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Periocular Region: An Ideal Biometric Trait for Face Recognition across Gender Transformation

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ABSTRACT:Face Recognition is an important stage in security checks. A lot of efficient methods are now adopted for this purpose. But the face recognition of gender transformed persons are still remaining as a tedious process as there occurs lot of changes to the person after getting transformed. A medical facility known as Hormone Replacement Therapy can be utilized by criminals or spoofers for masking or creating a new identity. Here a study is done on identifying such transformed persons using periocular region as the biometric trait for verification. The effectiveness of periocular region while comparing with other face components is also done by calculating their Equal Error Rate (EER).The work is done as two stages. First stage includes face detection, eye detection ,component cropping and feature representation. While the second stage includes similarity measurement and verification. Here periocular region showed better recognition accuracy than other face components

KEYWORDS : Periocular Region, Face Recognition, Plastic Surgery, Disguise, Gender Transformation, Hormone Replacement Therapy, Transgender, Medical alteration.

I.INTRODUCTION

The human face plays an important role in our social interaction, conveying people's identity. Using the human face as a key to security, biometric face recognition technology has received significant attention in the past several years due to its potential for a wide variety of applications in both law enforcement and non-law enforcement.As compared with other biometrics systems using fingerprint/palm print and iris, face recognition has distinct advantages because of its non-contact process. Face images can be captured from a distance without touching the person being identified, and the identification does not require interacting with the person. In addition, face recognition serves the crime deterrent purpose because face images that have been recorded and archived can later help to identify a person. But consider the case of face recognition of a Hormone Replacement Theraphy (HRT) transformed person. Through HRT one can transform his/her gender known as Gender Transformation. Gender transformation occurs by down selecting the natural sex hormone of a person in replacement for its opposite. This is known medically as hormone replacement therapy; however, more broadly this can be described as hormone alteration or medical alteration. Hormone replacement therapy (HRT) is any form of hormone therapy wherein the patient, in the course of medical treatment, receives hormones, either to supplement a lack of naturally occurring hormones, or to substitute other hormones for naturally occurring hormones. Common forms of hormone replacement therapy include:Hormone replacement therapy for menopause ,Hormone replacement therapy for transgender people ,Androgen replacement therapy .By gender transformation , a male gets converted to female and vice versa.

But it is not a single step procedure but it takes years of medical treatment. Transgender persons do not undergo HRT for the purpose of biometric obfuscation, however, the question that still remains is, "will someone use HRT for the purpose of masking or creating a new identity?". If so ,then can the face recognition systems identify the original identity of the gender transformed person. If a person got banned in a particular country due to any reasons, through HRT he can change his gender and become another one, and could get access to the same country. Thus he is masking or creating a new identity. This is a serious security issue. So this study deals with identifying whether a person is gender transformed or not.

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The problem of face recognition across gender transformation is unique and different from other medical alterations such as plastic surgery. Although, it seems that both HRT and plastic surgery introduces texture and shape variations to the face, the facial changes that are introduced by these two are in contrast with each other owing to their significant difference. Facial shape changes due to plastic surgery can be introduced to the face components such as forehead, eyelid, nose, chin, lip and ears. These face components are either reshaped or restructured through surgical procedures causing an overall shape change to the face and local texture changes around the face component. It is to be noted that HRT introduces wrinkles and lines in the skin in contrast to the plastic surgery, which tries to, removes them. Individuals undergoing HRT may also undergo surgical procedures for changes in their facial appearance, thus rendering the problem of face recognition across HRT to be unique and much difficult than individuals undergoing surgical procedures only. Eye region undergoes significant changes in plastic surgery. This is in contrast with the assumption that the periocular region is invariant to changes due to HRT . So can the periocular region be an ideal biometric trait for face recognition across gender transformation. So this study analyses the effectiveness of using periocular region as a trait for face recognition across gender transformation while comparing with other face components.

II.LITERATURE SURVEY

1. Face Recognition After Plastic Surgery

It has been observed that many face recognition algorithms fail to recognize faces after plastic surgery, which thus poses a new challenge to automatic face recognition. This paper gives a comprehensive study on Face Recognition After Plastic Surgery (FRAPS), with careful analysis of the effects of plastic surgery on face appearance and its challenges to face recognition. Then, to address FRAPS problem, an ensemble of Gabor Patch classifiers via Rank-Order list Fusion (GPROF) is proposed, inspired by the assumption of the interior consistency of face components in terms of identity. On the face database of plastic surgery, GPROF achieves much higher face identification rate than the best known results in the literature. To address this problem, a partial matching based plastic surgery detection algorithm is proposed, aiming to detect four distinct types of surgery, i.e., the eyelid surgery, nose surgery, forehead surgery and face lift surgery.

Plastic Surgery Detection Method :

The framework of GPROF is shown in Fig. 1, in which the main steps are described as follows [2]:

1. Localize the eye centers, align the face and normalize it to 64 × 80 pixels.
2. Illumination preprocess with local normalization
3. Divide the face into 2 × 4 patches of equal size. In this study, the size of each patch is 16 × 20 pixels without overlapping.
4. For each patch, extract Gabor magnitude features in five scale and eight orientations at each face image pixel, and use PCA and LDA to project the original Gabor features into a low-dimension discriminative subspace. Each patch is finally represented by a normalized feature vector of equal dimension.

2. Plastic Surgery Face Recognition Using Multimodal Biometric Features

This paper proposes a new Multimodal Biometric approach using principle component analysis and local binary pattern feature extraction algorithm cascaded with periocular feature for plastic surgery invariant face recognition. The method is capable of extracting shape as well as texture features and improve the recognition rate using periocular biometric. It makes the use of different features from face and periocular region to match face images before and after plastic surgery. The block diagram of proposed method is shown in Fig. 2.

Feature is extracted from both face and periocular region with the help of local binary pattern and then dimension reduction is done with the help of PCA. Then for classification Euclidian distance is used. If face is not match, then periocular biometric is performed for face recognition under plastic surgery. The flowchart contains the following steps: Data Collection, Pre-processing, Feature Extraction, Classification, and Periocular biometric.

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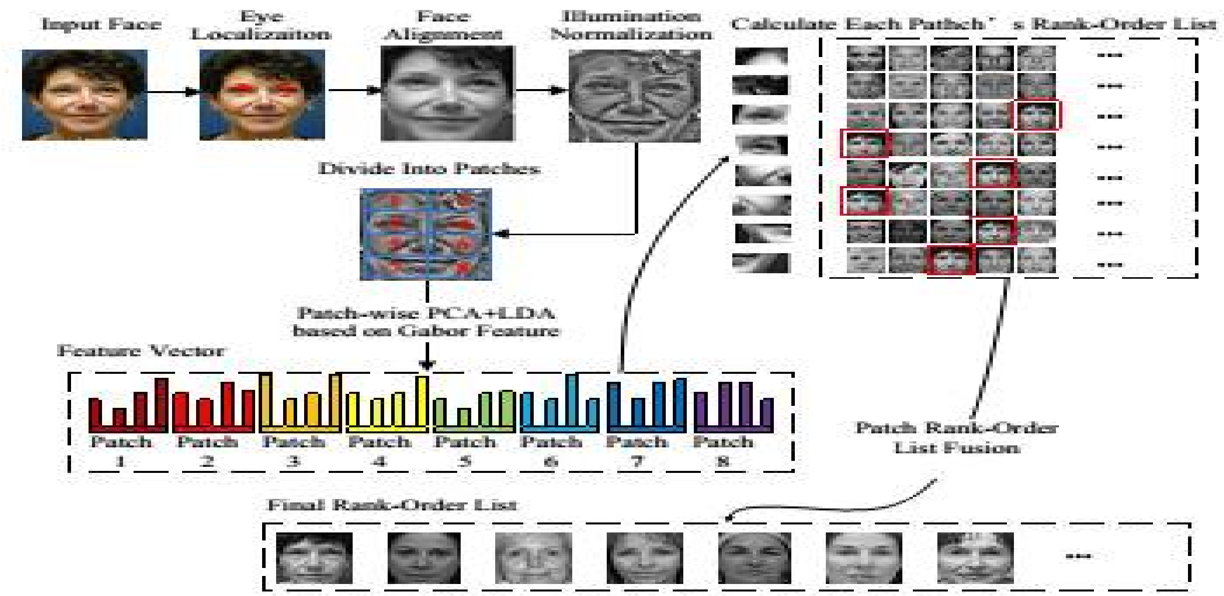

Fig 1: Frame work of proposed GPROF

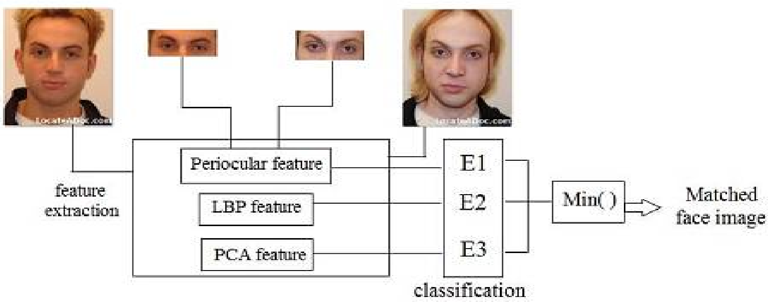

Fig 2: Block diagram of Multimodal biometric method

3. Eye region more reliable than the face :

The primary work of face recognition of gender transformed was done for first by G. Mahalingam and K. Ricanek, Jr in 2013. This work introduces a truly novel and extremely unique biometric problem: face-based recognition for transgender persons. A transgender person is someone who under goes a gender transformation via hormone replacement therapy; that is, a male becomes a female by suppressing natural testosterone production and exogenously increasing estrogen. Transgender hormone replacement therapy causes physical changes in the body and face. The performance of the full-facematchers are compared with that of the periocular region for the same feature sets. The results indicate that periocular recognition out performs the full face on the transgenderdataset under real world conditions .

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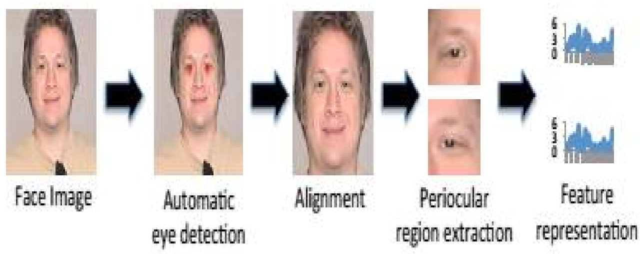
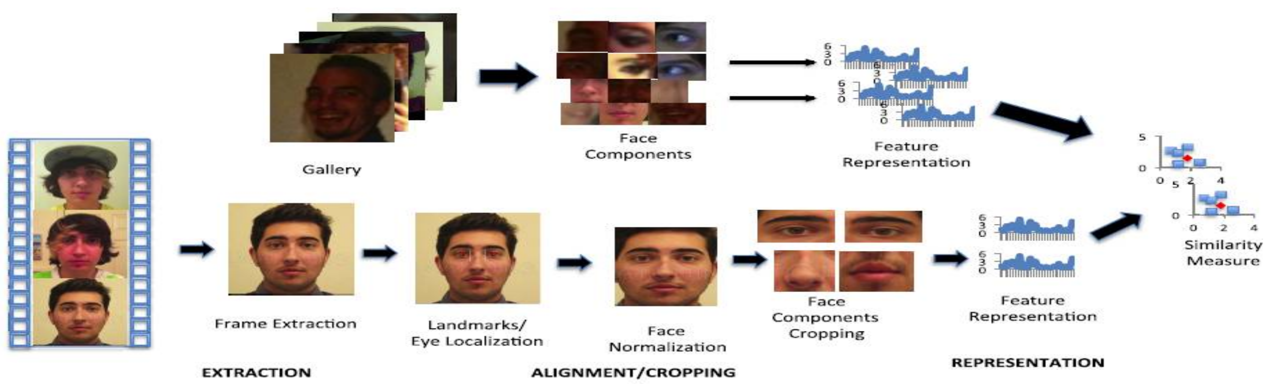


Fig 3: Frame work of periocular region extraction and representation

4 . Descriptor Based Methods in the Wild .
This paper focus our attention to relevant face recognition algorithms and techniques.
LBP (Local Binary Pattern)
The LBP feature vector, in its simplest form, is created in the following manner: Divide the examined window into cells (e.g. 16x16 pixels for each cell).For each pixel in a cell, compare the pixel to each of its 8 neighbours (on its left-top, left-middle, left-bottom, right-top, etc.). Follow the pixels along a circle, i.e. clockwise or counter-clockwise. Where the center pixel's value is greater than the neighbour's value, write "1". Otherwise, write "0". This gives an 8-digit binary number (which is usually converted to decimal for convenience).Compute the histogram, over the cell, of the frequency of each "number" occurring (i.e., each combination of which pixels are smaller and which are greater than the center). Optionally normalize the histogram. Concatenate (normalized) histograms of all cells. This gives the feature vector for the window.

III.DESIGN AND ANALYSIS

This is the block diagram of the proposed method. Face disguise is achieved organically as hormone manipulation causes pathological changes to the body resulting in a modification of face appearance. This paper analyzes and evaluates face components versus full face algorithms in an attempt to identify regions of the face that are resilient to the HRT process. The experiments reveal that periocular face components using simple texture-based face matchers , patch-based local binary patterns out performs matching against the full face.



This paper introduces the problem of face recognition under the presence of this new covariate, gender transformation. Gender transformation occurs by down selecting the natural sex hormone of a person in replacement for its opposite. This is known medically as hormone replacement therapy; however, more broadly this can be described as hormone alteration or medical alteration. A face component based recognition framework is proposed in a hope to improve the recognition performance. The face component framework has been selected to explore regions of the face that may be

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resilient to the face alterations caused by this medical procedure. The authors hypothesize that components will out perform full face as these components may undergo significantly less changes than the sum of their parts, full face. It is to be noted that the periocular region as defined in this paper refers to the region that includes the eyes, the eyebrows, and the periorbital region (soft tissue region contained around the eye-orbit). The framework is evaluated with a transgender dataset (organized by the authors) consisting of images of 38 subjects taken under unconstrained environment across time and gender transformation eyes of an HRT transgender would demonstrate less changes than the full face. The extraction of the eyes, nose, and mouth regions from the video sequences and its representation involves the following steps:

• Extraction of frames with valid face images from the video sequences.
• Alignment and cropping of the face components by registering the face image using the eye center coordinates.
• Representation of the face components using TPLBP feature descriptor

Figure 3 shows the framework for face component extraction and representation of a face image.

A . Dataset

Dataset used in this work is known as Transgender Data set which contain the videos of about 38 subjects during their period of HRT treatment. It includes more than a million extracted face images of these subjects .

B. Frame Extraction

A protocol that utilizes standard techniques to extract face images from the video frames. The frames from the video sequences can be extracted using the mmreader/videoReader at the rate of 29.3fps, which is the standard for video sequences.

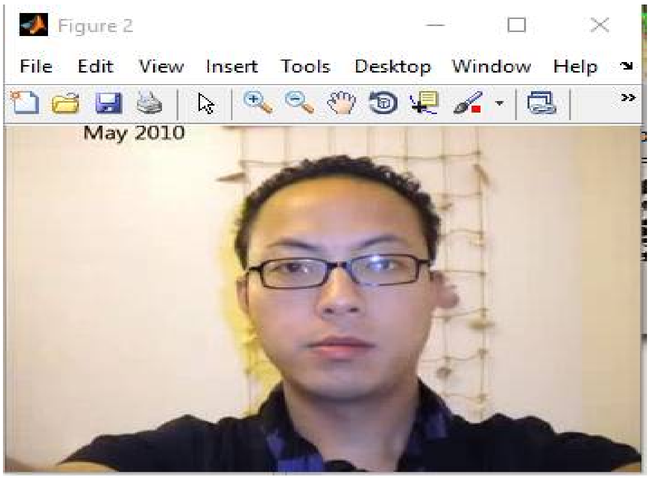

Fig 5:Frame extracted image

C. Face Detection

Viola Jones Detector: The problem to be solved is detection of faces in an image. A human can do this easily, but a computer needs precise instructions and constraints. To make the task more manageable, Viola–Jones requires full view frontal upright faces. Thus in order to be detected, the entire face must point towards the camera and should not be tilted to either side. While it seems these constraints could diminish the algorithm's utility somewhat, because the detection step is most often followed by a recognition step, in practice these limits on pose are quite acceptable . The algorithm has four stages

1.Haar Feature selection

2.Creating an integral image

3.Adaboost training

4.Cascading Classifiers

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The frames that were not detected by the face detector are discarded. It is to be noted that the face detector generates false positive-detects a face when there is not one-as well as false negatives-misses a face when it is present in the frame.

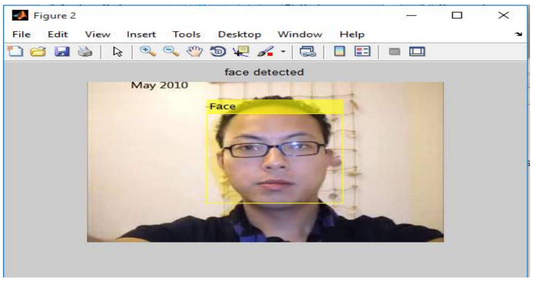

Fig 6: Face Detected image

1. Haar Features : All human faces share some similar properties. These regularities may be matched using Haar features.A few properties common to human faces:.The eye region is darker than the upper-cheeks.The nose bridge region is brighter than the eye region.The Viola-Jones face detector analyzes a given sub-window using features consisting of two or more rectangles. The different types of features are shown in Figure 7.

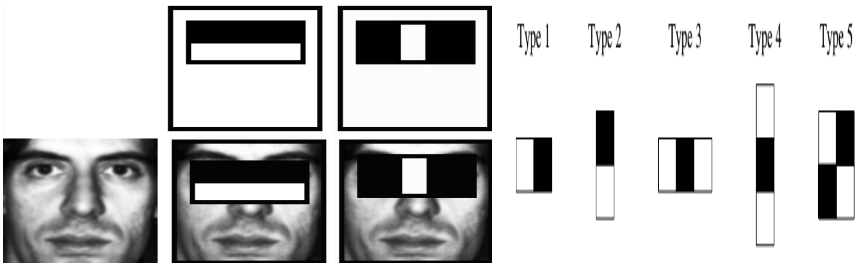

Fig 7; Haar Features

2. Integral image : The first step of the Viola-Jones face detection algorithm is to turn the input image into an integral image. This is done by making each pixel equal to the entire sum of all pixels above and to the left of the concerned pixel.

1	1	1
1	1	1
1	1	1

Input image

1	2	3
2	4	6
3	6	9

Integral image

Fig 8 : Integral Image

3. Adaboost Training : AdaBoost is a machine learning boosting algorithm capable of constructing a strong classifier through a weighted combination of weak classifiers. (A weak classifier classifies correctly in only a little bit more than half the cases.)

4. Cascaded Classifier : The basic principle of the Viola-Jones face detection algorithm is to scan the detector many times through the same image – each time with a new size. Even if an image should contain one or more faces it is obvious that an excessive large amount of the evaluated sub-windows would still be negatives (non-faces). This realization leads to a different formulation of the problem: Instead of finding faces, the algorithm should discard non-faces. The thought behind this statement is that it is faster to discard a non-face than to find a face. With this in mind a

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detector consisting of only one (strong) classifier suddenly seems inefficient since the evaluation time is constant no matter the input. Hence the need for a cascaded classifier arises. The cascaded classifier is composed of stages each containing a strong classifier. The job of each stage is to determine whether a given sub-window is definitely not a face or maybe a face. When a sub-window is classified to be a non-face by a given stage it is immediately discarded. Conversely a sub-window classified as a maybe-face is passed on to the next stage in the cascade. It follows that the more stages a given sub-window passes, the higher the chance the sub-window actually contains a face. The concept is illustrated with two stages in Figure 7.

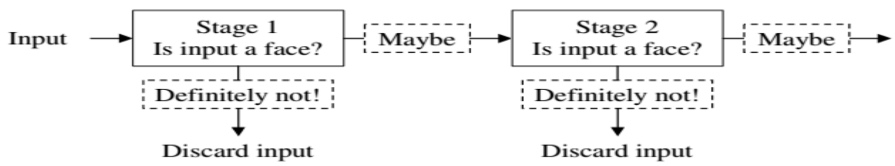

Fig 9 : Cascaded Classifier

D. Eye Detection : In order to eliminate the false positives the frames undergo a second detector; this detector is an eyedetector. The frames in which no eyes are detected are discarded during the second pass as not containing a face. This process is efficient as it offers the detection of eye-coordinates from the face images as well as detect the false positives.

Average of Synthetic Exact Filters (ASEF) [1]

Eye detection is one of the most important steps in the face-related systems such as the face recognition, gaze tracking, and eye blink detection. The various methods for eye detection have been proposed for a long time. ASEF filters differ from prior correlation filters in that the convolution theorem is exploited to greatly simplify the mapping between the input training image and the output correlation plane.

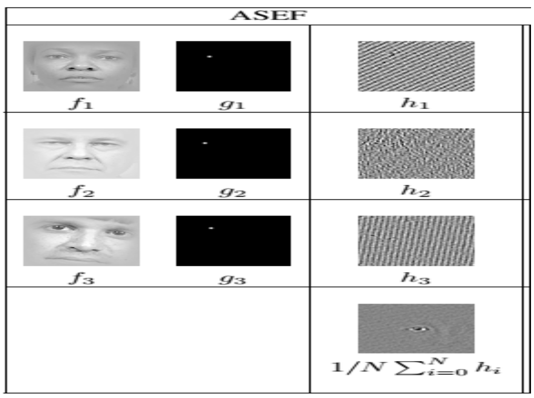

Fig 10: ASEF Filter

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In the Fourier domain the correlation operation becomes a simple element-wise multiplication, and therefore each corresponding set of Fourier coefficients can be processed independently. The resulting computations also naturally account for translational shifts in the spatial domain. As a result the entire correlation output can be specified for each training image. The first major difference between the correlation filter and ASEF filters is that ASEF filters are over constrained. Where SDF only specifies a single “synthetic correlation value” per training image, ASEF filters are trained using response images that specify a desired response at every location in each training image. This response typically is a bright peak centered on the target object of interest. One consequence of completely specifying the correlation output is a perfect balance between constraints and degrees of freedom for each training image, and therefore a complete “exact filter” is determined for every training image. Over-fitting is avoided by averaging the filters defined from each of the N training images.

E. Alignment and Cropping

The alignment of the face region is performed using the eye-center coordinates extracted by the eye detector [1]. The alignment and cropping of the face components are achieved by means of geometric normalization. The coordinates of the eye centers are used to scale, rotate, and crop the face to a set size. These geometric transformation are performed such that the centers of the eyes are horizontally aligned and placed on standard pixel locations thereby maintaining a pseudo fix interocular distance. Once the face image is aligned the components of the face can be obtained by defining a cropping boundary using the standard eye center locations. Cropping of the left and right periocular region is accomplished by defining a cropping boundary around each eye center. Consider the face on an xy-plane. The bounding box is created by fixing a ratio of distance for the height and width of the eyes from the eye center coordinates. The nose and mouth region are defined by a cropping boundary whose width is the distance between the two eye centers and the height being 60 pixels. The height of the nose is measured from the horizontal line that connects the two eye centers and the height of the mouth is measured from the height of the nose. The extracted face component images are then resized to 64×64 pixels.

F. Feature Representation using TPLBP

The aligned and cropped periocular images are represented individually using the Three-Patch Local Binary Patterns (TPLBP). TPLBP is apatch-based feature descriptor that extracts features from local patches around a central patch. The descriptor from each patch is concatenated to form one global descriptor for the entire image.

Three-Patch LBP Codes

Three-Patch LBP (TPLBP) codes are produced by comparing the values of three patches to produce a single bit value in the code assigned to each pixel. For each pixel in the image, we consider a w × w patch centered on the pixel and S additional patches distributed uniformly in a ring of radius r around it . For a parameter α, we take pairs of patches, α patches apart along the circle, and compare their values with those of the central patch. The value of a single bit is set according to which of the two patches is more similar to the central patch. The resulting code has S bits per pixel. Specifically, we produce the Three-Patch LBP by applying the following formula to each pixel.

$$TPLBP_{r,,S,w,\alpha}(\mathrm{p}) = \sum_{i=1}^{S} f\left(d(C_i, C_P\ )\right) - \mathrm{d}(C_{i+\alpha \mod S}, C_{P\ ,}))2^i$$

where C_i and $C_{i+\alpha \mod S}$ are two patches along the ring and $C_{P\ ,}$ is the central patch. The function d(.,.)is any distance function between two patches (e.g., L2 norm of their graylevel differences) and f is defined as

$$f(x) = \begin{cases} 1, & x \geq \tau \\ 0 & , x \leq \tau \end{cases}$$

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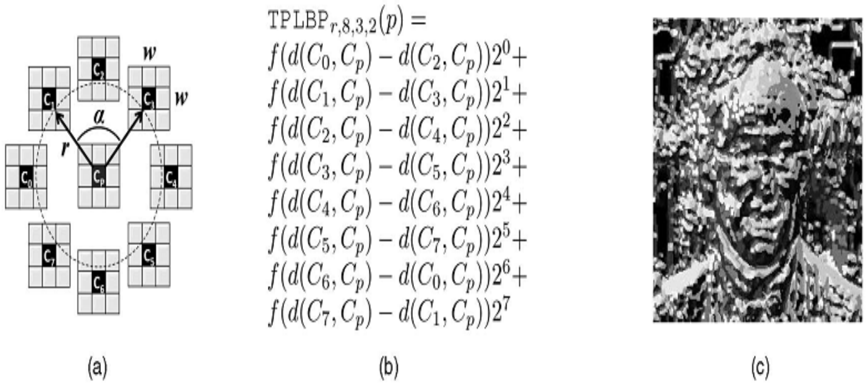

Fig.11. (a) Three-Patch LBP code with α = 2 and S= 8. (b) TPLBP code computed with parameters S=8, w =3, and α =2. (c) Code image produced

We use a value τ slightly larger than zero (e.g. 0:01) to provide some stability in uniform regions. As patches along the ring may not align with integer pixel coordinates, we use nearest neighbour sampling to obtain their pixels instead of interpolating their values. This speeds up processing with little or no effect on performance.

G. Similarity Measurements

Similarity is the measure of how much alike two objects are.similarity in datamining is usually described as a distance with dimensions representing features of objects.if the distance is small,it will be high degree of similarity whereas large distance will be low degree of similarity .simliarity is measured in range 0 to 1 [0,1].

Two main considerations about similarity

Similarity =1 if x=y

Similarity =0,if x≠y , x and y are objects.

The similarity between two feature vectors is measured as the Euclidean distance between two feature vectors.

Euclidean Distance :Euclidean distance is the most common use of distance.In most cases when people said about distance, they will refer to Euclidean distance. it is also known as simply distance. when data is dense or continuous, this is the best proximity measure. The Euclidean distance between two points is the length of path connecting them .the distance between two points is given by pythagorean theorem

Euclidean distance ε between two vectors x and y is

$$\varepsilon = \sqrt{\sum_{i=1}^{k}}(x_i - y_i)^2$$

H. Verification

For the task of verification, two images are considered to be from the same subject if the Euclidean distance between their feature vectors is below a threshold a set value. The normalized Euclidean distance is converted to a similarity score by simply subtracting the distance from one. Threshold is choosen by trail and error method.

Input the video which are both gender transformed and orginal .For each input video similarity scores is calculated for left eye,rieght eye, fusion of eyes, nose and mouth. By analyzing the scores ,a threshold is choosen properly such that if similarity score is below the threshold ,it will be an original video. Otherwise it will be considered as gender transformed.

Equal error rate = $\frac{FAR}{FRR}$

FAR (False Acceptance Rate) = No .of samples correctly detected / Total no of samples

FRR (False Rejection Rate) = No. of samples wrongly detected / Total no of samples.

EER for both periocular region, left eye, right eye, nose and mouth are calculated.

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IV. SIMULATION & RESULTS

For verification , a lot of videos from the confidential transgender dataset are taken in to study. They include both gender transformed as well as original. From the videos frames are extracted ,from which face is first detected followed by eye detection. Later feature extraction is done followed by comparing with the features of database to decide whether it is gender transformed or not .EER is found out to check effectiveness of periocular region.

Region	No of correct detection	No of wrong detection	EER
Left eye	12	8	0.662
Right eye	11	9	0.818
Nose & mouth	13	7	0.538
Periocular	17	3	0.176

Fig 12:Simulation Result

V. CONCLUSION

This Project work point outs the fact that periocular region is the region undergoing less changes even after HRT.The motivation behind this work is to demonstrate the reliability and robustness of the periocular region based representation in automated face recognition on subjects undergoing gender transformation using hormone replacement therapy. The potential of the periocular region is studied through various recognition and verification experiments on a challenging dataset and performance comparisons with other face components like nose, mouth, right eye ,left eye .Indeed, face recognition accuracies of the proposed periocular region based representation greatly exceed the accuracies obtained using the other face components. In addition, more precise approach for the periocular region alignment extends the possibility of improving the recognition accuracy of a recognition system.

Further this work crystalizes the problem of HRT based medial treatment on the face, illustrating that the impacts of this treatment fundamentally disrupts face recognition engines. Some enterprising spoofer could self medicate with hormone drugs to fool a facerecognition systems whether for access control or to gain entry to a foreign country. This work is a solution to such problem. Experiments proves the fact that EER is less for periocular region rather than other face components. Hence it is better than all other face components as a biometric trait for face verification.

In conclusion, this project work demonstrated the effectiveness of the periocular region as a useful biometric trait for the unique scenario of recognizing individuals across gender transformations, and in future possibly across other medical alterations. The periocular may be a viable replacement for full face matchers under the right circumstances.

In future ,we can improve the accuracy of proposed method by using SVM classifiers and HOG descriptor instead of the descriptors used here. We can also use KLT algorithm instead of viola jones detector .So by this project , masking of identity or creating new identity to fool recognition or security systems can be avoided .

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