# A TRAILBLAZING MODUS OPERANDI TO FACE IDENTIFICATION USING A RECKONING ARCHETYPAL PRINCIPAL COMPONENT ANALYSIS

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***Abstract***

Face identification is a task of designating human faces with exact names, akin to identifying between similar twins. The work was motivated and is imbibed by physiology and information theory domains. The approach treats the face identification of intrinsically 2-D face images. The system has a very resilient pre-processing method. The system then functions by projecting the face images as 'eigen faces'. The identification is done by principal component analysis (PCA). The implementation is done in Matlab. 213 images from JAFFE database was taken for testing the method. The system has proved good by yielding 87% identification rate.

***Keyword:*** Face identification; Canny-edge detector; Eigen image; Principal Component analysis.

## 1. Introduction

Face is the primary focus of social interaction, which conveys the identity and affect. Humans are capable of recognizing faces of any number seen through out their lifetime. The skill is highly individual centric, even with major changes such as viewing environments, visual power, ageing and distractions such as hair style and glasses. Bringing this ability into the machine or building a computational model paved way to a new arena of research called 'face identification'.

Machine models of face identification are very interesting as it does not provide only theoretical insight but has many practical applications. Upcoming research areas are human computer interaction, surveillance systems and object identification from still and video images for which the base is face identification. Making a face identification system is quite difficult because face data is complex, has many attributes, more visual percepts with meaning. It can't be constrained into any Artificial intelligence problem because the data set can have vast differentiations and dimensions.

This paper focuses on the glitch of extracting syntax attribute of a face i.e., only face identification. The technique comprehends on statistical representation using Eigen faces and a mathematical model for identification, Principal Component Analysis. The methodology of the work tries to build a system without detailed geometry, but system would score in terms of speed, simplicity, accuracy and insensitive to small changes in the facial image.

The paper is novel in the following ways: First, it does not follow the traditional method of matching complete faces for the identification task rather it uses a skeletal framework of face edges to match, Second, this method proves to be one of its kind as it is novel in the terms only the system can perform this matching process and not human eyes, it has cut through the literature that humans are the best recognizers. Directly from the database humans will not be able to identify, Third, the major issue is storage when it comes to images, the images trained are dealt with utmost care and the edge-etched images are only stored which uses only one fourth of the space that a normal storage would occupy. Fourth, the combination of Eigen faces a statistical method on machine learning PCA has adopted well for the work, which has shown less error rates. Fifth, the exemplary line, does not perform a mere face recognition because the dataset used has more than one face of the same person, so it has to exactly identifies the face image exactly.

## 2. Background and Related Work

Most of the exertion in computer identification of faces has concerted on detecting particular feature outline such as eyes, nose, mouth, and head. A face model was expressed by the position, size, and associations among these features. These methodologies have evidenced to be arduous to extend, and is quite insubstantial, requiring an initial guess to start with. Research in human face identification, has shown that individual features is an inadequate representation to account for the performance of identification [1](1977).

Bledsoe [2](1966) was the first to endeavor semi automated face identification with hybrid human-computer interface that classified faces on the footing of marks entered on photographs manually. The basic measurements for the classification were normalized distances and ratios among different spots such as eye corners, mouth corners, nose tip, and chin point. Later work at Bell Labs [3,4](1971) came out with a vector approach of 21 distinctive features, and identified faces using classical pattern classification techniques. The chosen features were principally subjective evaluations, (e.g., shade of hair, length of ears, lip thickness) made by human subjects, every feature of it would be quite tuff to automate. A paper by Fischler and Elschlager [5](1973) strove to measure such similar features predictably. They described a linear embedding algorithm that used both local feature and global measure to gauge facial features. This template matching local feature approach was continued and improvised by the Yuille, Cohen and Hallinan [6](1989). "Deformable templates", is the parameterized method in which the parameter values are computed by interactions with the image. Kohonen [7](1989) and kohonen and lahtio [8](1981) embodied an associative network with a simple learning algorithm that can recognize face images and recall a face image from an incomplete or a noisy version input to the network. These ideas were extended by V Fleming and Cottrell [9](1990) using nonlinear units, training using back propagation. Stonham's WISARD system [10](1986) is a general purpose archetype identification device based on neural network. Applying it to identification and expression recognition has shown some success rates. Most connectionist systems do not explicitly use the configurational properties dealing with faces but consider them as a 2-D pattern. Additionally, to target to reasonable performance level these systems require more number of training exemplars. The scalability aspect of such systems is still unknown.

An aliter approach of identification was done by characterizing a face by geometric measurements and performing pattern identification based on the same parameters [11,12] (1972, 1989). Kanade's [13](1973) face identification system was the first system in which all steps of the identification process were automated, using a generic consummate of feature characteristics. The system used, a purely statistical approach primarily on local histogram analysis and absolute gray-scale levels of the image.

A "smart sensing" approach on multi resolution template matching was the work by Burt [14 ](1988). This coarse-t-fine strategy uses a distinctive computer built to estimate the multi resolution pyramid images quickly, and has established identifying people in near real-time. This system works well under limited circumstances, but suffer form the problems of correlation- based matching, including sensitivity to image size and noise.

Aspects of face were not much looked into in the previous works. The conception of using Eigen faces was inspired by a technique developed by Sirovich and Kirby [15](1987, 1990) for efficiently representing pictures of faces using principal component analysis. Starting with an ensemble of original face images, a best coordinate system for image compression, where each coordinates is actually an image that was termed an Eigen picture. In 1996 Lew et al., came up with a Markov random field DFFS [16] pixel based model for identification. A geometrical facial methodology coined by Yow et al [17]., gave a good success ratio when tested on the CMU dataset. In 1998 learning model came into existence based on the simple markov processes, which stamped a new beginning. Yang et al.,[18] viewed into the new dimension of color images and suggested a multi-scale segmentation color model. Texture based identification models grabbed its place in 1998 and 1999, the Learning [19] and Neural Networks [20] models proved to be one of its kind. The next landmark was into the world of fuzzy worked out for color images by Wu et al., [21]. The curve again turned towards statistical approach of wavelet analysis on video images, a very good attempt by Garcia et al., [22]. Maio et al., [23] in 2000 worked on texture, and directional images with template houghs for static images. In 2001 Feraud et al., [24] used purely Neural networks for face identification.

Because the human face is a three dimensional (3D) object whose 2D projection (image) is sensitive to changes, utilizing 3D face information can improve the face identification performance [25]. Delak et al. [26] made a comparative study of PCA, LDA, and ICA in the FERET database. The most recent work on images using PCA was given a trial by Vijaya Lata Y et al [27]., using an open source software scilab.

## 3. Materials and Methods

### *3.1. Preprocessing*

As the first step in image processing, the preprocessing of the image is to be executed. Preprocessing the image means noise removal, brightness or contrast enhancements, obtaining the region of Interest (ROI). The ROI detection is very crucial, because it is with this ROI image the entire methodology is going to work. The final results are proportionate to the better methods used in this step. A better preprocessed image suitable for the application would for sure increase the results in quality and quantity. The region of interest (ROI) looked forward in this work is the outline from the acquired images. The flow of the entire preprocessing is shown in figure 1.

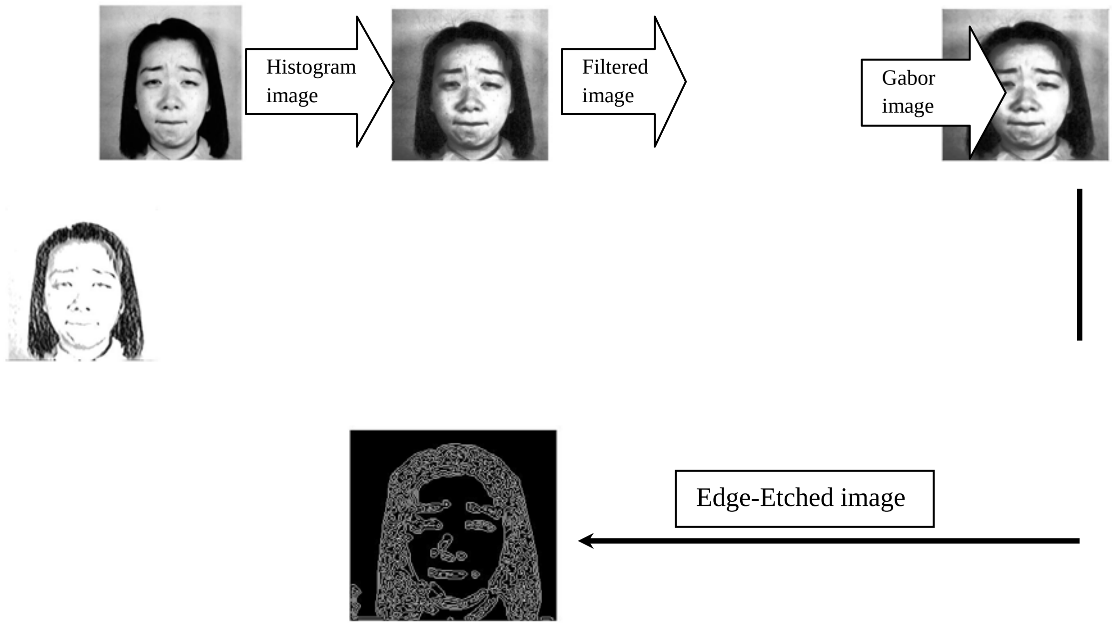
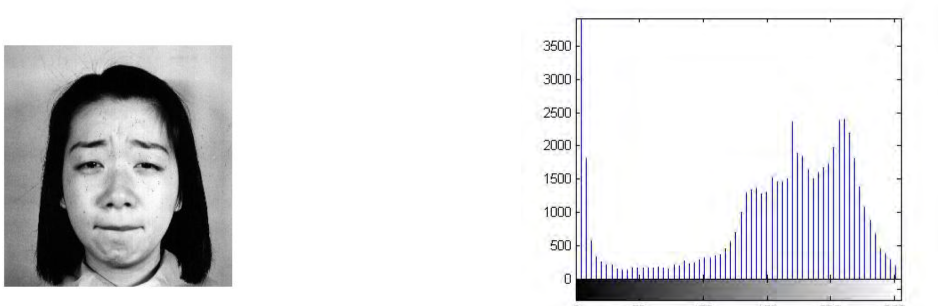



Figure 1: Flow of pre-processing

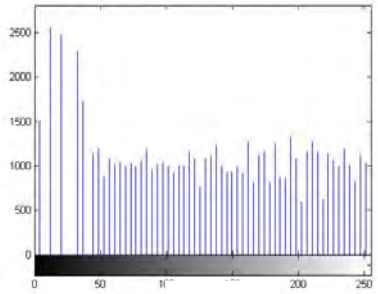
The basic image used is a .tiff image of dimension 256*256. A histogram equalization method is applied. Histogram equalization [28] convalesce the contrast in the gray scale and it aims to obtain a uniform histogram. The histogram equalization method also helps the image to recuperate the intensity distributions. This doesn't mean new intensities are introduced into the image. Prevailing intensity values will be chronicled to new values but the concrete number of intensity pixels in the resulting image will be equal or less than the original number. The figure 2 shows the images and the histogram plots before and after the histogram equalization method.




(A) (B)

The histogram equalized image is filtered using the median filter in order to make the image smoother. Smoothening the image removes noise and crafts the image clearer. The Gabor filter is applied to compose the Gabor image. Finally canny edge detection method [29] is applied to the Gabor image to find the edge etched clearly. Canny edge detection is used as it is best possible edge detector with low error rate. It is important that edges occurring in images should not be missed and it must clearly distinguish and demarcate non-edges. The secondary criterion is that the edge points are well localized, and always only a minimum distance exists between edge pixels found by the detector and the actual edge. A third criterion is to have only a single response to a single edge.

(C)




(D)

Figure2. (A) Original image (C) Histogram image (B) and (D) equivalent histogram plots.

The canny edge detector smoothes the image to eliminate noise then finds the image gradient to emphasize regions with high spatial derivatives. The algorithm then spoors along these regions and suppresses any pixel that is not at a maximum (non maximum suppression). The gradient array is further reduced by hysteresis. Hysteresis is used to track along the left over pixels that have not been suppressed. Hysteresis uses two thresholds and if the magnitude is below the first threshold (T1 low), it is set to zero (made a non-edge). If the magnitude is above the second threshold (T2 high), it is marked an edge. And if the magnitude is between the 2 thresholds, then it is set to zero unless there is a path from this pixel with a gradient above T2. A Gaussian mask was used for the convolution procedure. The canny parameters tailor made for this work used a smaller value of 'σ' which restricts the amount of blurring, maintains finer edges in the image. There is a trade-off using canny detector, it is computationally expensive but performs well with different images and scenarios.

### *3.2. Eigen faces*

Eigen faces are used to extract relevant information such as eyes, nose, lips, etc,. Eigen face approach is one of the widespread methods that apprehend the statistical variation between the facial images. The Eigen faces can be thought of as a set of features which exemplify the global variation among face images. The method can be well believed as the images are worked on as a case by case exemplar. Then each face image is reckoned using a subset of the Eigen faces, those concomitant with the largest Eigen values. In terms of language of information theory, to extract the relevant information in the face image, encode it as adroitly as possible, and compare one face with a database of models encoded similarly[30]. This information theory is only followed but not in hard core manner, but the base of it happens to be the same. A simple approach to extracting the information contained in an image is to show how to capture the variations in a collection of face images, independently encode and compare individual face images. The work portrayed here extracts the edge information of the image and stores it in the database instead of directly storing the image itself. The important information that is taken from the image is the complete edges of the images.

Mathematically, it is merely finding the Eigen vectors of the covariance matrix of the set of face images, treating an image as a point or a vector in a very high dimensional space. The Eigen vectors are arranged each vector accounting for a multifarious amount of variations among the face images. These Eigen vectors can be imagined as a set of features that together characterize the variation between the face images. Each image locations contributes more or less to each Eigen vector, so that it can display the Eigen vector as a sort of ethereal face which is called an 'Eigen face'.

*3.2.1 Generating Eigen faces:*

Assume a face image I(x,y) be a two-dimensional M by N array of intensity values, or a vector of dimension M*N. The training set used for the analysis is of size 256*256 resulting in a vector of dimension 65536 dimensional spaces. An ensemble of images, then, maps to a collection of points in this huge space.

Images of faces, being analogous in overall configuration, will not be randomly distributed in this huge image space and thus can be described by a relatively low dimensional subspace.

*3.2.2 Advantages of Eigen face approach:*

Eigen faces are extracted principal components from set of facial images, so, only important information of the face is taken and coded.
Every image can be represented by a simple array of numbers that saves space and clasps in the identification process.

### 3.3. Principal Component Analysis

PCA a classical technique which can work in the linear domain, applications having linear models are best suited such as signal processing, image processing, system and control theory and communications. The main idea behind using PCA for the identification is to express the large 1-D vector of pixels constructed from 2-D facial image into the compact principal components of the feature space[31]. This can be termed as Eigen space projection. Eigen space is calculated by identifying the Eigen vectors of the covariance matrix derived from a set of facial images (vectors). The main idea of the principal component analysis is to find the vectors which unsurpassed the account for the distribution of the face images within the entire image space. These vectors define the subspace of face images, which is named as “face space”. Each vector is of length N2 describes an N by N image, and is a linear combination of the original face images. The PCA algorithm [32] was written in Matlab and tested on color face images.

## 4. Results and Analysis

This work used the JAFFE database[33] with 213 images, all the images are frontal view and taken under same illumination configurations. The database images has 7 facial expressions (6 basic and 1 neutral) posed by 10 Japanese models. Each image has been rated by 60 Japanese subjects on the emotion adjectives. The facial identification of emotional images was taken as a challenge and dealt with in this work. The idea behind taking this dataset is, the problem is to exactly identify the face and not do a mere recognition. Because the dataset consisted of many images of the same person, the identification task would be a real test and challenging one. The emotions distortions in the images are exactly identified. The training dataset was built with random 150 images approximately 70% and the remaining images were left for testing. The training cycle included storing of the image in the database after pre-processing; only the edge-images were stored in the database. The snapshot of part of the training set used is shown in figure 3.

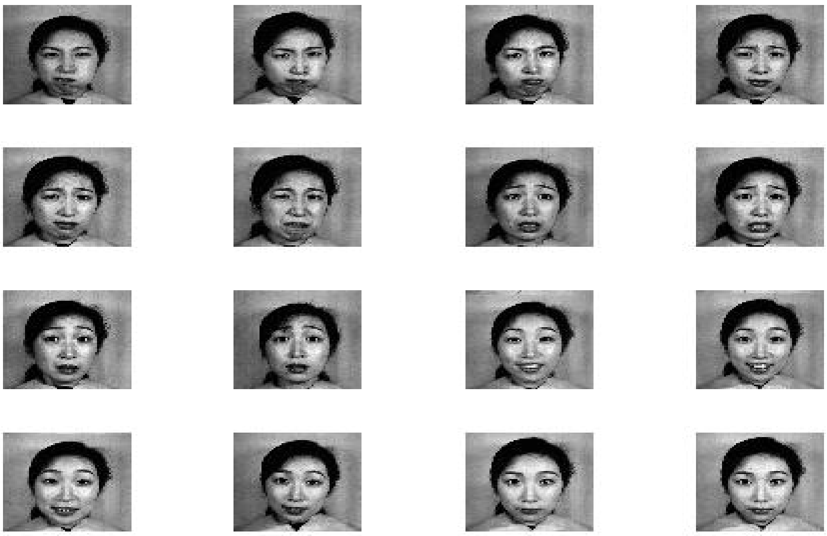


Figure 3: sample Training set images

The first aspect of discussion with the betterment of this method is, ‘storage’-the basic dimensions of the original and the edged images are 256*256. The system proves to be a better bet in terms of storage when considered with any face identification system. As a case exemplar the original image .tiff format is of size 64.1 Kb and the edge detected image in .jpg format is 25.9Kb. For a single image the storage analysis is stated, when worked for 215 images the storage required was very much less when considered with the traditional methods. Normal system requires approximately 12 Mb whereas the system designed would requires close to 5Mb of storage space only.

The second aspect of discussion with the betterment of this method is, ‘accuracy’- the database is basically coined with the same person with different emotions displayed. The idea behind choosing such a database is the methodology has to be proven and tested to the best. The same face can be deduced with a simple face identification system itself whereas the basic face image in the entire database is the same, the minute and intimate differences are to be accounted in the system, to deduce exactly the face with the same emotion. It is a tough and worthy task the system was put in to, the success rates yielded was good. 87% of images were rightly recognized. The error rate was 13% because there were few facial images which when taken a spatial derivative sounded large, one main consideration would be only the outline of face was considered to match, not the entire face.

The implementation was in Matlab 7.6.0. The final image reported on the system was done using the restoration technique. Displaying the image from the database would only show the edged image, so a restored image was necessary to make the Human Computer Interaction more user friendly, image restore technique was adopted to execute the same. The test image and its original that is retrieved is shown below in the figure 4.

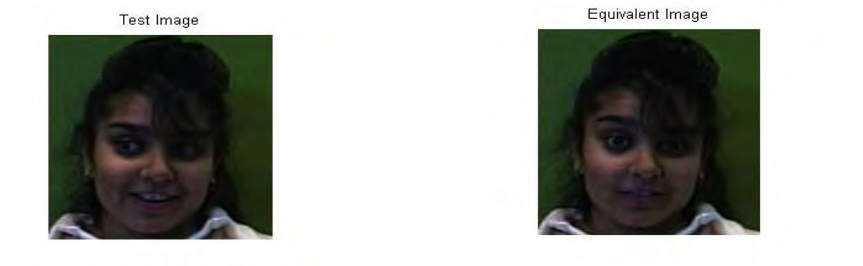



Figure 4. sample test image and the system fetched equivalent image.

## I. Conclusion and Future work

The face identification system designed has proved to be an impressive model. The result has been a significant 87% which is quite a captivating and note-worthy strike. It has overcome the general drawbacks by the use of a better preprocessing methodology. The obtained face identifier can be accounted as one of the most accurate and noteworthy model of the existent published face detectors. Its false alarm rate is very less when compared with the general face identifiers. It cannot be categorized under the traditional face recognizer, as it is capable of deducing minute changes with the same person’s face itself. A future lead would be to work the same on a 3-D image of face, to work with occlusions in an image, and incomplete images.

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