A COMPREHENSIVE STUDY OF INDEPENDENT COMPONENT ANALYSIS (ICA) IN THE CHARACTERIZATION OF HUMAN FACES.

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Abstract: Biometrics is the computer based validation of a person's identity and is becoming more and more essential due to the increasing demand for high security systems. The objective of this work is to implement and assess the performance of independent component analysis technique in the characterization of human faces. The ICA is implemented using MATLAB 7.0 package which defines the input layer, the hidden layer and the output layer of the network. The Independent component analysis is an array of higher order statistical neurons which learns by examples through a training process before it can function in its area of application. The face recognition code was also trained and tested using cropped face images of 50×50, 60×60, 70×70, 80×80 and they all have the same recognition rate which is 100%. In conclusion, face detection and recognition using independent component analysis is a robust and reliable method.

Keywords: Biometrics, Blind Source Separation, Facial Recognition, Independent Component Analysis, Pixel.

I. INTRODUCTION

Face recognition is a common task carried out by humans without much effort through the use of neuropsychological aspect of the brain. Human face is a complex array of features (eyes, nose, mouth etc) that require the special

dynamism of a human brain to connect and relate together for easy identification of a latter or future time [6]. A computational approach to this function of the human brain (face recognition), thus serve as useful tool in our present era. Many attempts to implement these computer based facial recognition system has been made in the past and a few has been successful. But a challenge faced by all these attempts is their inability to combine speed, accuracy, robustness and independence of the face images to face variation caused by 3D pose, facial expressions and aging.

The primary difficulty in analyzing and recognizing human faces arises because variations in a single face can be very large while variations between different faces are quite small. That is there is an inherent structure to a human face, but that structure exhibits large variations due to the presence of a multitude of muscles in a particular face [10]. Most research on face recognition fall into two main categories: feature based and holistic. Feature based approach to face recognition basically relies on detection and characterization of individual facial features and their geometrical relationships. The detection of faces and their application prior to performing verification on recognition makes these approaches robust to positional variations of the faces in the input image.

The holistic approaches to face recognition on other hand, involves encoding of the entire face

image and treating the resulting facial code as a point in a high – dimensional space, this approach would be used throughout the study of independent component analysis in the characterization of human faces.

In our present world, we are faced with several dangerous attacks carried out by humans. These attacks include terrorism, armed robbery, hired killing and many others. Detection and recognition of the faces involved in these actions will go a long way in drastically reducing these crimes. Hence, the need to carry out a study of face detection and recognition using ICA.

The aim of this paper is to perform a comprehensive study of independent component analysis in the characterization of human faces. The objectives are to carry out a detailed study of how the independent component analysis is applicable to frontal view face recognition and to analyze and make recommendations based on the result obtained during its application.

The requirement for a reliable personal identification in computerized access control has resulted in an increased interest in biometrics. Biometrics being investigated includes fingerprints [4], speech [5], signature dynamics [2] and face recognition [6]. Face recognition has the benefit of being a passive, non-intrusive system for verifying personal identity. The technique used in the most successful face recognition system today depends on the specific application of the system. Thus the need for a reliable facial identification which gives an independent verifiable output stemmed up the study of independent component analysis in face recognition for application in daily encounters of life.

Though independent component analysis has been seen to outperform many other source Models, its limitation should not be overlooked. With the use of the information maximization algorithms, a number of predictions were made which are also the limitations of this study. Hence, the information maximization (infomax) algorithm assumed that:

1. The pixel values in face images were generated from a linear mixing process. This linear approximation has been shown to hold true for the effect of lighting on face images. Other influences such as changes in pose and expression may be linearly approximated only to a limited extent.
2. The ‘causes’ of the pixel gray levels in face images had a super-Gaussian (peaky) response distribution. These gray levels in the face images are unknown, and it is possible that better result could have been obtained with other source models.

II. REVIEW OF RELATED WORKS

Face recognition and interpretation have been a common topic in the long history of research; this has been prominence in computer recognition of faces where features like nose, mouth, eyes, face position, size and the relationships among these features are covered. A number of automated or semi-automated face recognition strategies have modeled and classified faces based on normalized distances and ratios among feature points such as eye corners, mouth corner, nose tip and chin point. Not quite long, Yuille and his colleagues [9] continued and improve on this by strategizing and parameterized models of the face and its features in which the parameter values are determine by the image interactions.

Nonetheless, computer vision liberation remains the most popular approach to face recognition which renders the former approaches not remarkable in such a way that such approaches have proven difficult and have often been quite fragile, requiring a good initial guess to guide them. Human have remarkable abilities to recognize familiar faces under a wide range of conditions, including the ravages of aging. Research in human strategy of face recognition has shown that individual features and their immediate relationship comprise an insufficient representation to account for the performance of adult human identification [9].

Feature based approach were more predominant in the early attempt of automating the process of face recognition, some of this early work

involve the use of very simple image processing techniques (such as edge detection, signatures, and so on) for detecting faces and their features. Another example is when edge map was first extracted from an input image and then match to a large oval template with possible variations in position and size. The presence of a face was then confirmed by searching the edges at estimated locations of certain features like the eyes and mouth. They used an improved edge detector involving heuristic planning to extract an accurate outline of a person's head from various backgrounds [6].

More recently, a proposed technique is now been made for locating a face in a clotted image that employ a deformable template similar to the ones used before. They based their template similar to the outline of the head and allowed it to deform according to certain spring-based models. This approach perform quite well when tested on a small data set, but it sometimes gave rise to false alarms [8]. Other recent approaches have used hierarchical coarse-to-fine searches with template based matching criteria.

Once a face has been located, its features must be computed. Early examples of these are the on facial profile feature. An interesting recent discussion of feature-based methods, which compares them to holistic approaches, is found in [8]. Other researchers who have a similar approach are: [1] did a research on Kernel Independent Component Analysis. [7] did a research on Face Recognition by Independent Component Analysis. [3] did a vision research on independent components of natural scenes and edge filters.

III.SYSTEM DESIGN AND METHODOLOGY

The system is trained to recognize the small group of people in the database which is known as a group of authorized people. All other people are unauthorized or aliens and are rejected. This is why application of Independent Component Analysis (ICA) was studied for this task. The ICA used contains three stages: Image normalization is the first stage where the face area is detected in the image then the template matching is used to localize the face. The eye (iris) centers needs to be detected because the distance between them is used as a normalization factor. The eyes were located in facial images of different size using the luminance component and the eyes must be open in input images. This stage is followed by grayscale conversion using prescribed matlab functions. Number of input units is equal to the number of persons to be recognized. After training, highest output of ICA indicates recognized person for test image.

All input images were previously normalized by angle, size, position and lightning conditions, the sample size where also reduced as well which significantly speeds up training process. ICA representation allows JPEG and MPEG compressed images to be processed almost without decompression.

In the experiment with Independent Component Analysis, several subjects were studied. Exploration of thresholding rules allow the decisions of the ICA to be accepted or rejected. A thresholding rule was introduced, which allow improving recognition performance by considering all outputs of ICA. This is called 'sphering'. It calculates the difference between the weight of the tested image with the nearest Euclidean distance training image and then multiplies the result with a whitening matrix of the image and this in turn gives a generalization of principal component analysis called Independent Component Analysis.

The algorithm developed for the system is as stated below:

1. Creating a database of images
2. Normalize the face image (cropping and resizing)
3. Gray scale conversion (this permits the consideration of all available information in each image by converting it to binary.
4. Matrix to vector conversion
5. Apply Principal component Analysis for dimension reduction of all the trained images and for calculating the eigenvectors of the pixel wise covariance matrix over the set of face images.

6. Perform ICA on the first m (e.g 60) eigenvectors
7. Sphere the input matrix X
8. Update the weights W of the images for n (e.g 1000) iterations
9. Initialize the learning rates
10. A set of statistically independent source images are contained in the rows of the output matrix U
11. Match the introduced face with the ones in the database
12. Classify the images into either recognized or unrecognized.

IV.RESULTS AND ANALYSIS

The data (faces) in the database used for training and testing were face images of students of Ladoke Akintola University of Technology, Ogbomosho, Oyo State, Nigeria (from different departments) which contains face images of dimension 105 x 150 taken in a controlled environment of different illuminations. This group of faces made recognition accuracy more perfect.

One hundred (100) individual faces were taken with a digital camera. Each individual has six images with different face expressions and lightings. Microsoft photo Editor was used in reducing the original 480 x 640 pixels gotten from the camera to 105 x 150 pixels without distortion of the images.

The resized images were named using the format x & y where1 <= x <= 100 and 1 < y <=6. In each class, the first five images were used for training while the last image was used for testing. Also, one of the faces in each of the classes was used to test the system to determine its efficiency.

Table 1: Facial Recognition Performance Using ICA

Percentage Recognition Accuracy - RA

Image Resolution	CL	MC	UID	ID	TT(sec)	ART(sec)	RA(%)
50x50	100	0	0	100	49.3125	0.063531	100
60x60	100	0	0	100	57.8906	0.065469	100
70x70	100	0	0	100	69.6094	0.067187	100
80x80	100	0	0	100	87.1719	0.078281	100

The total number of rightly classified faces - CL
The total number of misclassified faces - MC
The total training time - TT
The average recognition time - ART
The total numbers of unidentified faces - UID
The total numbers of identified faces - ID

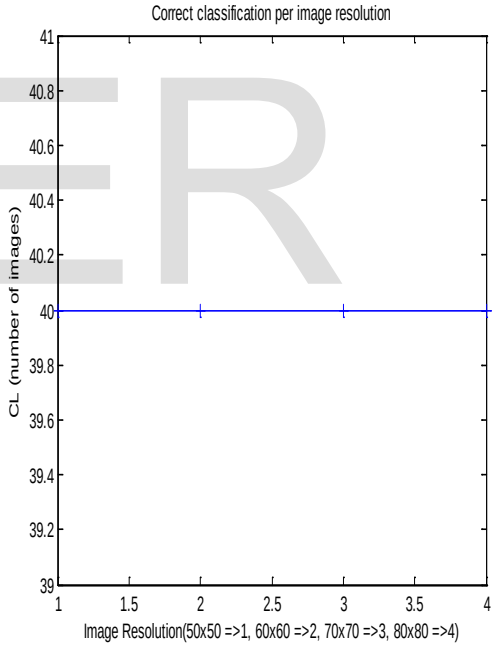

Figure 1: Correct Classification per Image Resolution

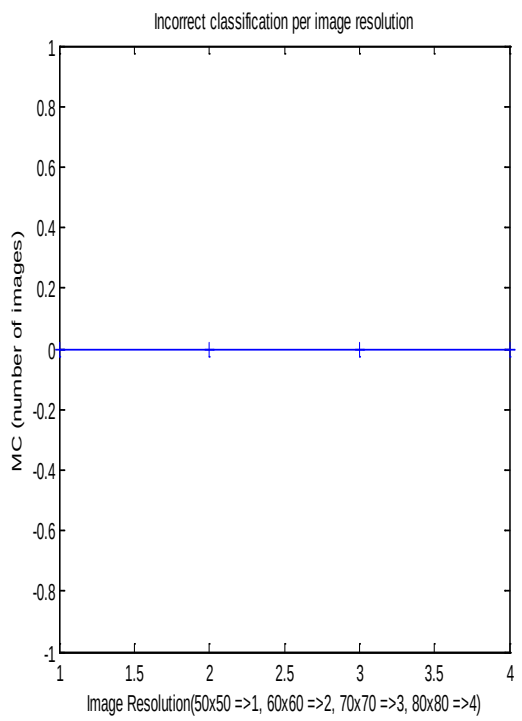

Figure 2: Incorrect Classification per Image Resolution

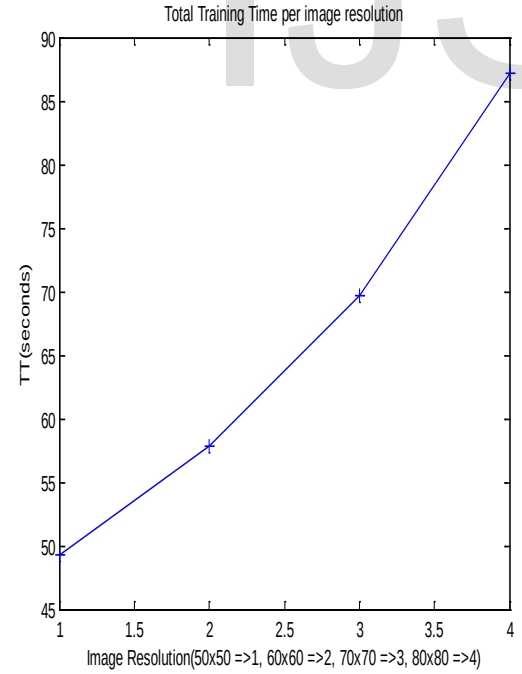

Figure 3: Total Training Time per Image Resolution

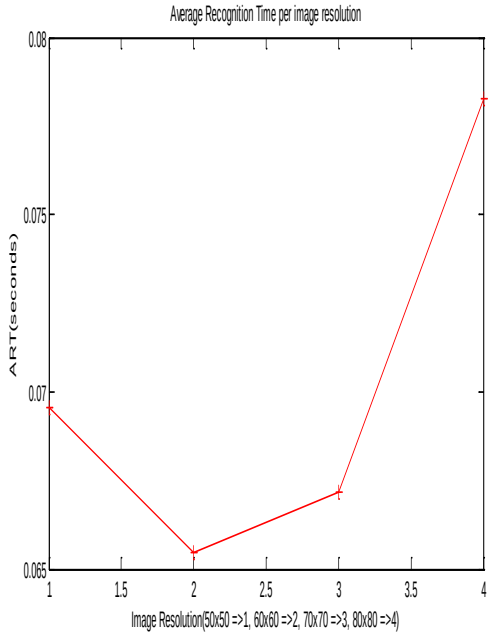

Figure 4: Average Recognition Time per Image Resolution

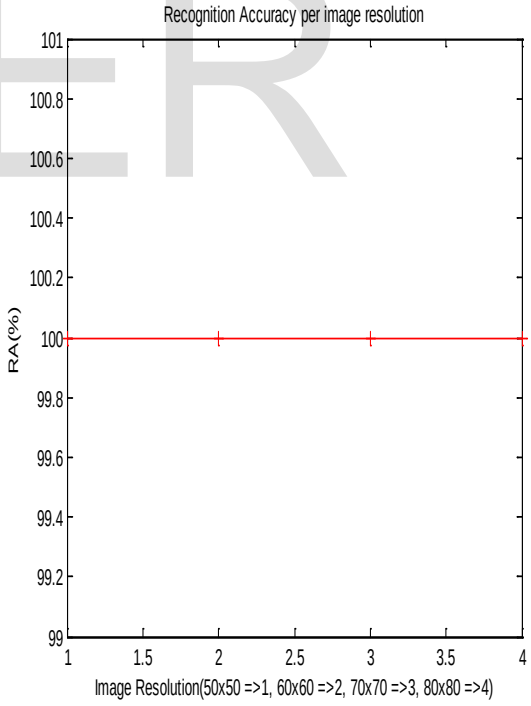

Figure 5: Recognition Accuracy per Image Resolution

The analysis with ICA using various resolutions has been seen to give the same recognition accuracy independent of the amount of images in the database and the type of illumination. From the experimental results shown in the graph of the figures 1- 5, we can deduce that the Training time of the system increases as the resolution increases, all images are correctly classified as recognized and unrecognized image during training. Therefore, the system is able to classify images as either known or unknown. Also, it was noticed during the processes that, the more the amount of data used for the program training, the longer it takes for the program to converge at its performance goal. This indicates that the system has a limitation of not being able to be used for data on a large scale. Therefore to improve system efficacy, and to make the system more robust with the ability to take more data, the number of neurons and hidden layers can be increased to the required level.

V. CONCLUSION

Real time security and surveillance due to certain limitations and restrictions (like constrained environment, speed of the system and its accuracy) have made this area of research more challenging for biometrics researches. The proposed method of frontal-view face recognition using Independent Component Analysis has been developed to overcome these limitations up to a reasonable extent and recognition accuracy has improved besides enhancing speed. Results have been obtained by using four images for training and two images for testing purposes per class.

The following observation has been drawn from the study that;

- Variation in the numbers of training images affects both the recognition accuracy and the speed.
- The better the environment were the images were captured the higher the recognition accuracy of the system but the system accuracy in general tends towards 100%.
- The more the number of training images the longer the time taken for recognition, and thus, the lower the speed of the system.

Thus in conclusion, the study of Independent Component Analysis and its application to frontal-view face recognition was successful and recognition was carried out by the MATLAB code written to perform the operation.

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