th>Recognition Rate %</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yale, AR Face DB</td>
<td>[65] 2003 ICA, SVM</td>
<td>SVM Using Kernel Functions</td>
<td>Yale Face DB contains 165 images (11 per individual). AR Face Database 300 face images (12 per individual) was used.</td>
</tr>
<tr>
<td>FERET, AT&amp;T Face DB</td>
<td>[67] 2011 2D-PCA, SVM</td>
<td>2DPCA - SVM on AT&amp;T Database: Accuracy=97.7%</td>
<td>The FERET DB contains 1564 sets of images for 14,126 images that include 1,199 individuals and 365 duplicate sets of images. AT&amp;T DB contains 400 images of 40 individuals; each person has ten images.</td>
</tr>
<tr>
<td>XM2VTS Face DB</td>
<td>[68] 2006 ALDA, SVM</td>
<td>ECOC - Mink-Sigmoid = 96.69%</td>
<td>DB contains 4 recordings of 295 subjects taken over a period of four months. Each recording contains a speaking head shot and a rotating head shot.</td>
</tr>
<tr>
<td>ORL Face DB</td>
<td>[69] 2008 Kernel PCA, LS-SVM</td>
<td>The experimental results on the front</td>
<td>PCA has the defects as requiring a large storage space and a large computational complexity, and perhaps losing important discriminative information after dimension reduction</td>
</tr>
</tbody>
</table>

The results show the correct recognition rate is up to 96%, and the correct recognition rate on the basis of Hidden Markov Model.
Table 5 shows Face Recognition Comparison Approaches on the Basis of SVM.

3. CONCLUSION

This survey paper presents a survey on different Feature Extraction and Classification techniques introduced in Face Recognition system from the past decade. Most of the existing techniques are comprehensively described in Five steps; Face Image Acquisition, Preprocessing, Feature Extraction and Feature Matching. The Recognition Rate of Face biometric mainly depends on selecting the features. It provides a general framework, different Preprocessing Techniques, Feature Extraction Algorithms and Classifiers for the Face biometrics. Eigen features are obtained from the image (ace) using PCA technique which yields an accuracy of 97%. However, the use of Eigen features technique has some limitations since Recognition Accuracy reduces for real time images. Further the paper also reveals Feature Extraction in transform domain using Gabor Wavelets and Discrete Wavelet Transforms (DWT) and the extracted features are classified using Neural Network Classifiers. Although, these methods provides better Recognition Rate for images from different databases but the performance degrades if a face image contains occlusions, sunglasses, beard, blurred image etc. Use of Hidden Markov Model (HMM) combined with Support Vector Machine promises to provide better results for high resolution images. There has been several techniques introduced for improving the Recognition Rate for Face Recognition system, but implementation of a technique which yields better recognition accuracy for both Offline and Real Time images is still a challenging. To overcome these problems, our research work exploits the combination of Image Local Structural Information combined with Multi Directional Features. The Combination of these techniques is expected to provide better Recognition Rate when compare to existing techniques.

REFERENCES


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