A Novel Method for Face Recognition using Neural Networks with Optical and Infrared Images

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Abstract— The Face recognition is an important and secured way to protect the frauds at everywhere like government agencies are investing a considerable amount of resources into improving security systems as result of recent terrorist events that dangerously exposed flaws and weaknesses in today's safety mechanisms. Badge or password-based authentication procedures are too easy to hack. Biometrics represents a valid alternative but they suffer of drawbacks as well. In this paper, a neural based algorithm is presented. The dimensionality of face image is reduced by the Linear Discriminant Analysis (LDA) and Haar Wavelet+LDA. To recognize the user based on Neural Network done by Feed Forward Neural Network and Fuzzy Neural Network with Optical and Infrared image. To identify the correct person to improve the detection rate and also to reduce the time complexity.

Keywords: Face recognition, Infrared image, Feed Forward Neural Network, Fuzzy Neural Network

I. INTRODUCTION

Presently the face recognition has been used mostly to overcome the hackers, crackers and unauthorized activities in the world. There have been so many biometric methods and system is available like Iris scanning, is very reliable but too intrusive, fingerprints are socially accepted, but not applicable to non-consentient people. On the other hand, face recognition represents a good compromise between what's socially acceptable and what's reliable, even when operating under controlled conditions. In last decade, many algorithms based on linear/nonlinear methods, neural networks, wavelets, etc. have been proposed. Nevertheless, Face Recognition Vendor Test 2002 shown that most of these approaches encountered problems in outdoor conditions. This lowered their reliability compared to state of the art biometrics. Face recognition technology is the least intrusive and fastest biometric technology. Face recognition is one of the most relevant applications of image analysis. An automated system which equals human ability to recognize faces is a challenging module to build. Although humans are good enough in identifying known faces, but sometimes we may not that much skilled enough when we must deal with a large amount of unknown faces. Human's limitations are overcome by the computers, which has large amount of memory and computational speed.

Biometric-based techniques have emerged as the most promising option for recognizing individuals in recent years since, instead of authenticating people and granting them access to physical and virtual domains based on passwords, PINs, smart cards, plastic cards, tokens, keys and so forth, these methods examine an individual's physiological and/or behavioural characteristics in order to determine and/or ascertain his identity. Passwords and PINs are hard to remember and can be stolen or guessed, cards, tokens, keys and the like can be misplaced, forgotten, purloined or duplicated, magnetic cards can become corrupted and unreadable. However, an individual's biological trait cannot be misplaced, forgotten, stolen or forged. Biometric-based technologies include identification based on physiological characteristics such as face, fingerprints, finger geometry, hand geometry, hand veins, palm, iris, retina, ear and voice and behavioural traits such as gait, signature and keystroke dynamics.

However, face recognition can be done passively without any explicit action or participation on the part of the user since face images can be acquired from a distance by a camera. This is particularly beneficial for security and surveillance purposes. Furthermore, data acquisition in general is fraught with problems for other biometrics: techniques that rely on hands and fingers can be rendered useless if the epidermis tissue is damaged in some way i.e., bruised or cracked. Iris and retina identification require expensive equipment and are much too sensitive to any body motion. Voice recognition is susceptible to background noises in public places and auditory fluctuations on a phone line or tape recording. Signatures can be modified or forged. However, facial images can be easily obtained with a couple of inexpensive fixed cameras. Good face recognition algorithms and appropriate preprocessing of the images can compensate for noise and slight variations in orientation, scale and illumination. Finally, technologies that require multiple individuals to use the same equipment to capture their biological characteristics potentially expose the user to the transmission of germs and impurities from other users. However, face recognition is totally non-intrusive and does not carry any such health risks.

II. PROPOSED SYSTEM

We proposed modified version of dicriminant analysis. Face recognition system is a computer application for automatically identify or verifying a person from a digital image or video frame from a video source. Facial recognition system typically used in security system. In this system automatically searching of faces from the face databases, typically resulting in a group of facial images ranked by computer evaluated similarity. Some facial recognition algorithm identifies faces by extracting landmarks, or features from an image of the subject face. For example, face recognition algorithm may analyze the relative position, size, shape of the eyes, nose cheekbones and jaw to recognize faces. Linear Discriminant analysis explicitly attempts to model the difference between the classes of data.

LDA is a powerful face recognition technique that overcomes the limitation of Principle component analysis technique by applying the linear discriminant criterion. This criterion tries to maximize the ratio of the determinant of the

between-class scatter matrix of the projected samples to the determinant of the within class scatter matrix of the projected samples. Linear discriminant group images of the same class and separates images of different classes of the images. Discriminant analysis can be used only for classification not for regression. The target variable may have two or more categories. Images are projected from two dimensional spaces to c dimensional space, where c is the number of classes of the images.

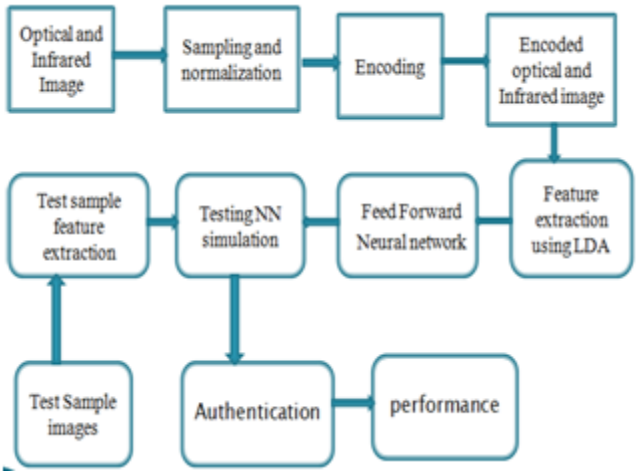

Fig. 1: Block Diagram of Feed Forward Neural Network

- The Optical and infrared face image is sampled and normalized.
- Encoded image has been taken and the result image is obtained.
- Feature extraction is done using Linear Discriminant Analysis (LDA) and the learning is based on feed forward neural network.
- Testing and simulation of neural network.
- Test image samples optical/infrared is feature extracted and match with the encoded image for authentication.

To identify an input test image, the projected test image is compared to each projected training image, and the test image is identified as the closest training image. The LDA method tries to find the subspace that discriminates different face classes shown in the Fig.1

A. *Database Used:*

Interest in HFB arises from applications involving matching between heterogeneous face images. NIR face images, which overcome uncontrolled illumination changes, as the query, and match them against VIS face images in the target set as required by applications. Study on relationship and mapping between heterogeneous face images is also an interesting problem from pattern recognition and machine learning viewpoints. A face database, composed of visual (VIS), near infrared (NIR) and three-dimensional (3D) face images, is collected. Called the HFB Face Database, it is released now to promote research and development of Heterogeneous Face Biometrics (HFB). HFB by matching face images from different image sources has become a new direction for face recognition research. The earliest HFB could be face identification based on face sketches in forensic investigations. Tang and his colleagues developed a PCA based method for face sketch recognition against face photos. The proposed a framework for inter-modality face matching called common discriminant feature extraction (CDFE). CDFE can be considered as a modified linear discriminant analysis (LDA) method for heterogeneous face matching, in which scatter matrices are defined on two different types of images, and local consistency of manifold is imposed to regularize the dimension reduction. It was applied to sketch-photo image matching and NIR-VIS face image matching.

B. *Feature Extraction:*

Feature extraction is a special form of dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be very redundant e.g. the same measurement in both feet and meters, or the repetitiveness of images presented as pixels, then the input data will be transformed into a reduced representation set of features also named features vector. Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input. Feature extraction involves reducing the amount of resources required to describe a large set of data. When performing analysis of complex data one of the major problems stems from the number of variables involved. Analysis with a large number of variables generally requires a large amount of memory and computation power or a classification algorithm which over fits the training sample and generalizes poorly to new samples. Feature extraction is a general term for methods of constructing combinations of the variables to get around these problems while still describing the data with sufficient accuracy.

C. *Linear Discriminant Analysis:*

Linear Discriminant Analysis, or simply LDA, is a well-known classification technique that has been used successfully in many statistical pattern recognition problems. The primary purpose of LDA is to separate samples of distinct groups. Transforming the data to a different space that is optimal for distinguishing between the classes. Linear Discriminant analysis explicitly attempts to model the difference between the classes of data. LDA is a powerful face recognition technique that overcomes the limitation of Principle component analysis technique by applying the linear discriminant criterion. Linear discriminant group images of the same class and separates images of different classes of the images. Discriminant analysis can be used only for classification not for regression. The target variable may have two or more categories. Images are projected from two dimensional spaces to c dimensional space, where c is the number of classes of the images. To identify an input test image, the projected test image is compared to each projected training image, and the test image is identified as the closest training image

LDA generalizes this process for multiple classes and arbitrarily large numbers of variables. Its main limitation is the implicit assumption that the true covariance matrices of each class are the same. Linear Discriminant Analysis is a well-known scheme for feature extraction and dimension reduction. It has been used widely in many

applications such as face recognition, image retrieval, microarray data classification, etc.

D. Haar Wavelet Transform:

Wavelet is an increasingly popular tool in image processing and computer vision. Many applications, such as compression, detection, recognition, image retrieval have been investigated. Wavelet transform has nice features of space-frequency localization and multi resolutions. The main reasons for Wavelet transforms popularity lie in its complete theoretical framework, the great flexibility for choosing bases and the low computational complexity Wavelets decompose complex signals into sums of basis functions – in this respect they are similar to other discrete image transforms. However, wavelets are local in both frequency and time and are able to analyze data at different scales or resolutions

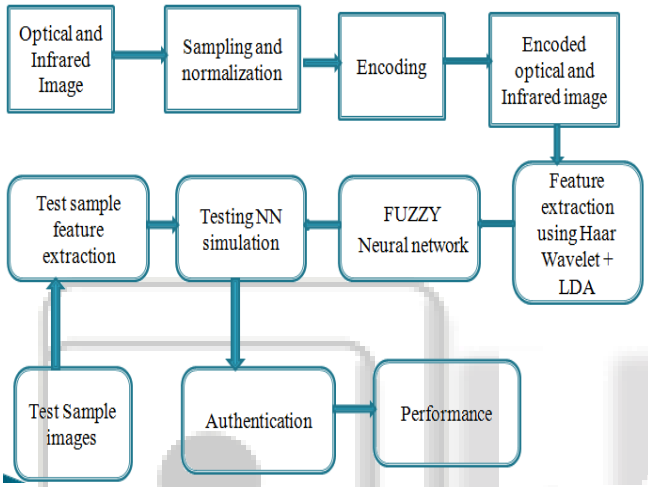

Fig. 2: Block Diagram of Fuzzy Forward Neural Network

Wavelet transform captures both frequency and time i.e. location information. The Haar transformation is used here for dimensionality reduction since it is the simplest wavelet transform of all and can successfully serve our purpose. Wavelet transform has merits of multi-resolution, multiscale decomposition, and so on. and wavelet transform is a very good tool to analyze multi-scale and multi-directional texture. Wavelet transform is also used for image dimensionality reduction, by removing redundancies and preserving original features of the image. The sizes of the facial images are normally large. So, the wavelet transform is used before image similarity is measured

E. Feed Forward Neural Network:

A neural network is a system of programs and data structures that approximates the operation of the human brain. A neural network usually involves a large number of processors operating in parallel, each with its own small sphere of knowledge and access to data in its local memory. Typically, a neural network is initially "trained" or fed large amounts of data and rules about data relationships. A program can then tell the network how to behave in response to an external stimulus for example, to input from a computer user who is interacting with the network or can initiate activity on its own within the limits of its access to the external world.

In making determinations, neural networks use several principles, including gradient-based training, fuzzy logic, genetic algorithms, and Bayesian methods. Neural networks are sometimes described in terms of knowledge layers, with, in general, more complex networks having deeper layers. In feed forward systems, learned relationships about data can feed forward to higher layers of knowledge. Neural networks can also learn temporal concepts and have been widely used in signal processing and time series analysis. Current applications of neural networks include: oil exploration data analysis, weather prediction, the interpretation of nucleotide sequences in biology labs, and the exploration of models of thinking and consciousness.

The motivation for applying feed forward net is to achieve a balance between memorization and generalization. It is not necessarily advantageous to continue training until the error reaches a minimum value. The weight adjustments are based on the training patterns. As a long as error the for validation decreases training continues. Whenever the error begins to increase, the net is starting to memorize the training patterns. At this point training is terminated.

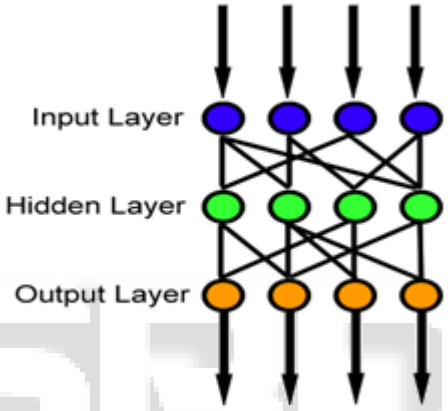

Fig. 3: Layout of Feed-Forward Neural Networks

A collection of neurons connected together in a network shown in the Fig.3 can be represented by a directed graph:

- Nodes represent the neurons, and arrows represent the links between them.
- Each node has its number, and a link connecting two nodes will have a pair of numbers
- Networks without cycles (feedback loops) are called a feed-forward networks or perceptron.
- They do not compute anything, but simply pass the values to the processing nodes.
- Output nodes are associated with the output variables.
- A neural network may have hidden nodes they are not connected directly to the environment ('hidden' inside the network).
- Neural networks can have several hidden layers.

FFNN is a more general network architecture, where there are hidden layers between input and output layers. Hidden nodes do not directly receive inputs nor send outputs to the external environment. FFNNs overcome the limitation of single-layer NN. They can handle non-linearly separable learning tasks.

Number of Hidden Units the activation function can vary with the function, then it can be seen that an n-input, m-output function requires at most 2n+1 hidden units. If more number of hidden layers are present, then the calculation for the P's are repeated for each additional

hidden layer present, summing all the P's for units present in the previous layer that is fed into the current layer for which P is being calculated. Learning Rate- in FFNN, the weight change is in a direction that is a combination of current gradient and the previous gradient. A small learning rate is used to avoid major disruption of the direction of learning when very unusual pair of training patterns is presentedThus the feed forward neural network classifies the input image as recognized image. Feed forward networks consist of a series of layers. The first layer has a connection from the network input. Each subsequent layer has a connection from the previous layer. The final layer produces the network's output.

F. Fuzzy Neural Network:

A fuzzy neural network or neuro-fuzzy system is a learning machine that finds the parameters of a fuzzy system (i.e., fuzzy sets, fuzzy rules) by exploiting approximation techniques from neural networks. A neuro-fuzzy system based on an underlying fuzzy system is trained by means of a data-driven learning method derived from neural network theory. This heuristic only takes into account local information to cause local changes in the fundamental fuzzy system. It can be represented as a set of fuzzy rules at any time of the learning process, i.e., before, during and after. Thus the system might be initialized with or without prior knowledge in terms of fuzzy rules. The learning procedure is constrained to ensure the semantic properties of the underlying fuzzy system. A neuro-fuzzy system approximates a n-dimensional unknown function which is partly represented by training examples. Fuzzy rules can thus be interpreted as vague prototypes of the training data. A neuro-fuzzy system is represented as special three-layer feedforward neural network first layer corresponds to the input variables. The second layer symbolizes the fuzzy rules. The third layer represents the output variables. The fuzzy sets are converted as (fuzzy) connection weights. Some approaches also use five layers where the fuzzy sets are encoded in the units of the second and fourth layer, respectively.

1) Advantages of Neural Networks:

1) Can be applied to many problems, as long as there is some data.
2) Can be applied to problems, for which analytical methods do not yet exist
3) Can be used to model non-linear dependencies.
4) If there is a pattern, then neural networks should quickly work it out, even if the data is 'noisy'.
5) Always gives some answer even when the input information is not complete.
6) Networks are easy to maintain.

III. SIMULATION RESULTS

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar no interactive language such as C or FORTRAN.

MATLAB stands for MATrix LABoratory and the software is built up around vectors and matrices. This makes the software particularly useful for linear algebra but MATLAB is also a great tool for solving algebraic and differential equations and for numerical integration. MATLAB has powerful graphic tools and can produce nice pictures in both 2D and 3D

MATLAB features a family of application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis

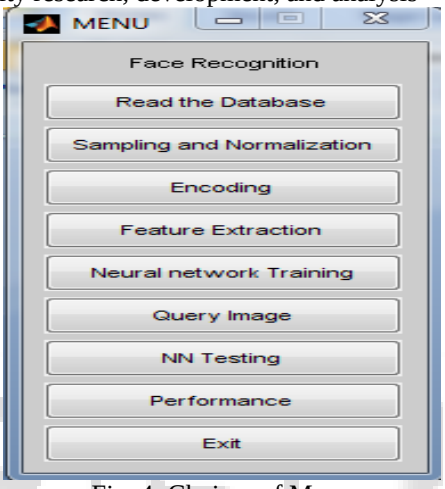

Fig. 4: Choices of Menu

Figure 3 shows the choices of menu used in the matlab simulation to select the appropriate step by step procedure.

Fig. 5: Optical Images

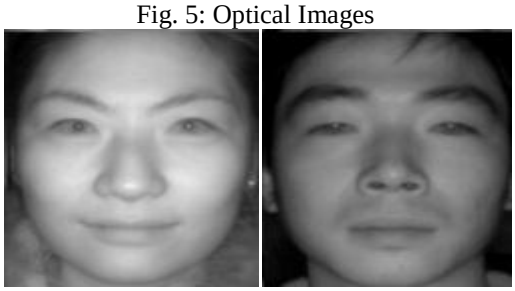

Fig. 6: Infrared Images

Fig.4 and 5 shows the optical images and infrared images, are given as the input to the simulation. The images are taken from the databases used.

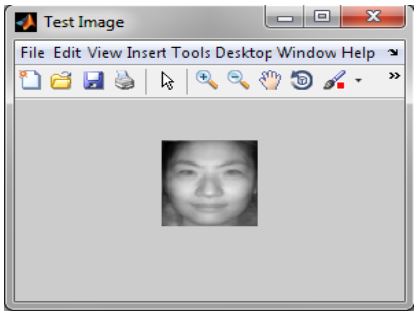

Fig. 7: Test Image

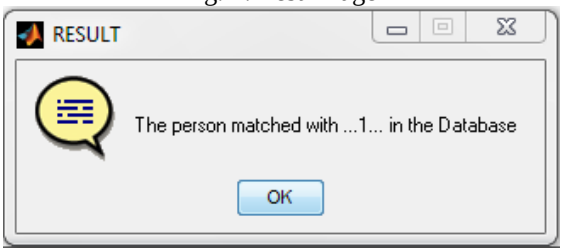

Fig. 8: Result of NN Testing

Fig.6 shows the test image to test the images of other images to match with database images and the figure 7 shows the neural network testing of test image. The test image is matched with the one in the database images.

IV. Conclusion and Future Work

In this project, proposed an approach called Linear Discriminant Analysis (LDA) and Haar wavelet + LDA for matching infrared images to optical face images. The Proposed method is validated on MATLAB platform .In LDA, a new descriptor is developed to represent both optical and an infrared image is subsequently applied for fast and effective matching and also presented a Neural Network (NN) based face recognition system by using Feed Forward Neural Network (FFNN) and Fuzzy Neural Network, the images has been tested for the performance. The test samples of optical and infrared images are feature extracted and the testing is done by the feed forward neural network Fuzzy Neural Network for authentication and security.In future the data base image can be used with sketch and pencil draw images.

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