UP^3: User Profiling from Profile Picture in Multi-Social Networking

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***Abstract*—Profiling Online Social Network (OSN) Users by matching their Profile Pictures in Multi-Social Networking requires their own frontal face images in consideration. Present State-of-the-Art algorithms are ineffective in detecting mouth and nose on the face, making it inefficient to be used in matching different faces by localizing their facial features. This work proposes a novel approach to improve the effectiveness and efficiency of face detection by bifurcating the detected face horizontally and vertically. The algorithm runs only on the portion of the detected face Bounded Box (BB) to generate bounded boxes of other facial objects, and later the Euclidian distance between the BBs with respect to that of the face is computed to get Logarithm of Determinant of Euclidian Distance Matrix (LDEDM) in Relative-Distance method and stored in the database. The LDEDM so computed is unique for the user image under consideration and is used for the purpose of matching the identity of the user images from the database. The Equal Error Rate (EER) is considerably low with the proposed User Profiling from Profile Picture (UP^3) algorithm indicating better performance.**

Keywords*—Data Mining; Face Detection; Online Social Networks; Profile Picture; Relative Distance; User Profiling.

I. INTRODUCTION

With the increase in the usage of social network and image sharing services, huge data is being generated every day. The profile of a social network user consists of their profile picture, name, date of birth, e-mail ids and other details. As the pictures with human faces increase in social networks, the need for face detection in the still images as well as in video streaming have increased for various reasons. Detection of face and localization are the important and critical factors of any face detection system. The main goal of face detection system is to check and identify whether there are any face/faces available in the given image, if so then localizing the facial features.

In real-time images, detection of faces is challenging due to the different lighting conditions, complex background, face appearance, occlusion, facial expression and illumination. There are many face detection techniques available presently like Haar Cascade Classifier, Neural Networks, SVMs and Hidden Markov Models. Most of the researchers have used Viola-Jones algorithm and have improved upon it to detect facial objects. Open Source Computer Vision-OpenCV software tool has several optimized and implemented algorithms for image processing.The intention of face detection is to achieve real-time face detection in the image considered with high detection rate consuming less computational time.

The performance of face detection system depends on the variations in illumination levels, noise and also the conditions of the environment of the image. Basically, there are two features using which the faces in the images can be found: i) Point features which compares central pixel with neighboring pixels in local structure pattern that are sensitive to noise. This method is good for computer vision problems but largely sensitive to the noise. ii) Regional features like Haar-like feature and sparse features are sensitive to illumination changes where regional features compare sum of intensities of two rectangular regions with reduced noise in the image.

Advancements in computer technology opened the path for development automated system for face detection. Law-enforcement agencies use face detection systems to detect faces, to match and find the fingerprint from the database of criminals. Even in many institutions and banks, face detection is in need, since very few authorized workers are accessible to sensitive areas of the workplace. To securely provide access to such identified authorized workers, face detection is the best security system. Basically, the automated detection systems work with classifiers, and all the general algorithms available till now depend on sliding window approach.

As human-machine interfaces increase, the need for real-time face detection has increased. The pose, facial expression, indoor-outdoor light, illumination etc., makes face detection difficult. Development of generalized recognition system is more crucial than for a specific application. With the available detection system using software applications, the detection rate is high, but often requires to detect faces which in turn increases the processing time, a burden for real-time applications. Drawback of existing algorithms is that they lack in detecting non frontal faces.

Moreover, to prepare a training dataset, it requires huge amount of human intervention and thus costly. Segmentation and classification methods to detect faces also have disadvantages in terms of presence of noise whereas Landmarks and

978-1-4673-6540-6-/15/$31.00

localization requires priori knowledge of pose and orientation of the face. Though some algorithms achieve high detection rate, they still have restrictions. The need to develop generalized recognition algorithm for all situations with no pre-assumptions is still an active research topic.

In order to detect and localize the face in the image of arbitrary size, natural framework is considered where binary classification is applied on the image to avoid misclassification risk. Since there will not be any prior information about the availability of the face in the given image, the algorithm used in face detection system must reduce the false recognition of faces to achieve higher performance. In general the basic idea in developing the algorithms is the factor which distinguishes the objects in the image from the faces using classifiers.

Motivation: Images are easily and largely available on social networking sites motivating us to work on feature detection of 2-dimensional images. The tools for differentiating objects from faces are in need to be developed urgently which help in general for all situations. The classifiers are to be fine-tuned to achieve clear identification of facial objects. The approach for identifying different facial objects and localizing them and comparing with the training dataset to get matched images is still a challenge and need too.

Contribution: Given a database of images, we have proposed a novel approach to improve the effectiveness and efficiency of face detection by bifurcating the detected face horizontally and vertically. The algorithm runs only on the portion of the detected face BB to generate bounded boxes of other facial objects, and later the Euclidian distance between the BBs with respect to that of the face is computed to get LDEDM in Relative-Distance method and stored in the database. The LDEDM so computed is unique for the user image under consideration and is used for the purpose of matching the identity of the user images from the database. Our proposed approach detects both single and multiple facial features in the given input image.

The rest of the paper is organized as follows: Section-II gives a brief review of the Related Work, whereas the Background Work is presented in Section-III. The problem definition is discussed in Section-IV. The Proposed System Model is illustrated in Section-V. The proposed User Profiling from Profile Picture (UP^3) algorithm is presented in Section-VI. Section-VII demonstrates Simulation Results and Performance Analysis of the proposed system. Section-VIII is summarized with Conclusions and scope for future work.

II. RELATED WORK

Kyungjoong et al. [1] proposed a novel feature extraction method called Semi-Local Structure Patterns (SLSP) based on regional local differences. The statistical analysis depicts that SLSP transforms noticeable amount of face image noise into uniform patterns and shows that it outperform the conventional face detectors by encoding relative sizes of central with that of its neighboring regions into a binary code. Based on two-field feature extraction scheme, Chih-Rung et al. [2] proposed a cascade face detection architecture which works faster in integral image calculation and feature extraction reducing the amount of memory needed for storing and average detection time of features achieving high face detection rate.

Seyed et al. [3] proposed face constellation which localizes and enables multi-view face detection. To achieve this, probabilistic classifier based formulation are used resulting in better performance. Mauricio et al. [4] proposed a methodology containing automatic techniques for face segmentation and landmark detection in range images using only depth information as input and found to be robust for facial expressions.

Kang-Seo et al. [5] proposed aa algorithm to detect face using 33 block rank patterns of gradient magnitude images and a geometrical face model. Experiments show that their method is robust to illumination changes. Raphael et al. [6] provided a novel search technique using mutation information gain heuristic and hierarchical model to efficiently prune search space and proposed an active testing framework which performs faster face detection and localization in images. Series of experiment conducted on the proposed framework shown that it significantly reduces the number of classifier evaluations increasing the speed exponentially while detecting and locating faces compared to sliding window approach.

Hatice et al. [7] proposed a method to automatically determine temporal segments and their synchronization for modality fusion, and their role in affective recognition. To achieve this, individual models are separately trained. Firstly, monomodal affect recognition is obtained using only the detected neutral and apex frames. Secondly, based on the apex phase which is fused for classification at the feature level, affective face and body modalities are synchronized, where both modalities are combined before classification. At decision level, probabilities from single modalities are combined. Hongliang et al. [8] proposed matting algorithm for automatically segmenting human faces. The algorithm is also designed for face recognition and verification, security system, and computer vision.

Paul et al. [9] described a visual object detection framework capable of processing images rapidly while achieving high detection rates. The three key contributions of this method are i) image representation called Integral Image to compute the features used by detector ii) a learning algorithm, based on AdaBoost, which selects a small number of critical visual features and yields in extremely efficient classifier. iii) method for combining classifiers in Cascade. This framework detects objects minimizing computational time while achieving high detection accuracy.

Christina et al. [10] introduced an android application named Secure Me, a combination of high level attribute and low level features in face image retrieval to provide accurate result in extraction of similar face. It provides secure data storage facilities by using authentication techniques. Mandeep et al. [11] represented classification of emotions using Singular Value Decomposition (SVD) both on real-time as well as JAFFE database and show that their algorithm effectively distinguishes different expressions by identifying features.

P. Deepa Shenoy et al. [12] proposed Distributed and Dynamic Mining of Association Rules using Genetic Algorithms (DDMARG) to explore the problem of mining association rules in the distributed environment after analyzing the time complexities of single scan Dynamic Mining of Association Rules using Genetic Algorithms (DMARG), with Fast UPdate (FUP) algorithm for intra transactions and E-Apriori for inter transactions. Kailash et al. [13] proposed a faster approach named GPU architecture using enhanced Haar-like features to perform real time face detection.

Yi-Qing [14] proposed a learning code and a learned face detector algorithmic description which is applied on color images. The integral image, Adaboost and an attentional cascade are used together for fast and accurate detection. Ijaz et al. [15] presented improved algorithm, a hybrid of Viola-Jones and skin color pixel detection, which increases accuracy and consumes less time. Ramachandra A C et al. [16] proposed Cross-validation for Graph Matching based Offline Signature Verification (CGMOSV) algorithm which gives better Equal Error Rate (EER) for skilled forgeries and random forgeries. Using signature extraction method, high resolution for smaller normalization box is obtained and optimized threshold value is determined with Cross-validation principle.

Sureshkumar et al. [17] proposed a system having high performance in image retrieval using attribute-enhanced sparse coding and attribute embedded inverted indexing. P. Deepa Shenoy et al. [18] proposed to generate large item sets with the principle of Genetic algorithm in dynamic transaction databases. The authors analyzed to show that Dynamic Mining of Association Rules using Genetic Algorithms (DMARG) outperforms both FUP and E-Apriori with respect to its execution time and scalability. Veena H Bhat et al. [19] proposed a unique way of generating, storing and analyzing data with its application in digital forensics.

III. Background Work

There are various kinds of face detection algorithms to detect human faces. The facial lineament of the two dimensional human face image is extracted using Viola-Jones [9] algorithm. The algorithm detects the features on the occult faces as well as distant faces. It is an object detection framework to provide competitive object detection rates in real-time. The algorithm has mainly four stages: (1) Haar Feature Selection, (2) Creating Integral Image, (3) Adaboost Training algorithm and (4) Cascaded Classifiers.

The detection framework involves computing the sum of image pixels within the rectangular area. The inbuilt functions of Viola-Jones are utilized to detect various characteristics based on the merge threshold, the frequency assigned to Haar-like features to detect within the given threshold value. The functions are effectively run on the human face to find the prominent attributes. These generate bounded box matrix of size 1x4 which includes the *x,y* coordinates, i.e. the starting point of detected attribute box, along with the width and the height of the box. The matrix stores the values dynamically with every new image run.

IV. PROBLEM DEFINITION

The well-known Viola-Jones [9] algorithm is not effective in detecting mouth and nose on the face. It falsely detects eyes and several other objects in the image as mouth and even falsely detects nose in the area other than the face. This kind of object detection is inefficient to be used in matching different faces by localizing their facial features. Profiling Social Network Users by matching their Profile Pictures in Multi-Social Networking sites requires their own frontal face images in consideration.

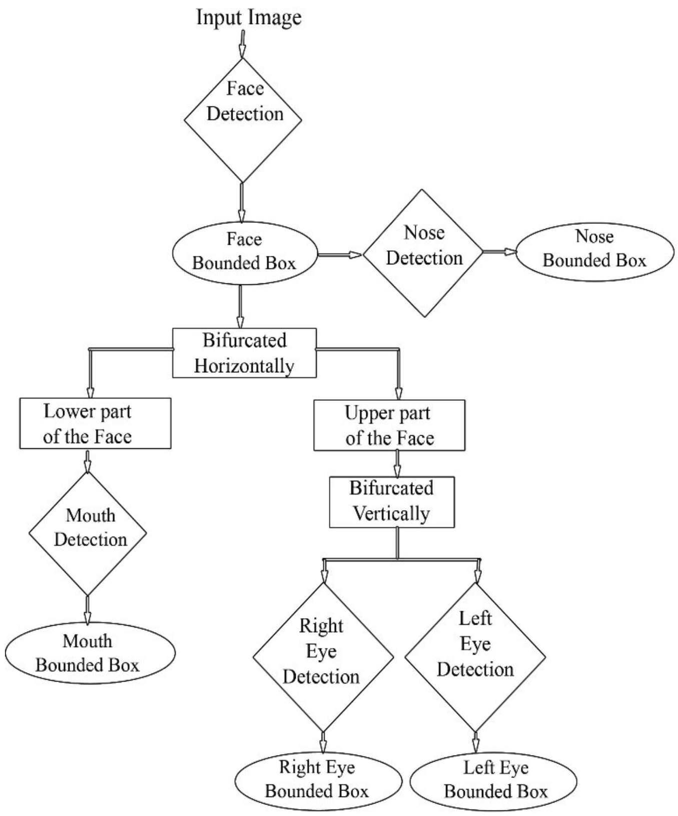

Fig. 1: Feature Extraction Process.

V. PROPOSED SYSTEM MODEL

To overcome the problems of mouth and nose detection, this work proposes a novel approach and improves the effectiveness and efficiency of face detection. Our proposed approach detects both single and multiple facial features in the given input image.

A. Feature Extraction and Bounded Box

The facial lineament detection methods of the Viola-Jones [9] algorithm is utilized along with the following improvisation upon it. The face detection method runs on the image under consideration and generates face bounded box. Then the improved mouth detection process is accomplished by bifurcating the detected face horizontally to obtain the upper and lower half of the face as shown in Fig.1. The upper and lower half of the face is stored into two image matrices. The lower half face matrix is used to detect the mouth. The algorithm runs only on the small portion of the image i.e. on the lower half of the face to generate mouth bounded box. The improved algorithm runs much faster than the original Viola- Jones algorithm.

With respect to eye detection, unlike present methods, a pair of eyes detection is changed to single eye detection by further dividing the upper part of the face vertically. For single eye detection, the detection algorithm for left eye and right eye is executed on the upper half part of the face. The algorithm effectively runs over the upper half part of the face image detecting left and right eyes simultaneously on the face and their respective bounded box values are generated.

To solve the inaccuracy of nose detection in the place other than the face, the nose detection algorithm is made to run only on the facial area given by the face bounded box. This assumption prevented the false detection of nose in the area other than face in the images and resulted in the faster nose detection in the image resulting in nose bounded box.

The Viola-Jones algorithm has drawback in multi-face detection as shown in Fig.2, which detects more than actual faces and other facial features outside the face in the image. We tried running improved merged algorithm on multiple face image which detected facial feature like mouth, nose and eyes only on the first face in the image. The algorithm is further improved by adding iterative loop to detect all the features on each face in the image, as shown in Fig.3. Thus the proposed UP^3 algorithm detects attributes with multiple faces in the image and stores bounded box matrix value of each feature for different faces dynamically for the current image.

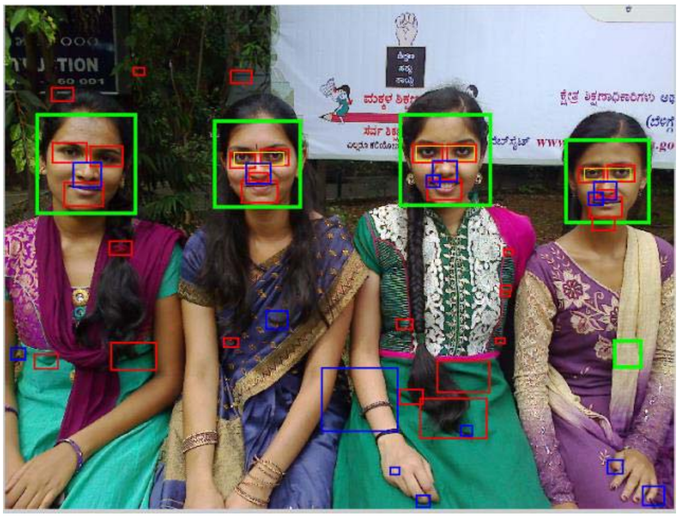

Fig. 2: Facial Features Detected using Viola-Jones Algorithm.

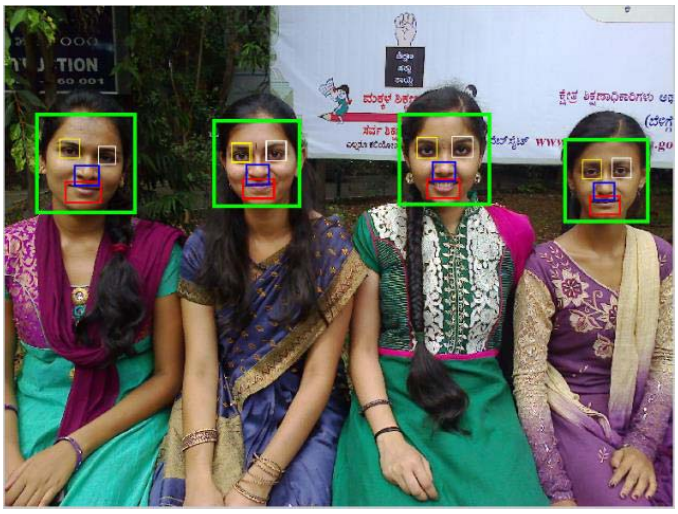

Fig. 3: Facial Features Detected using Proposed UP^3 Algorithm.

B. Relative-Distance Approach

The bounded box matrix generated during the algorithm run time is used in Relative-Distance method. The *x,y* coordinate values of the bounded boxes of mouth, nose, right eye and left eye are used to calculate the relative distance of each lineament with respect to that of the face. The Euclidian distance between the BBs is computed to get LDEDM in Relative-Distance method. The LDEDM so computed measures the distance between the two coordinate points on the face image for the purpose of matching the identity of the user image from the database for any incoming image.

The distance between *x,y* coordinates of face bounded box with that of the *x,y* coordinates of other features bounded box on face is computed and stored in a 2 X 2 matrix. The determinant of the matrix is computed and the logarithmic value of the determinant i.e. LDEDM is stored in the database.

C. System Model

Further, the functionality of the algorithm is tested on the inverted image to check if the prominent attributes are being detected correctly on the inverted image. The test with Viola-Jones algorithm revealed an inaccurate detection of features for the inverted image. The issue is resolved in the proposed UP^3 algorithm by rotation of the image based on the upper body feature detection [9] on the image. The proposed improved merged algorithm is used further for the facial detection and proved to be accurate and efficient in facial attributes detection.

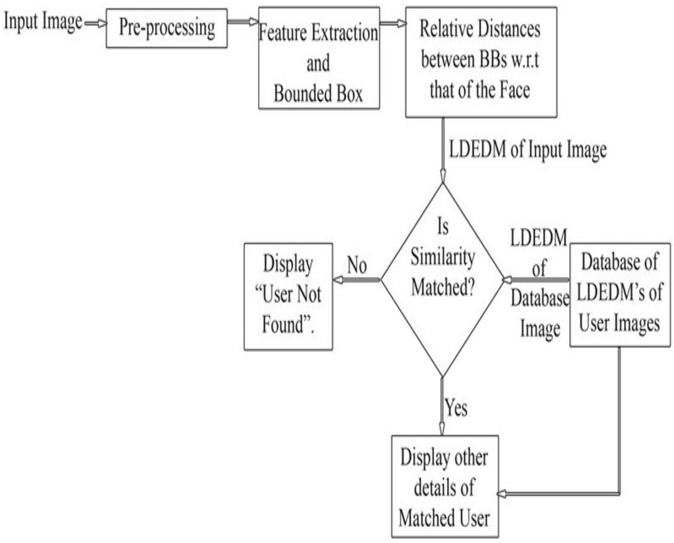

Fig. 4: System Model Diagram.

The basic information collected in the database for each individual is displayed on successful result of the matching component of the proposed UP^3 algorithm which checks the computed logarithm value of the current input image with the values stored in the database for the match. The absolute difference value between the generated LDEDM and the stored LDEDM is defined within the range for a successful match with respect to other details in the database as shown in Fig.4.

VI. ALGORITHM

Considering one image at a time, facial features in the image are detected. If the image is inverted, then it is rotated upright to locate the face. Bounded Box values for the detected face and also for that of nose are generated. Then the face is divided horizontally where mouth detection is performed on the lower part of face and its BB value is generated. Later the upper part of face is further divided vertically which helps in detecting BBs of right and left eye effectively.

Algorithm 1 *LDEDM Function*

```
while True do
    for Every Profile Image in the Network do
        if Upper body detected then
            goto Detection
        else
            Rotate the Image
        end if
        Detection: Detect the Face and the Nose and Compute
        -their BB values.
        Divide the detected face BB horizontally at the middle.
        Detect the Mouth in the lower half of the division and
        -compute its BB values.
        Bisect the upper half of the divided image vertically.
        Detect the Right Eye on left half and Left Eye on right
        -half of the bisected image and compute their BB values.
        for Every BB != that of the Face do
            Calculate the Euclidean Distance between x,y
            -coordinates of the BB and that of the Face and
            -Record in a 2 X 2 Euclidean Distance Matrix.
        end for
        Compute the Logarithmic of Determinant of Euclidean
        -Distance Matrix (LDEDM) and store it.
    end for
end while
```

The BBs of each facial object detected is considered for computing the relative distance with respect to that of face. The Euclidean Distance between *x,y* coordinates of each BB and of the face is computed and it is stored in a 2 x 2 matrix. Thus the Logarithmic of Determinant of Euclidean Distance Matrix (LDEDM) of the considered image is stored in database using LDEDM-Function shown in Algorithm 1.

Algorithm 2 *User Profiling from Profile Picture (UP^3) Algorithm*

```
while True do
    for Every Test Image Considered do
        Compute LDEDM using LDEDM-Function
        for Every LDEDM of computed Data set do
            Find the Absolute Difference between LDEDM of Test
            -Image and that of Data set.
            if Absolute Difference is within the defined range then
                Display Other details of the Matched User
                -correspondingly.
            else
                Display User Not Found.
            end if
        end for
    end for
end while
```

Each test image considered is fed to the proposed UP^3 algorithm shown in Algorithm 2. The LDEDM value of the image under consideration is computed using the LDEDM-Function shown in Algorithm 1. Preprocessing of the image under consideration is done to make sure it is not an inverted one and that it is the frontal face image.

The LDEDM of test image is compared with that of the LDEDMs of dataset images. If the absolute difference between those two LDEDMs fall within the threshold range, then the algorithm outputs all other details of the Matched User found in the database, else User Not Found message will be displayed.

VII. SIMULATION RESULTS AND PERFORMANCE ANALYSIS

The proposed UP^3 algorithm is implemented with MATLAB 2013a in system having Intel Pentium i7 with 4GB RAM configuration upon Windows-8 platform. Initially we have constructed a database by collecting 180 User details along with their Profile Pictures from Linked-In social networking site. For each collected Profile Picture, LDEDM is computed and stored in the database. The database created consists of Name of the User in the image, User image and its LDEDM, Highest Education of the User and their University/College name.

For testing purpose 10 User Profile Pictures have been considered, out of which 8 Profile Pictures are collected from the Facebook of the same users appearing in Linked-In. Other 2 pictures are collected from outside the social networking sites which do not appear in constructed database as well.

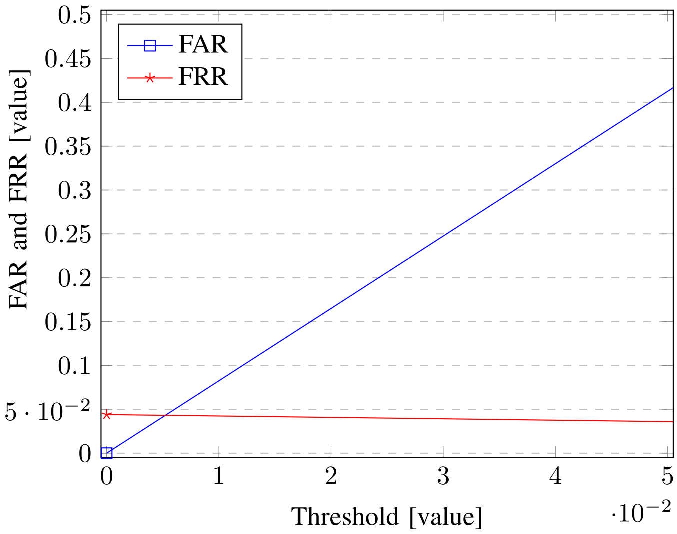

Fig. 5: Equal Error Rate of the System.

The performance of the proposed UP^3 algorithm is analyzed based on the following measures:

i) False Acceptance Rate (FAR) is the measure that incorrectly/falsely matches an image to a wrong user in the database.

$$\text{FAR} = \frac{\text{Number of Falsely Accepted Images}}{\text{Total Number of User Images in Database}}$$

ii) False Rejection Rate (FRR) is the measure that incorrectly/falsely rejects an image of the right user in the database.

$$\text{FRR} = \frac{\text{Number of Falsely Rejected Images}}{\text{Total Number of User Images in Database}}$$

iii) Equal Error Rate (EER) is a threshold independent performance measure obtained at the point where both FAR and FRR values are same.

The proposed UP^3 algorithm is run on each picture under consideration for testing upon varying threshold from 0.0 to 1.0 and the output of the algorithm is recorded. Based on the output of the algorithm, the FAR and FRR values are computed. Fig.5 Shows the FAR and FRR values against the threshold considered during testing.

The EER value 0.043 obtained from testing shown in Fig.5 depicts better performance of the proposed UP^3 algorithm as it is very low at 0.05 threshold. Thus the proposed UP^3 algorithm is proved to be robust and efficient for Face Detection and User Profiling in Multi-Social Networking.

VIII. Conclusions

The paper presents UP^3 algorithm for Profiling Online Social Network Users. We have proposed and evaluated a novel approach which improves the effectiveness and efficiency of face detection by bifurcating the detected face horizontally and vertically. The LDEDM compute is unique for the user image under consideration and is used for the purpose of matching the identity of the user images from the database. Our simulation results show that the EER is considerably low with the proposed UP^3 algorithm indicating better performance overcoming the drawbacks of State-of-the-Art works.

The UP^3 algorithm when applied on Multi-Social Networking sites, helps in identifying criminals. This approach is suitable in Recruiting process to cross validate the candidature of the applicants through their Online Social Network Status and Activities. The avenues for future work are in carving user profile with their Multi-Social Networking activities through one single platform.

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