

Joint Gender and Face Recognition System for RGB-D Images with Texture and DCT Features

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Abstract

Gender and face recognition are one of the important challenge in various areas of security and surveillance. Joint Gender and face recognition system is devoted to the development of an automatic system capable to recognizing the faces using the facial and attribute features and to distinguish peoples gender by analyzing their faces on digital images using Discrete Cosine Transform (DCT) and Principal Component Analysis (PCA) features. Such systems can find application in different fields, such as robotics, human computer interaction, demographic data collection, video surveillance, online audience measurement for digital signage networks and many others. RGB-D image is used for face recognition as it contains more information than 2D image thus improves the accuracy. RISE algorithm is used to compute a descriptor from the facial image based on the entropy and saliency features. Geometric facial attributes are extracted from the color image then both the descriptor and attribute match scores are fused for face recognition. In order to increase the security of the system proposed a method to perform gender recognition after performing face recognition. Naive Bayes classifier is used to recognize the HOG features for gender recognition. The experimental results indicate that the gender recognition using DCT achieves higher accuracy on color images when compared with gender recognition using other methods.

Keywords: Face Recognition, Gender Recognition, RISE Features, Attribute Features, Naive Classifier, Discrete Cosine Transform, Principal Component Analysis

I. INTRODUCTION

Face recognition and gender recognition is one of the important challenging problem especially in the presence of covariates such as pose, illumination, expression, disguise, and plastic surgery. The face is one of the most important biometric feature of the human beings and normally used for identification and authentication in several areas of security. Each person has their own innate face and mostly a different face. As a human, to recognize the different faces is not a difficulty, but it become difficult to the system to recognize the human faces because of the dynamic nature of human face.

Face recognition is an active research area, and they can be used in wide range applications such as surveillance and security, telecommunication and digital libraries, human-computer intelligent interaction, and smart environment. Likewise, the Gender recognition is also plays an important role due to plastic surgery, hair variations, and many others. Gender identity is one's personal experience of one's own gender. All societies have a set of gender categories that can serve as the basis of the formation of a person's social identity in relation to other members of society. However, gender identity has been used in identification cards over the years as identification.

There are several methods are used for the purpose of face recognition such as Principal component analysis(PCA) [1], Fishers Linear Discriminant analysis (FLDA) [2], Local Binary patterns (LBP) [3], Sparse Representation Classifier (SRC) [4] and methods for gender recognition includes Face area analysis[5], Elastic graph matching procedure, recognizing gender from full body images and so on. These all algorithms are based on the 2D information of the face images, that is RGB image. These 2D images are not robust to the covariates such as, variations in face, surgical procedures, disguises, illumination differences and so on. 3D images offer a comparatively resilient representation of the faces under these covariates. 3D images can capture more information about a face, thus enabling higher preservation of facial detail under varying conditions. While, the high cost of specialized 3D sensors limits their usage in large scale applications. Fig.1 shows the RGB-D image, which includes both RGB and depth image.



Fig. 1: RGB and depth image

There are a number of algorithms are also available, which makes use of RGB-D images for various tasks in computer vision such as, object tracking, face detection, gender recognition, and robot vision. Billy Y.L. Li, Ajmal S. Mian, Wanquan Liu, Aneesh Krishna proposed a face recognition algorithm based on RGB-D image under Varying Poses, Expressions, Illumination and Disguise. Initially it detects the nose tip which can be easily detectable via the depth map and the face image is cropped. Then the face is then transformed into a canonical frontal representation and pose correction is performed using a reference face model. The holes and spikes are filled using sample resampling and image is converted using Discriminant Color Space (DCS) transform and the three channels are stacked into one augmented vector. This vector and the depth map are individually matched via Sparse Representation Classifier and the scores are combined. This combined score can be used to better match the faces and recognize the face using the model obtained after the classification.

Gaurav Goswami, Mayank Vatsa and Richa Singh, proposes an face recognition algorithm [16] based on the texture and attribute features of the RGB-D image. The proposed method makes use of this method for the purpose of face recognition. This algorithm creates the entropy of the given RGB-D image and saliency map based on the given 2D face. The attribute based features are also extracted from the depth map. Then the match score is computed by fusing both these values and an efficient face recognition is performed.

Gender recognition is performed based on the Discrete Cosine Transform (DCT) features of the face, which used for the feature extraction and Principal Component Analysis(PCA) is used for the dimensionality reduction. Then the model is created using Naïve Bayes classifier for efficiently recognize the gender. The proposed work which consists of several steps includes (1) Preprocessing (2) RISE : RGB-D image descriptor based on Saliency and Entropy (3) Attribute feature extraction (4) Fusion of the match scores (5) Gender recognition based on DCT and PCA features (6) Classification. The method, which makes use of IIIT-D RGB-D face database of 106 individuals, which contain images for both training and testing purposes.

The rest of this paper is organized as follows. In section II, literature survey is briefly described. Section III describes the methodology. In section VI presents the experimental results and analysis and finally section V summarizes the system.

II. RELATED WORKS

In the literature, many Face and gender recognition algorithms (e.g. [6]-[16]) have been proposed. Face and gender recognition is one of the most potential research topics as it finds number of applications in access control, automated crowd surveillance, law enforcement, information safety, multimedia communication, human-machine interface, etc. Because of this importance in lots of areas, there are several methods have already developed starting from Elastic Graph Matching to RGB-D based face recognition. Each of the method are having its own advantages in different areas.

In [6] Saeed Dabbaghchian , Masoumeh P. Ghaemmaghami and Ali Aghagolzadeh et.al proposes a face expression technology feature extraction using discrete cosine transform and discrimination power analysis. After applying the DCT to an image, some coefficients are selected and others are discarded in data dimension reduction. The feature extraction approach is database dependent and is able to find the best discriminant coefficients for each database. However the method doesn't consider noise.

In [7] Kohonen, who demonstrated that a simple neural net could perform face recognition for aligned and normalized face images. The type of network he employed computed a face description by approximating the eigenvectors of the face image's autocorrelation matrix, these eigenvectors are now known as eigenfaces. Kohonen's system was not a practical success, however, because of the need for precise alignment and normalization.

Turk and Pentland [8] then demonstrated that the residual error when coding using the eigenfaces could be used both to detect faces in cluttered natural imagery, and to determine the precise location and scale of faces in an image. They then demonstrated that by coupling this method for detecting and localizing faces with the eigenface recognition method, one could achieve reliable, real-time recognition of faces in a minimally constrained environment. This demonstration that simple, real-time pattern recognition techniques could be combined to create a useful system sparked an explosion of interest in the topic of face recognition.

In [9]Kyoung I. Chang Kevin W. Bowyer Patrick J. Flynn face recognition performs the comparison and combination of 2D and 3D face recognition algorithm. This algorithm makes use of a PCA-based approach tuned separately for 2D and for 3D. However, we also find a recognition rate of 98.5% in a single probe study and 98.8% in multi-probe study, which is statistically significantly greater than either 2D or 3D alone. In general, the results shows that the path to higher accuracy and robustness in biometrics involves use of multiple biometrics rather than the best possible sensor and algorithm for a single biometric.

In [10] Himanshu S. Bhatt, Samarth Bharadwaj, Richa Singh and Mayank Vatsa, face recognition algorithm which makes use of a Multiobjective Evolutionary Algorithm. In this research, the algorithm is proposed to match face images before and after plastic surgery. This method unifies diverse information from all granules to address the nonlinear variations in pre- and post-surgery images. Aging and occlusions are a challenge to this algorithm.

In [11] T. I. Dhamecha, R. Singh, M. Vatsa, and A. Kumar face recognition mainly concentrating on disguised faces. In this, it uses localized feature descriptors which can identify the disguised face patches and this makes the improves matching accuracy. This proposed framework is called Anavarta. There are mainly two stages for this framework, patch classification and patch based face recognition. The recognition accuracy of familiar and same ethnicity subjects is found to be significantly better than that of unfamiliar and different ethnicity. The faces with similar disguise accessories account considerably high error rates.

In [12] N. Engelhard, F. Endres, J. Hess, J. Sturm, and W. Burgard face recognition present a RGB-D SLAM system. That is, this method generates colored 3D models of objects and indoor scenes using the hand-held Microsoft Kinect sensor. This approach enables a robot to generate 3D models of the objects in the scene. But also applications outside of robotics are possible. For example, this system could be used by interior designers to generate models of flats and to digitally refurbish them and show them to potential customers.

In [13] B. Y. L. Li, A. S. Mian, W. Liu, and A. Krishna face recognition system, that makes use of low resolution 3D sensor for face recognition under challenging conditions such as varying poses, expressions, illuminations and disguise. Simultaneously dealing with different variations is a challenging task for face recognition. The algorithm can recognize faces under different poses, expressions, illumination and disguise using a single algorithm, which is compact and scalable. This give a recognition rate of 96.7% for th RGB-D data and 88.7% for the noisy depth data alone.

In [14] R. I. Hg, P. Jasek, C. Rofdal, K. Nasrollahi, T. B. Moeslund, and G. Tranchet face recognition system based on the Microsofts Kinect for Windows Face detection. This algorithm also makes use of both color image and depth image for the purpose face recognition. In this, a scene is set to produce different face positions. The system detects the face 93.62 % of time for pose direct looking into the camera. However, this detection rate drops for the other poses which makes sense, because the employed method for face detection in this algorithm is based on finding facial triangles, which is obviously not visible in rotated images where the user does not face Kinect.

In [15] Gaurav Goswami, Mayank Vatsa, and Richa Singh face recognition, uses the RGB image and depth image for the purpose of face recognition. It is basically based on the texture and attribute features of the image. Because of the cost of 3D sensors are very high, use of 3D sensors becomes a challenge in this area. This RGB-D images can be captured using low cost RGB-D sensors such as Kinect.

In [16] Sajid Ali Khan, Muhammad Nazir, Nawazish Naveed, Naveed Riaz, recognition of gender from images are done through PCA and DWT features. Initially it detects the face using the Viola Jones technique and the facial features are extracted using Discrete Wavelet Transform (DWT) and Principal Component Analysis(PCA).

III. PROPOSED WORK

The steps involved in the proposed algorithm are shown in Fig. 2 and 3. The block diagram for training and testing are given separately. The proposed Face and Gender recognition algorithm mainly consists of three processes:

- Preprocessing
- Face Recognition
- Gender Recognition

The process of face and gender recognition plays an important role in security and surveillance areas. These both are a common way that is used in identification and authentication areas such as in identity cards and all. In this proposed method, the system developed a model for both face and gender recognition using Random Decision Forest (RDF) and Naïve Bayes (NB) respectively. These both are trained separately using IIIT-D RGB-D database.

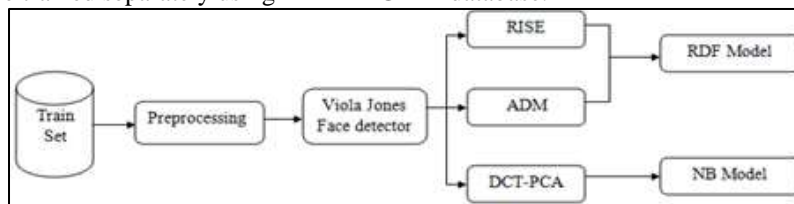


Fig. 2: Block diagram of training of images

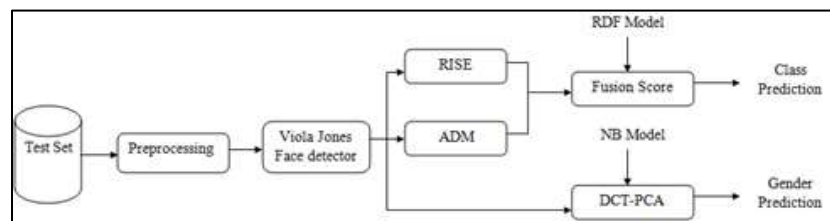


Fig. 3: Block diagram of testing of images

A. Preprocessing

First, an automatic face detector (Viola-Jones face detector) is applied on the RGB image to extract the face region. Viola Jones face detector works based on the Haar features. The corresponding region is also extracted from the depth map to crop the face region in depth space. The images are resized into size which is divisible into 5 X 5 blocks. Depth map is then preprocessed to remove noise such as holes and spikes. Depth map of a face is divided into 25 X 25 blocks and each block is examined for

existence of holes and spikes. Depth values identified as hole/spike are rectified using linear interpolation, i.e. assigned the average value of their 3 X 3 neighborhood.

B. Face Recognition

The face recognition is done by combining RISE (RGB-D Image Descriptor Based on Saliency and Entropy) and AFE (Attributes Based Feature Extraction) by using Match score fusion. The combination of these texture and attribute features will improve the accuracy of the face recognition process. The steps involved in in face recognition algorithm are illustrated in Fig.4.

1) RISE: RGB-D Image Descriptor based on Entropy and Saliency

The entropy and saliency map can be used for face recognition, and it can be drawn from the depth and RGB image obtained from Kinect. The depth image, is having high inter class similarity and may not be directly useful for this purpose. But, the depth data obtained from Kinect can be utilized to increase robustness towards covariates such as expression and pose after relevant processing/feature extraction. The color image contains the texture properties of the face and the depth image contains the facial geometry of the face. So, both of these properties can be used for feature extraction and the classification. As shown in Fig.4. four maps can be created. But the saliency map obtained from depth image is too noisy, so it can't be used for the feature extraction. HOG descriptor is used to extract the features from the maps. Based on all these values, RDF classifier is used to create the RDF model and used for the decision taking.

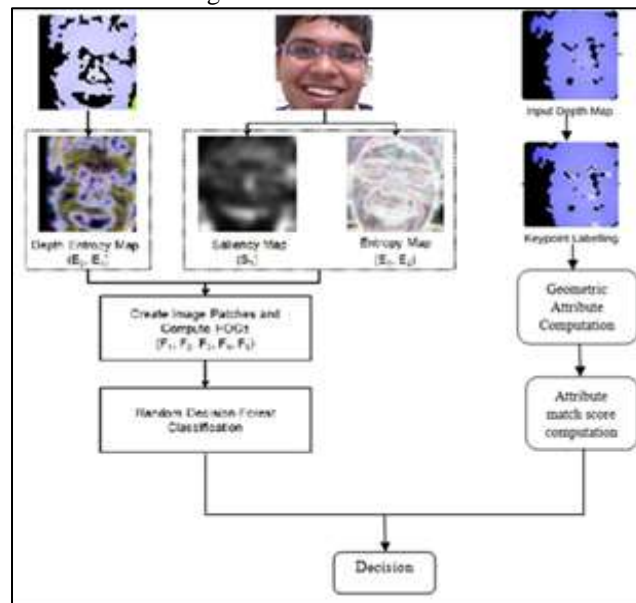


Fig. 4: Proposed Face detection algorithm

a) Entropy and Saliency

Entropy is defined as the measure of uncertainty in a random variable. Similarly, the entropy of an image characterizes the variance in the grayscale levels in a local neighborhood.

The entropy H of an image neighborhood x is given by Equation.

$$H(x) = - \sum_{i=1}^n p(x_i) \log_2 p(x_i)$$

Where $p(x_i)$ is the value of the probability mass function for x_i . In the case of images, $p(x_i)$ signifies the probability that grayscale x_i appears in the neighborhood and n is the total number of possible grayscale values, i.e., 255. If x is a $M_H \times N_H$ neighborhood then,

$$p(x_i) = nxi / M_H \times N_H$$

Here, nxi denotes the number of pixels in the neighborhood with value x_i . $M_H \times N_H$ is the total number of pixels in the neighborhood.

We also uses the properties of saliency map of RGB image, which gives useful facial information. The distribution of visual attention in the entire image describes the saliency. Or, it finds the capability of local regions to attract the viewers visual attention.

b) Extracting Entropy Map and Visual Saliency Map

In this step, it extracts the region of interest or a set of patches of the given maps. Let I_{rgb} represents the RGB image and I_d represents the depth image then two image patches are extracted for both I_{rgb} and I_d . Two patches, $P1$ of size $M/2 \times N/2$ centered at $[M2, N2]$, and $P2$ of size $3M/4 \times 3N/4$ centered at $[M2, N2]$ are extracted from I_{rgb} . Similarly, two patches $P3$ and $P4$ are extracted from I_d .

c) Extracting Features Using HOG

HOG is highly used as feature and texture descriptor in many applications like object detection, recognition, and other computer vision applications. This descriptor produces the histogram of a given image in which pixels and which are binned according to the magnitude and direction of their gradients. So that, the HOG of the above maps gives the gradient direction and magnitude of the image variances in a fixed length feature vector. So, by using HOG, the information in the saliency and entropy maps can be easily represented with a HOG histogram.

d) Classification

Classification is performed to train the set of images and create a model to take the decision for the test input. There are several classifiers can be used for this such as, Nearest Neighbor (NN), Random Decision Forests (RDFs), and Support Vector Machines (SVM) can be used. Any classifier that should be robust enough to handle large number of classes. And should be computationally inexpensive during probe identification and should take the accurate decision about the test input. Among several classifiers, RDFs being an ensemble of classifiers, can produce non-linear decision boundaries and can support large number of classes. RDFs are also robust towards outliers compared to the Nearest Neighbor algorithm, because in RDF, it treat every tree in the forest as a small subset of data. Therefore, the probability of an entire collection of trees making an incorrect decision will be low.

2) Attribute Feature Extraction

Attribute based feature extraction, which is highly used in image retrieval and face verification. The proposed Attributes feature extraction algorithm extracts geometric attributes. Multiple geometric attributes can be utilized to describe a face such as the distances between various key facial features including eyes, nose, and chin. By analyzing the human face, we can have certain face landmarks can be identified and located and that can be utilized to extract geometric attributes that can be used for face recognition in conjunction with the entropy and saliency features. So that, for this algorithm, it mainly consist of two stpes, which is Keypoint labeling and geometric attribute computation.

a) Keypoint Labelling

To extract geometric attributes features, first we need to find certain face landmarks with the help of depth map. The points such as nose tip, eye sockets, and chin are considered as the these points. In a detected face depth map, the nose tip is closest point from the sensor, the two eye sockets are always located above the nose tip and at a higher distance than their local surrounding regions, the chin is detected as the closest point to the sensor below the nose tip. By using these points, certain other points such as the nose bridge an eyebrow coordinates can also be located. By using these landmark points for all faces, geometric measurements can be computed. The key points are labeled in the depth map and shown in Fig.5.

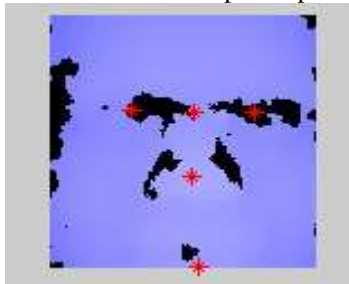


Fig. 5: Keypoint Labelling

b) Geometric Attribute Computation

From the detected landmark points of the face, various measurements of the face can be computed such as: inter-eye distance, eye to nose bridge distance, nose bridge to nose tip distance, nose tip to chin distance, nose bridge to chin distance, chin to eye distance, eyebrow length, nose tip distance to both ends of both eyebrows, and overall length of the face. Since the measured value of these parameters may vary across pose and expression, multiple gallery images are utilized to extract the facial features. Attributes are computed individually for each gallery image and the average distances are used. Likewise, a number of attributes are computed for each class.. These contribute towards the attribute feature vector for the RGB-D face image.

c) Attribute Match Score Computation

The attributes for a probe are computed similar to gallery images. Once the attributes are computed for a probe, the match score \emptyset is computed for each subject in the gallery using Equation

$$\emptyset = \sum_{i=1}^N w_i * (A_i - a_i)^2$$

Here, A_i and a_i are the i^{th} attributes of the probe image and the gallery image respectively. w_i is the weight of the i^{th} attribute and N is the total number of attributes.

3) Combining RISE and AFE

The match scores that obtained from RISE and attribute based feture extraction method is combined using match score fusion. Match score fusion is performed using the weighted sum rule. Let \emptyset_{RISE} be the match score obtained using the RISE approach

and ϕ_{AFE} be the match score obtained by the attribute based feature extraction approach. The fused match score ϕ_{fused} used is computed as,

$$\phi_{final} = w_{RISE} * \phi_{RISE} + w_{AFE} * \phi_{AFE}$$

Where w_{RISE} and w_{AFE} are the weights assigned to the RISE and ADM match scores respectively.

This combined score value is used to take the decision of face recognition. That is, based on the maximum value obtained for each class, it determines the decision of class.

C. Gender Recognition

Gender identification plays an important role in Human-computer interaction and also is used as a pre-processing step for face recognition. It is applicable in different areas like criminology, security systems, safety monitoring systems and many more. The process of Gender recognition is done by using the DCT (Discrete cosine transform) feature extraction and PCA (Principal Component Analysis) for dimensionality reduction.

1) Extracting Features using DCT AND PCA

Discrete cosine transform (DCT) is a powerful transform to extract proper features for face recognition. After applying DCT to the entire face images, some of the coefficients are selected to construct feature vectors. DCT feature extraction consists of two stages. In the first stage, the DCT is applied to the entire image to obtain the DCT coefficients, and then some of the coefficients are selected to construct feature vectors in the second stage.

PCA is a statistical approach used for reducing the number of variables in face recognition. While extracting the most relevant information (feature) contained in the images (face). Because the face image is often with a high dimension, it is difficult to use the original data directly, so it is critical to choose the effectively distinguished features for extraction and reduction.

2) Classification

Nave-Bayes classifier is used to train the dataset, so that the system could identifies the gender of the input image. This classifier is working based on Bayes theorem of conditional probability. When input becomes very high, this classifier should be used. This classifier builds using probabilistic model. Here only two class label are present, which are male and female. So, we used binary classification. Based on the obtained NB model, it takes the decision of male or female.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

The method was implemented in a MATLAB 2014 prototype. In the experiments, 3 Computed Tomography (CT) medical images downloaded from [16] were used as test images. Since we use Otsu's method for background segmentation no parameters are need to be specified in that step. To find out the principal gray scale values in the segmented background the percentage of threshold needs to be specified, which denoted by R. Also the number of histogram pairs to be expanded, denoted by S is also needs to be specified.

Suppose, the system have trained a male person, and he is belongs to class 1. So the training includes different images of the same person with both depth and RGB image as shown in Fig.6 and 7.



Fig. 6: RGB images taken for training

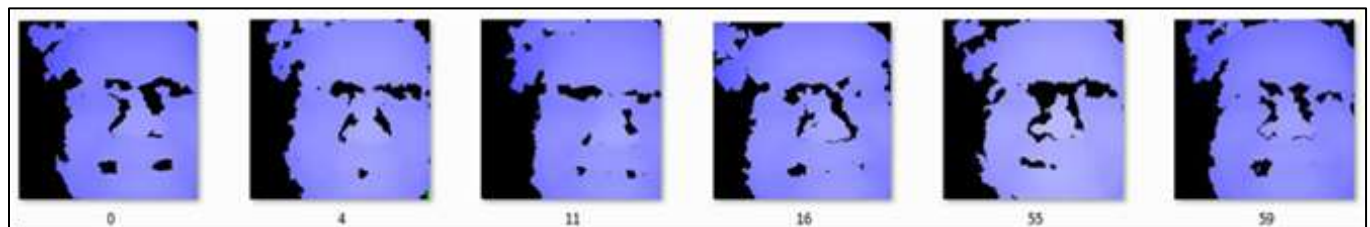


Fig. 7: Depth images taken for training

The systems have trained both the RGB image and depth image of the same person with face belongs to class 1 and as a male person. That is, RDF and NB classifier have created the model for taking the decision.

After this training of all the images in the dataset, we can test the images by giving input, which is depth and RGB image.



Fig. 8: Input RGB Image

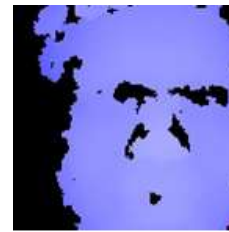


Fig. 9: Input depth Image

Initially, the system will do the preprocessing step, which is detects the face using Viola Jones face detector algorithm. And then convert the image into the size which is divisible by 5x5 blocks as shown in Fig.10.



Fig. 10: Viola Jones Face

After that, the images are given into the RISE algorithm, which creates the Entropy map for RGB and Depth image and Saliency map for RGB image as shown in Fig.11.

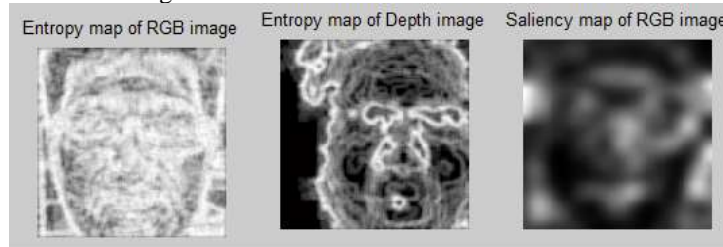


Fig. 11: Entropy and Saliency maps Obtained

When the maps are obtained, it will extract the region of interest, or it takes the two patches from each image for better feature extraction. After that the keypoint labeling is done based on the attribute based feature extraction algorithm.

The experiment results are analyzed by using the three factors which are, precision, recall and accuracy. The method trained using 12 individuals dataset, in which each individuals dataset contain a number of images. Then the method of face recognition is performed using 12 images of each individual. Likewise, a number of female and male images are given separately for gender recognition training. Then the model is created using RDF classifier and Naïve bayes classifier for face and gender recognition respectively.

Another comparison is performed is component wise analysis of face recognition algorithm with the proposed algorithm. That is, RISE and ADM algorithms are individually tested and which is analyses with the proposed method. The analysis is performed by finding different performance matrices such as Precision, Recall and accuracy. In our case, the true negatives and false positives will be zero. So the precision will be 100 %. The true positives are the number of images which correctly identifies the class. And false negatives are the number of images which responded as Unknown person. By the equation of recall and accuracy we will get the recall and accuracy of proposed method as 95.13% and 88.271% respectively.

Table – 1

Performance matrices measures

Performance matrices	RISE Only	ADM Only	RISE+ADM
Total TP	112	84	137
Total TN	0	0	0
Total FP	0	0	0
Total FN	32	60	7
Precision	100%	100%	100%
Recall	77.77%	58.33%	95.13%
Accuracy	77.77%	58.33%	88.271%

The performance analysis of the above Table 1. Is plotted below.

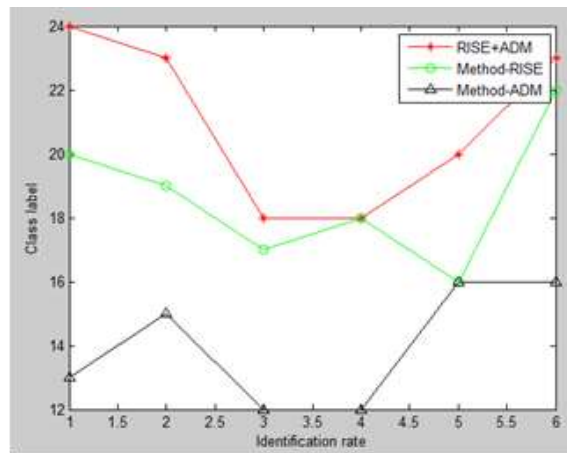


Fig. 12: Comparison of RISE+ADM, RISE only and ADM Only

The class labels are identified by taking the maximum value of the match score value. But, if we give any input, it takes the maximum value and return as the input image belongs to that class. In that case, if we give any number of wrong inputs, it will predict some classes. To avoid that problem, we are given a threshold value of 170. The value 170 is taken by analyzing the images in training set. The ROC Characteristics graph of face recognition is given in Fig.12.

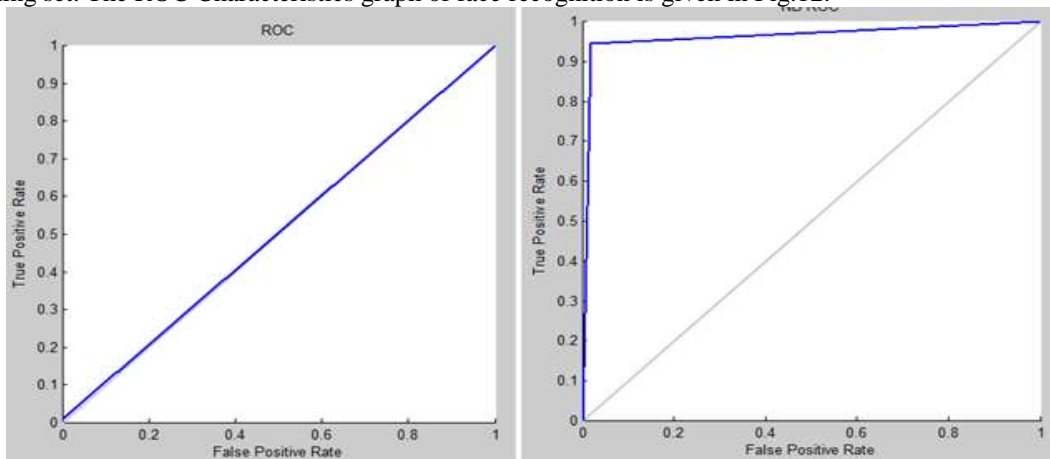


Fig. 13: ROC Characteristics for Face recognition and gender recognition

The gender recognition is also performed using a number of male and female images in the dataset. These male and female folders are temperately trained for this purpose. The ROC Characteristics graph is plotted for face gender recognition is given in Fig.13.

V. CONCLUSION

This work presented a novel Joint face and gender recognition system to efficiently classify the images. In order to improve the performance of face recognition in the presence of covariates such as pose, expression and illumination, RGB-D image is used. AFE algorithm is proposed to extract and match geometric attributes. AFE is then combined with the RISE algorithm for identification. Here geometric attribute is extracted from color image as depth map contains lots of noise. In various biometric applications, gender recognition from facial images plays an important role. In order to increase the security of the system proposed a method to perform gender recognition after performing face recognition. Here investigated Discrete Cosine Transform(DCT) for gender recognition. So DCT Features are extracted from the facial image. Naive Bayes classifier is then used to recognize the facial features for gender recognition. The experimental results indicate that the gender recognition using DCT achieves higher accuracy on color images when compared with gender recognition using DWT.

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