Application of IRIS Scan to Improve the Accuracy of Existing Face Recognition System using Computer Vision and Machine Learning

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Abstract: **This paper presents the application of iris scan to improve the accuracy of existing face recognition system using computer vision and machine learning. The motivation of this research work was initiated with the desire to address the problems identified in the current trend (face recognition system) after an exhaustive literature review of some existing works relating to human vision technology. Success and limitations were noted of which we single out the major setback of the existing system (inability to recognize identical twin, caricature faces and faces with plastic surgery). The main aim is to present a novel literature that improves the result of existing face recognition system using a new approach (iris scan). The new face recognition process includes face detection, iris localization, histogram equalization, edge detection, normalization, feature extraction among other image processing techniques, training, classification and label. Some existing works will be reviewed and analyzed. The new system will be implemented using image acquisition tool, image processing tool, computer vision tool and mathlab. The implementation and result will be tested and result recorded.**

Keywords: **face detection, computer vision, training, classification. Feature extraction, iris scan.**

I. INTRODUCTION

Since the early years of the 21st century, we find ourselves continually moving further away from the necessity of physical human interaction playing a major part of our everyday tasks [1]. Striding ever closer to an automated society, we interact more frequently with mechanical agents, anonymous users and the electronic information sources of the internet, than with our human counterparts [1]. It is therefore perhaps ironic that identity has become such an important issue.

Recently, Biometric identification systems became available to allow recognition and verification of "true" individual identity through biological and physiological features such as fingerprints, palm, DNA, voice patterns, irises, hand measurements and facial patterns [2]. Among these aforementioned biological characteristic features, the human face (face recognition) has been described as the "Holy Grail" of biometric identification systems, due to a number of significant advantages over other methods of identification. To mention a few, face recognition is one of the few biometric methods that possess the merits of both high accuracy and low intrusiveness [3]. It has the accuracy of a physiological approach without being intrusive. For this reason, since the early 70's [3] face recognition has drawn the attention of researchers in fields from security, psychology, image processing, computer vision among others. However this technology, despite the exhaustive research works on it so far, has not been fully perfected in terms of recognition precision.

Today, face recognition is the only area of computer vision, image processing and pattern recognition with more than a decade history of challenged problems and independent critical evaluations. These challenged problems have provided the face recognition research community with a large corpus of data for algorithm and research development. Periodic evaluations have been conducted according to [4], to measure progress in the performance of these algorithms, and result shows that as face recognition technology has matured, so has the sophistication of the challenged problems. The major problem yet to be solved despite these series of research works has been to differentiate identical twin and caricatured faces.

The early attempts to solve this problem employed gray level images scale with unknown face sizes. View-based detectors are popular in this category, including Rowley's neural networks classifier [5], Sung and Poggio's correlation templates matching scheme based on image invariants [6], Eigen-face decomposition and Model based techniques, however, despite the huge success recorded, there is still an ongoing research in this field to make facial recognition system faster and accurate. Though face recognition is considered to be a very crucial authentication system, there is still need to produce a truly robust and efficient system that can produce good results in real time and under any condition.

To solve this problem, our research investigation shows that no video images of one or both of the irises of an individual's eyes, whose complex patterns are unique [7]. The iris has the great mathematical advantage that its pattern variability among different persons is enormous, being part of the human face [8]. [8] also demonstrated this effect using the integro-differential operator algorithm for iris recognition systems. This research work provides a new applicable dimension to this trend, implementing it (iris scan) to face recognition system with Mathlab as the implementation tool.

Objectives of the Study

i. To develop a system that improves the existing system methods of face recognition using iris scan.
ii. To develop a system that employs machine learning for training and classification of extracted features.
iii. To detect, recognize and track facial features using computer vision technology
iv. To design a system that will compare and match a query image with the real image.
v. To develop a system that match a caricatured face with its original facial image

II. LITERATURE REVIEW

In 2011, [9] researched on Real Time Robust Embedded Face Detection Using High Level Description. Their techniques, achieve good performance in terms of detection, but are not suited for real time application systems. The work has a recognition accuracy of (90%). [2] Researched on the Implementation of Daugman's algorithm and adaptive noise filtering technique for digital recognition of identical twin using mathlab, achieving a very high recognition rate which was not specified. [10] Worked on a study of face recognition of identical twins by human. However, their work recorded 78.825% accuracy. [11] Researched on geometric approach for face recognition and revealed that the problem of face recognition is as a result of the difference in human pose, face expression, hairstyle, image style and lighting conditions. In 2002, Yang et al. researched on the detection of faces in images. Their study buttressed face detection approaches into four major categories: Knowledge-based, Feature invariant, Template matching and Appearance-based approaches. They singled out Knowledge-based approaches based on a set of rules such as human knowledge to detect faces. But their work does not specify any approach that will solve the problem of face recognition with precision. [12] Researched on the Study & Analysis of Different Face Detection Techniques. In this research they studied and compared some of the existing approach on face recognition. They conclude that to evaluate the performance of face detectors, various metrics must be employed e.g., learning time, execution time, the number of samples required in training, and the ratio between the detection rate and the false alarm. However their work does not specify any method that will solve the problem of face recognition with precision for instance recognizing identical twin.

III. METHODOLOGY

The methodologies employed for the system development will be discussed below:

Face Detection

This is a computer vision application that employs camshift algorithm to track and detect the query image from a video stream. It refers to a subset of computer technology that is able to identify people's faces within digital images. The implementation will be done employing image acquisition tool and camshift algorithm in mathlab.

Iris Localization

After the face has been detected, the eye (iris and pupil) which is an important part of this research work has to be captured respectively. This process involves the accurate detection of the iris and pupil features using the integro-differential operator as follows [8]:

$$\text{Max}(r; x1; y1)\ \left(G\sigma(r) * \frac{\partial}{\partial \mathbf{r}} \oint_{r,xo,yo} \frac{I(x,y)}{2\pi r} \mathbf{ds}\right) \ldots\text{.i}$$

I(x, y) is the intensity of the pixel at coordinates (x, y) in the query iris image [2]. r represents the radius of various circular regions with the center coordinates at (x1, y1). σ is the standard deviation of the Gaussian distribution. Gσ (r) represents a Gaussian filter of scale sigma (σ). (x1, y1) is the assumed centre coordinates of the iris and s is the contour of the circle given by the parameters (r, x1, y1). This process blurred the iris image at a scale set by **σ**, which searches iteratively for a maximum contour integral derivative with increasing radius at successively finer scales of analysis through the three parameter space of center coordinates and radius (x1; y1; r) defining a path of contour integration[13]. To implement this process computer vision tool will be used.

Histogram equalization

This is a preliminary filtration process employed for the captured face image background processing. It is a step employed to prepare the query image for further image processing by filtering off the background noise before recognition process is implemented.

Edge Detection

Edge detection is an image processing techniques that examines the local discontinuity at each pixel element in the facial image amplitude, orientation, and location of a particular subarea in the query image. This method simplifies and minimizes the image data to be processed and detects the boundary between two homogeneous regions between various facial features in a sketching format.

Image Normalization

Once the face and its features are segmented, the next stage is to normalize these face parts, to enable generation of general facial analysis through feature extraction. The normalization process help achieve constant illumination in the facial image.

Face feature extraction

According to [4] this is the dimensionality reduction that represents the discriminative part of the image in a compact feature vector. This is implemented with mathlab using the histogram of oriented gradient technique to extract the training and label features in a given query image.

The Iris Scan with Gabor wavelet

2D Gabor wavelet algorithm is adopted according to [8] extracting iris information by projecting the area of a given iris image into a complex 2D Gabor wavelets. The algorithm segments the iris image into quadrants and extracts each phase information using the equation according to [8].

$$H\{ra, rt\} = asq\{ra, rt\} \int_p \int_{\phi} e^{-vw(\emptyset - \theta)} e^{(-r-p)^2/\alpha^2} e^{(r0;\ y0)} * \frac{(r0;\ y0)}{B^2 I}(p, \phi) p dp d\emptyset \geq 0 \quad \ldots\ldots ii$$

From the equation H{ra, rt}; can be regarded as a complex-valued bit whose real and imaginary parts are either 1 or 0 (asq) depending on the sign of the 2D integral; $I(\emptyset, \theta)$ is the query iris image in a dimensionless polar coordinate system that is size- and translation-invariant, and which also corrects for pupil dilation; α and β are the multi-scale 2D wavelet size parameters, spanning an 8-fold range from 0.15mm to 1.2 mm on the iris; w is wavelet frequency, spanning 3 octaves in inverse proportion to β; and (r0; y0) represent the polar coordinates of each region of iris for which the phasor coordinates H{ra, rt} are computed, according to [8].

Classification (Euclidean and Spearman distance)

For the training and classification of the statistical extracted features, we employ a supervised machine learning technique called the k-nearest neighbor classifiers. It is a simple algorithm and a non parametric method that classifies data based on similarity measures such as distance metrics which are defined by the standard Euclidean distance [3] and spearman's correlation [13].

Given a number of columns of x to be less than 10 the equidistance is calculated and the label is predicted as shown in equation (i). However, if the number of x is more than 10, the Exhaustive Searcher model is employed, this model considers the spearman distance function for classification (see equation iii). Given an *m1*-by-*n* data matrix X, which is treated as *m1* (1-by-*n*) row vectors $x_1, x_{2\ldots\ldots}, \ldots, x_{m1}$, and *m2*-by-*n* data matrix Y, which is treated as *m2* (1-by-*n*) row vectors $y_1, y_2, \ldots, y_{m2}$, the various distances between the vector x_s and y_t are defined as follows [14]:

Euclidean distance:

$$d_{st}^2 = (xs - yt)(xs - yt) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots iii$$

Standardized Euclidean distance:

$$d_{st}^2 = (xs - yt)V - 1(xs - yt) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots iv$$

Where V is the m-by-*n* diagonal matrix whose *j* the diagonal element is $S(j)^2$, where S is the vector containing the inverse weights.

Spearman distance

$$D_S = 1 - \frac{(r_s - \bar{r}_s)\ (r_t - \bar{r}_t)'}{\sqrt{(r_s - \bar{r}_s)\ (r_t - \bar{r}_t)'}\ \sqrt{(r_s - \bar{r}_s)\ (r_t - \bar{r}_t)'}} \ldots.v$$

Where:

r_{sj} is the rank of x_{sj} taken over $x_{1j}, x_{2j}, \ldots x_{mx,j}$.

r_{tj} is the rank of y_{tj} taken over $y_{1j}, y_{2j}, \ldots y_{my,j}$,

r_s and r_t are the coordinate-wise rank vectors of x_s and y_t, i.e., $r_s = (r_{s1}, r_{s2}, \ldots r_{sn})$ and $r_t = (r_{t1}, r_{t2}, \ldots r_{tn})$.

$$\bar{r}_S = \frac{1}{n} \sum_{rsj} = \frac{(n+1)}{2}$$

$$\bar{r}_S = \frac{1}{n} \sum_{rtj} = \frac{(n+1)}{2}$$

Prediction of Label (Result)

For the prediction of the classified label: the mathematics function below is employed as in [14].

$$q = \underset{q=1,,,,,k}{\arg\min} \sum_{k=1}^{k} T\left(\frac{k}{x}\right) C\left(\frac{q}{k}\right) \ldots\ldots\ldots\ldots vi$$

Where: q is the predicted classification.

k is the number of classes.

$T\left(\frac{k}{x}\right)$ is the posterior probability of class *k* for observation *x*.

$C\left(\frac{q}{k}\right)$ is the cost of classifying an observation as *y* when its true class is *k*

Implementing the function given a set *x* of *n* points and a distance in equation (iii) and (iv) or (v) respectively, k nearest neighbor (K-NN) search finds the (k) closest points in *x* to a query point or set of points y or s and t as in spearman distance equation.

Implementation Result

The figures below are employed to model the implementation result of the new face recognition system. Figure 1 is the face detection model from the query image, while computer vision is employed to locate facial features especially the eye (see figure 2) for iris scan. The facial features are further processed employing other image processing techniques such as edge detection process. The feature extraction and iris scan completes the image processing circle. A supervised machine learning algorithm is employed as shown in the process chart to train and classify the features employing eclidean or spearman distance algorithm depending on the size of the dataset images. And the final result is presented in figure 5 as the label.

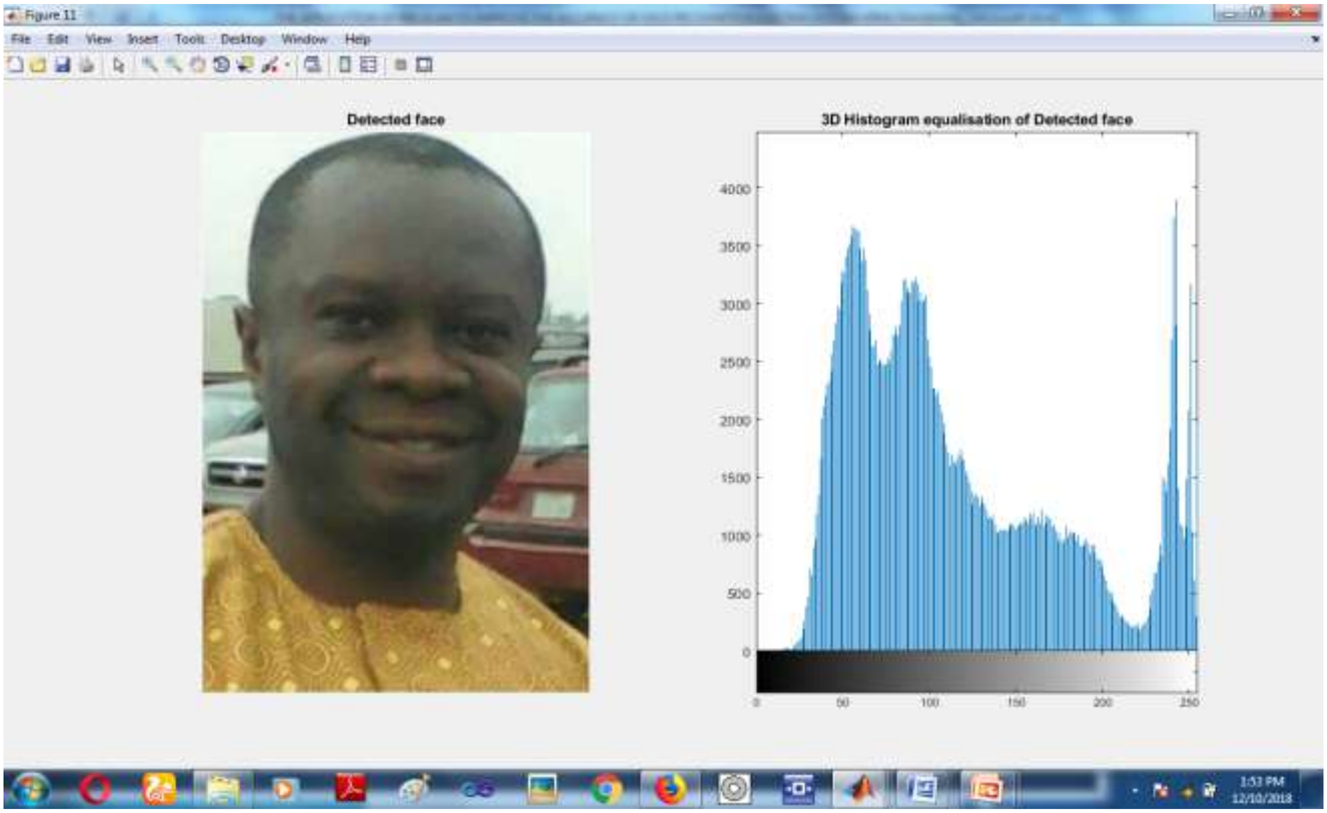

Figure 1: face detection model with background processing

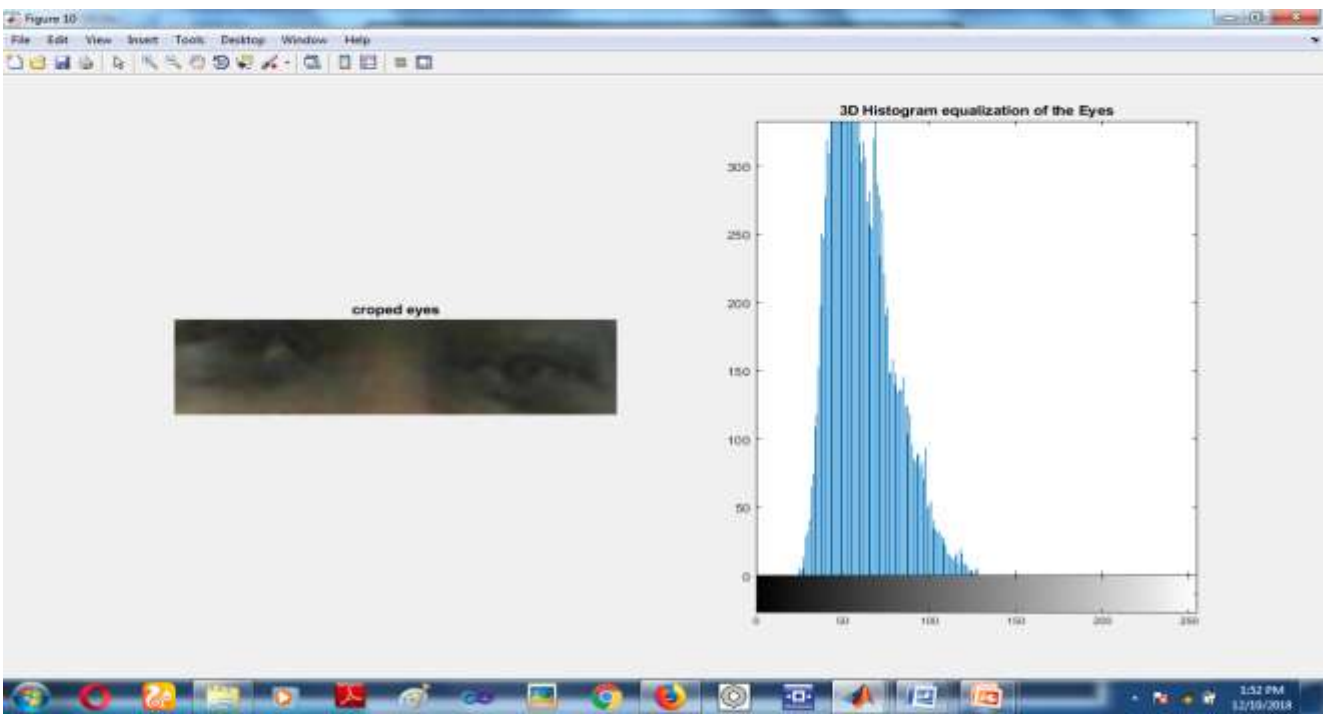

Figure 2: Iris localization with background filtration

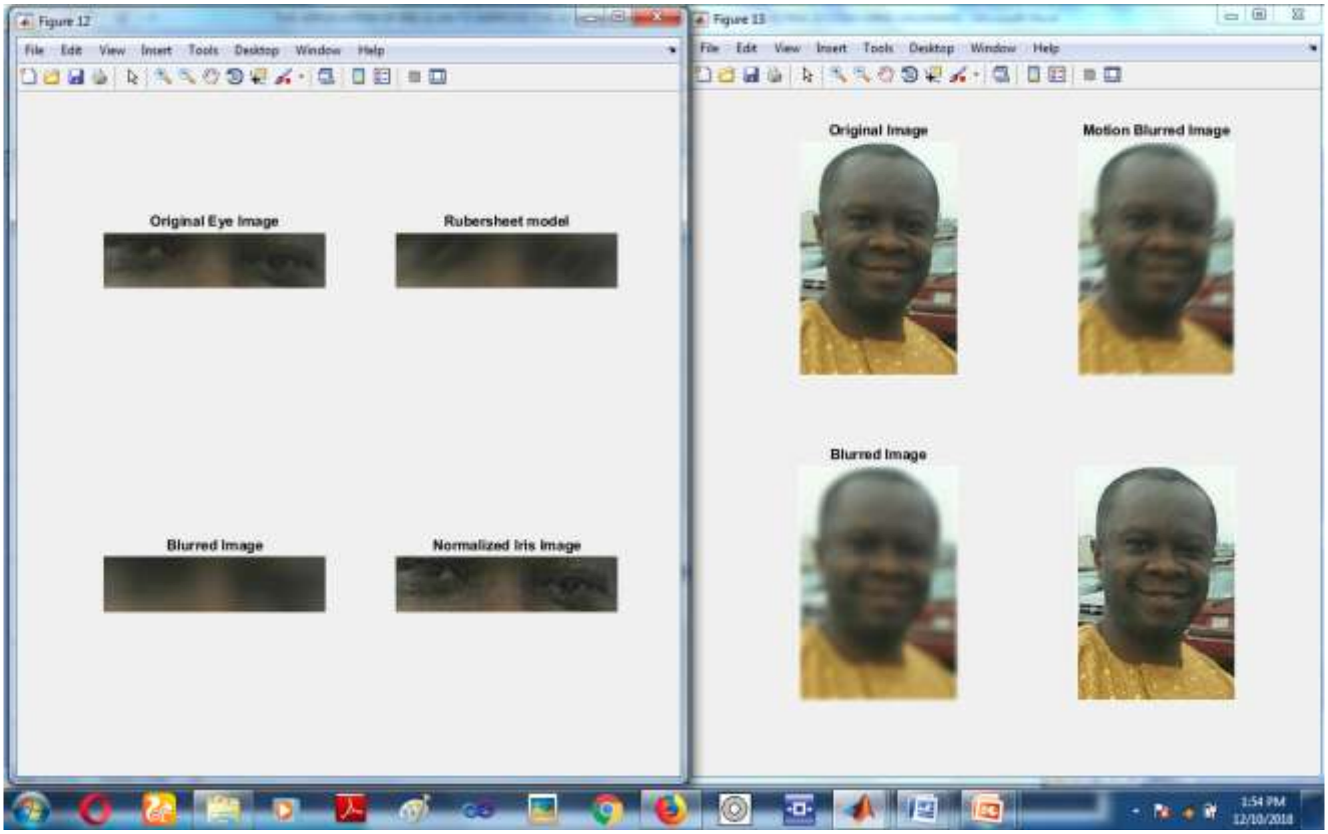

Figure 3: complete iris and face image filtration with normalization

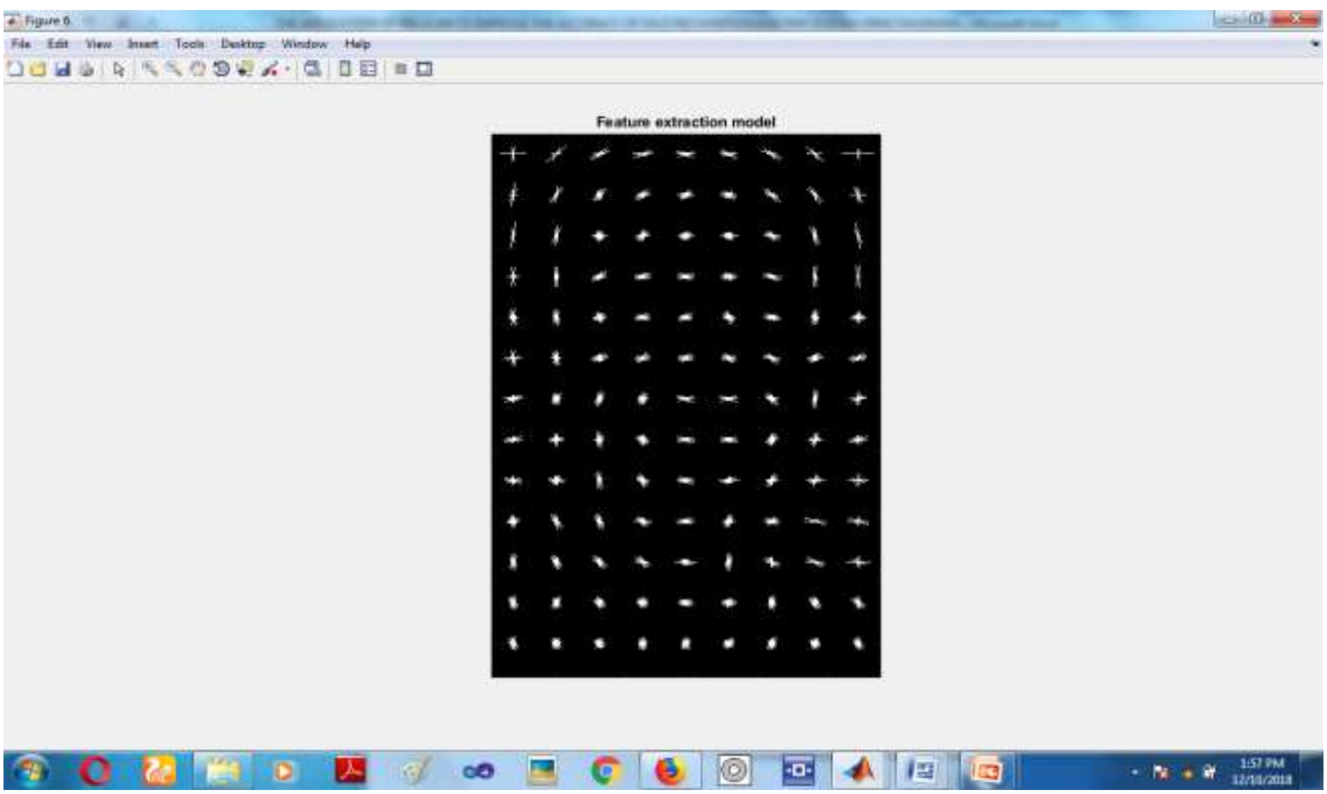

Figure 4: feature extraction model of the query image

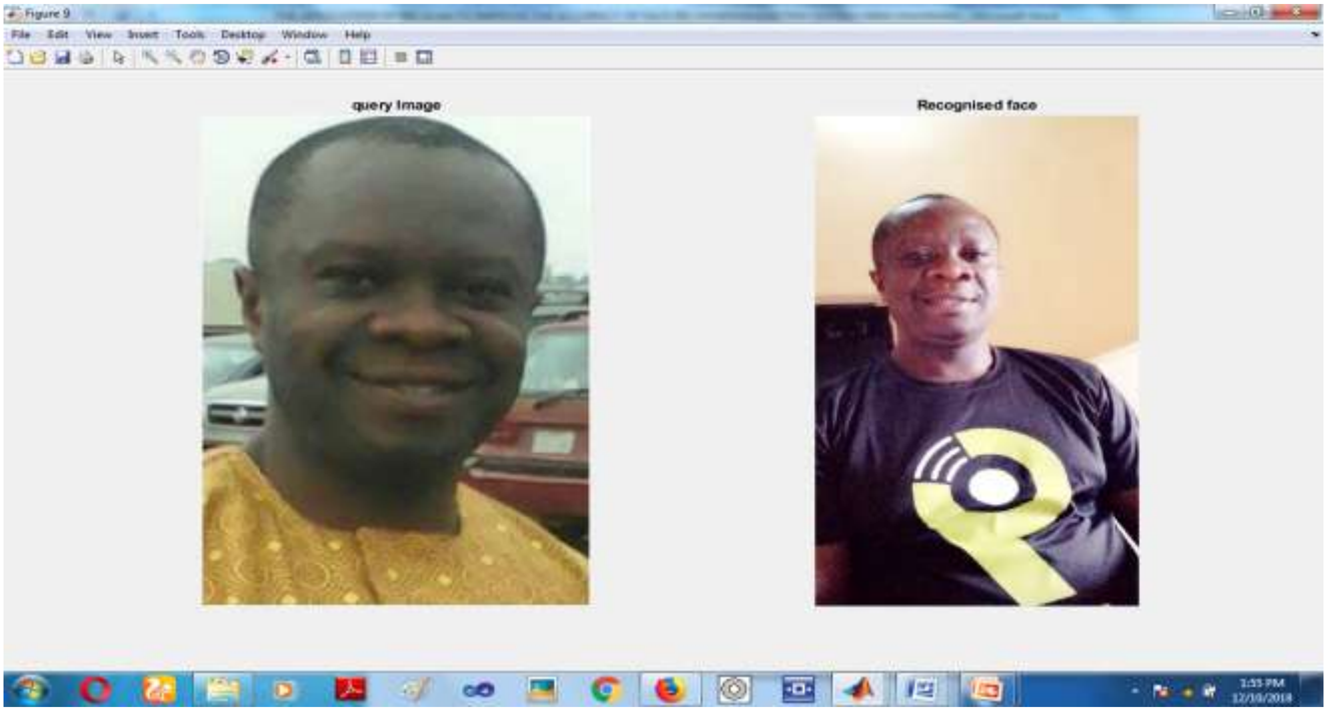

Figure 5: recognition result

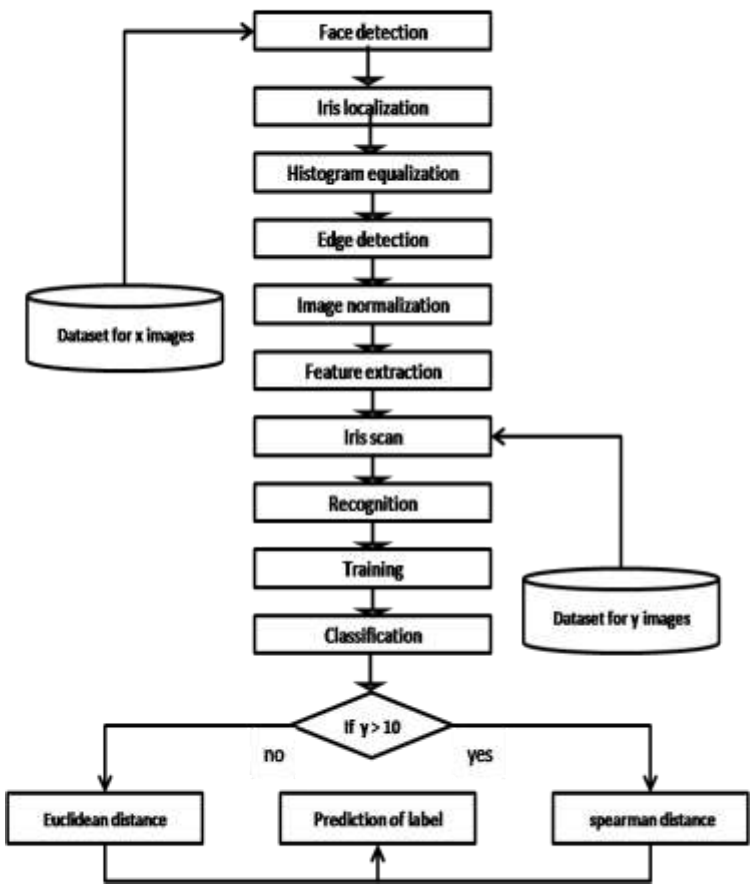

Figure 6: Process flow chart

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