Face Recognition Using SOM

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***Abstract*—**Automatic recognition of individuals has been a challenging task since a long time and no such flexible and robust system has been designed so far that could provide complete human recognition, access and security to important information and physical resources. Among the various Biometric Techniques, facial analysis and recognition techniques have progressed significantly in the last decade and emerge to be a promising area to identify humans. However, the reliability of face recognition methods still require challenging tasks to be performed by the research community to develop a highly robust system by overcoming possible facial appearance variations. In this paper, we present a biometric based system known as Face Recognition System. This system uses SOM (self-organizing maps), a Neural Network Technique to identify an individual by changing a high dimensional facial feature dataset into a low dimensional facial feature dataset, thus preserving abstract facial features only. The proposed system will be implemented in MatLab. Among the various neural networks, SOM needs low computational requirements and seems to be cost effective in terms of both processing speed and memory.

Keywords- Biometric System, Face Recognition, Neural Network-SOM Introduction

I. INTRODUCTION

We Face Recognition is an application to automatically identify a person after comparing with a database of images. A probe image is taken with the help of a camera from a still source or video frame, and after accounting for various possible face appearance variations, is compared with the database images for identity [1]. Researchers have got a great interest in this field for its applications in various domains. One of the commercial applications of the face recognition systems could be start with small basic login applications and leading to the development of a high security access control system, secure biometric based transaction or highly secured surveillance system.VE RESEARCH IN TECHNOLOGY reserves the right to do the final formatting of your paper.

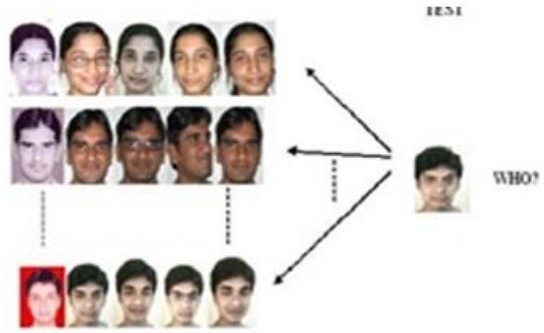


Fig.1: Comparing a new image with a database

II. APPEARANCE VARIATIONS

A. Variations In Illumination

Different lighting conditions can affect the recognition rate. Some face detection or recognition methods try to be invariant to illumination changes by implicitly modeling them or extracting invariant features. Others propose a separate processing step, a kind of normalization, in order to reduce the effect of illumination changes.

Fig.2: Effect of Illumination changes [2]

B. Pose

The variation of head pose or, in other words, the viewing angle from which the image of the face was taken is another difficulty and essentially impacts the performance of automatic face analysis methods. For this reason, many applications limit themselves to more or less frontal face images.

Fig.3: Variations in Pose [3]

C. Expressions

The appearance of a face with different facial expressions varies considerably. For access control systems the subjects are often required to show a neutral expression. Thus, invariance to facial expression might not be a big issue.

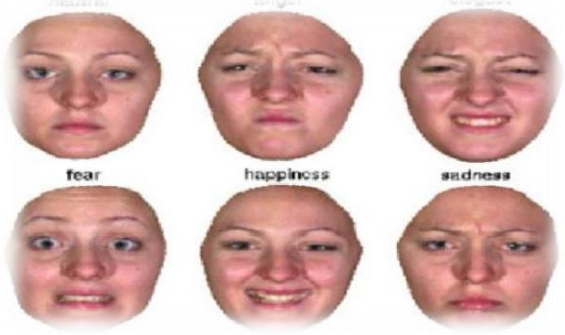


Fig.4: Variations in Expressions [4]

D. Ageing

Varying age is also an important factor influencing the performance of many face analysis methods. This is the case for example in face recognition when the reference face image has been taken some years before the image to recognize.

Fig.1: Ageing variations *[5]*

E. Occlusion

Occlusions occur quite frequently in real-world face images. They can be caused by a hand occluding a part of the face, e.g. the mouth, by long hair, glasses, sun glasses or other objects or persons. In most of the cases, however, the face occludes parts of itself. For example, in a view from the side the other side of the face is hidden.

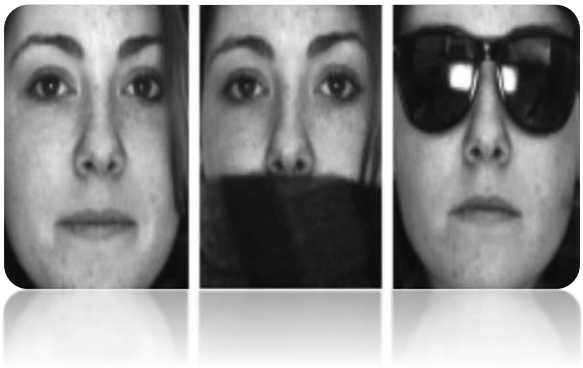


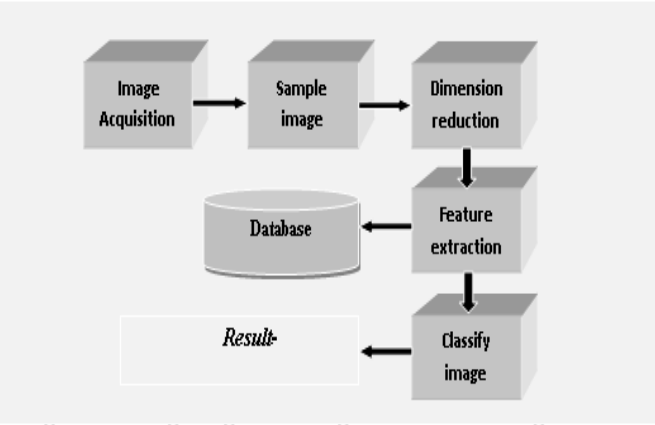
Fig.2: Partial occlusion in images *[6]*

F. Low Resolution

Fig.3: Typical frame from a surveillance video *[7]*

Among the various biometric technologies, almost all require the target to be present in front of the system. As in case of finger printing one has to put finger prints on device and other has to stand in a fixed position in front of a camera for iris or retina identification. However, face recognition does not need the target actively participate but can be scanned passively from a distance and also has mass scanning feature which is not easy in case of other biometric techniques. It can be widely used for surveillance, access control and law enforcement applications and can help to stop criminal and terror activities to quite a large extent.

The general facial recognition system works through the following processes:



system.

III. APPLICATIONS

There are numerous application areas in which face recognition can be exploited, a few of which are outlined below.

- Security (access control to buildings, airports/seaports, ATM machines and border checkpoints [8] [9]; computer/ network security [10]; email authentication on multimedia workstations).
- Surveillance (a large number of CCTVs can be monitored to look for known criminals, drug offenders, etc. and authorities can be notified when one is located [11]; General identity verification (electoral registration, electronic commerce, banking, identifying new-borns, national IDs, drivers' licenses, passports, employee IDs).
- Criminal justice systems (forensics, mug-shot/booking systems, post-event analysis)
- Investigation Purposes (searching image databases of licensed drivers, benefit recipients, missing children, immigrants and police bookings)
- Smart Card applications (in lieu of maintaining a database of facial images, the face-print can be stored in a smart card, bar code or magnetic stripe, authentication of which is performed by matching the live image and the stored template) [12].
- Multi-media environments with adaptive human computer interfaces (behavior monitoring at childcare or old people's centers, recognizing a customer and assessing his needs).
- Video in indexing (labelling faces in video) [13]

IV. RELATED WORK

The earliest work on face recognition can be traced back at least to the 1950s in psychology [14] and to the 1960s in the engineering literature [15]. Some of the earliest studies include work on facial expression emotions by Darwin [16]. But research on automatic machine recognition of faces started in the 1970s [17] and after the seminal work of Kanade [18]. In 1973, Fischer and Elschanger tried to measure similar features automatically [19]. In the same year, Kanade formulated a fully automated face recognition system. He used an algorithm which extracted sixteen facial features automatically and achieved performance rate of 45-75 % [20]. In the 1980's there were a diversity of approaches actively followed, most of them continuing with previous tendencies. Some works tried to improve the methods used measuring subjective features. For instance, Mark Nixon presented a geometric measurement for eye spacing [21]. The template matching approach was improved with strategies such as "deformable templates". This decade also brought new approaches. Some researchers build face recognition algorithms using artificial neural networks [22].

The first mention to eigenfaces in image processing, a technique that would become the dominant approach in following years, was made bySirovich and Kirby in 1986 [23]. Their methods were based on the Principal Component Analysis. Their goal was to represent an image in a lower dimension without losing much information and then reconstructing it [24]. Their work would be later the foundation of the proposal of many new face recognition algorithms. The 1990's saw the broad recognition of the mentioned eigenface approach as the basis for the state of the art and the first industrial applications. In 1992 Mathew Turk and Alex Pentland of the MIT presented a work which usedeigenfaces for recognition [25]. Their algorithm was able to locate, track and classify a subject's head. Since the 1990's, face recognition area has received a lot of attention, with a noticeable increase in the number of publications. In 1995, a review paper gave a thorough survey of face recognition technology [26]. At that time video-based face recognition was still in a nascent stage [27]. During the past decades, face recognition has received increased attention and has advanced technically. Many commercial systems for still face recognition are now available.

Recently, significant research efforts have been focused on video-based face modelling/tracking, recognition and system integration. New databases have been created and evaluations of recognition techniques using these databases have been carried out. Now, the face recognition has become one of the most active applications of pattern recognition, image analysis and understanding.

Lin (2000) in his survey paper said that face recognition is attracting much attention in the society of network multimedia information access. For the applications of videophone and teleconferencing, the assistance of face recognition also provides a more efficient coding scheme. In this paper, they give an introductory course of this new information processing technology. Also the paper shows the readers the generic framework for the face recognition system, and the variants that are frequently encountered by the face recognizer

and several famous face recognition algorithms, such as eigenfaces and neural networks.

Heisele et al (2001) presented in their paper a component-based method and two global methods for face recognition and evaluated them with respect to robustness against pose changes. In the component system they first locate facial components, extract them and combine them into a single feature vector which is classified by a Support Vector Machine (SVM). The two global systems recognize faces by classifying a single feature vector consisting of the gray values of the whole face image. In the first global system they trained a single SVM classifier for each person in the database. The second system consists of sets of viewpoint-specific SVM classifiers and involves clustering during training. They performed extensive tests on a database which included faces rotated up to about 400 in depth. Their experiment shows that using facial components instead of the whole face pattern as input features significantly simplifies the task of face recognition.

Lu et al (2002) presented new method that utilizes a new variant of D-LDA to safely remove the null space of the between-class scatter matrix and applies a fractional step LDA scheme to enhance the discriminatory power of the obtained D-LDA feature space based on linear discriminant analysis. And it can be considered as a generalization of a number of techniques which are commonly in use. The DF-LDA method presented here is a linear pattern recognition method. Compared with nonlinear models, a linear model is rather robust against noises and most likely did not over fit.

Juwei Lu et al (2003) propose a kernel machine-based discriminant analysis method, which deals with the nonlinearity of the face pattern's distribution. The proposed method also effectively solves the so-called "small sample size" (SSS) problem which exists in most FR tasks.

Zhao et al (2004) proposed a novel face recognition method based on multi-features using a neural networks committee (NNC) machine. In this paper four different feature domains have been used for extracting features from input images, including the interest operator (IO), the principal component analysis (PCA), the Fisher's linear discriminant (FLD) and the Kernel Fisher linear discriminant (KFLD).In addition radial basis function neural networks (RBFNN) are adopted to implement the committee members. The experimental results show that the classification accuracy of their proposed NNC is much higher than that of single feature domain.

Guo et al (2005) proposed that an example-based learning for computer vision can be difficult when a large number of examples to represent each pattern or object class are not available. In such situations, learning from a small number of samples is of practical value. Their major contributions to this work are : 1) systematic evaluation of several popular methods in machine learning for a vision problem in the small sample case; 2) introduction of a novel algorithm called FSLP, and an analysis of how it can do feature selection together with classifier training while also circumventing the curse of dimensionality problem; and 3) analysis of the expected relative performance of these algorithms for learning in the small sample case, regardless of the classification task.

Kong et al (2005) in their paper provided an up-to-date review of research efforts in face recognition techniques based on two-dimensional (2D) images in the visual and infrared (IR) spectra such as PCA,ICA,LFA,LEM,EGM,HMM, local feature based etc.

Eleyan et al (2006) developed and compared two face recognition systems, one based on the PCA followed by a feed forward neural network (FFNN) called PCA-NN, and the other based on LDA followed by a FFNN called LDA-NN, are developed. The two systems consist of two phases which are the PCA or LDA pre-processing phase, and the neural network classification phase. This proposed systems show improvement on the recognition rates over the conventional LDA and PCA face recognition systems that use Euclidean Distance based classifier. Additionally, the recognition performance of LDANN is higher than the PCA-NN among the proposed systems.

Ahonen et al (2006) proposed a novel and efficient facial representation based on dividing a facial image into small regions and computing a description of each region using local binary patterns. These descriptors are then combined into a spatially enhanced histogram or feature vector. The texture description of a single region describes the appearance of the region and the combination of all region descriptions encodes the global geometry of the face. The LBP operator has been widely used in different applications such as texture classification, image retrieval, etc. The results of this experiment clearly show that facial images can be seen as a composition of micro patterns such as flat areas, spots, lines, and edges which can be well described by LBP.

Gandhe et al (2007) discuss and implemented different method of face recognition such as Principal Component Analysis, Discrete Wavelet Transform Cascaded with Principal Component Analysis, Contour Matching and Isodensity Line Maps Cascaded with Hopfield Neural Network. All these algorithms are tested on ORL Database and BioID Database. In Isodensity Line Maps+ Hopfield Neural Network Method none of spurious states equal to 0.15N, where N is the no. of neurons in the Hopfield neural network. But still method has scope to

1. To rescale the energy function in Hopfield network to avoid the spurious states and to improve the recognition rate. 2. Use neurofuzzy approach to improve recognition rate.

Wright et al (2008) proposed a method for automatically recognizing human faces from frontal views with varying

expression and illumination, as well as occlusion and disguise. They consider the recognition problem as one of classifying among multiple linear regression models, and argue that new theory from sparse signal representation offers the key to addressing this problem. Based on a sparse representation computed by -minimization, this new framework provides new insights into two crucial issues in face recognition: feature extraction and robustness to occlusion. For feature extraction they show that if sparsity in the recognition problem is properly harnessed, the choice of features is no longer critical as number of features is sufficiently large and the sparse representation is correctly computed. The theory of sparse representation helps predict how much occlusion the recognition algorithm can handle and how to choose the training images to maximize robustness to occlusion.

Agarwal et al (2010) presented a methodology for face recognition based on information theory approach of coding and decoding the face image. Proposed methodology is connection of two stages – Feature extraction using principle component analysis and recognition using the feed forward back propagation Neural Network. This scheme is independent of excessive geometry and computation. Recognition system is implemented based on eigenface, PCA and ANN.

Gumus et al (2010) proposed an evaluation, using various methods for face recognition. They used wavelet decomposition and Eigenfaces method which is based on Principal Component Analysis (PCA) as feature extracting techniques. After generating feature vectors, distance classifier and Support Vector Machines (SVMs) are used for classification step. They examined the classification accuracy according to increasing dimension of training set, chosen feature extractor–classifier pairs and chosen kernel function for SVM classifier. Considering weighted means of recognition rates, Wavelet based recognition gave better results than PCA based approach.

Paisitkriangkrai et al (2011) proposed effective and efficient framework for learning an adaptive online greedy sparse linear discriminant analysis model for face recognition. This is the first time to apply the online sparse linear discriminant analysis algorithm to object detection. By applying this online technique the classification performance can be further improved at the cost of minor increases in training time.

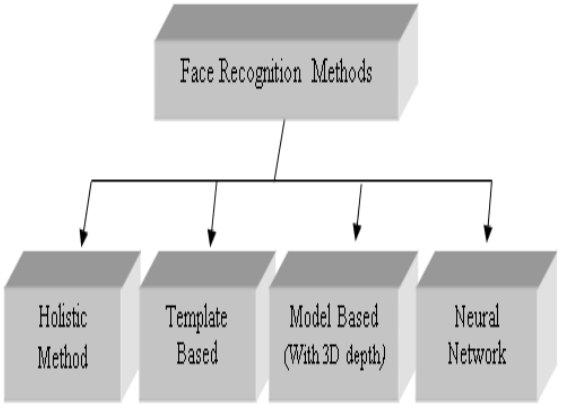
Jain et al (2012) presented a new way to recognize the face using facial recognition software and using neural network methods. That makes a facial recognition system to protect frauds and terrorists.

Ahmad et al (2012) proposed a method for automatic face recognition system where they have usually surveillance cameras at public places for video capture and these cameras have their significant value for security purpose. It is widely acknowledged that the face recognition has played an important role in surveillance system as it doesn't need the object's cooperation. The actual advantages of face based identification over other biometrics are uniqueness and acceptance. In this paper they tested the PCA, LDA, LBP and Gabor.

The first companies to invest in such researches were enforcement agencies. For example, the Woodrow W Bledsoe case law. Nowadays diverse enterprises are using face recognition in their products. One good example could be entertainment business. Products like Microsoft's Project Natal [28] or Sony's PlayStation Eye [29] will use face recognition. It will allow a new way to interact with the machine. The idea of detecting people and analyzing their gesture is also being used in automotive industry. Companies such as Toyota are developing sleep detectors to increase safety [30]. These and other applications are raising the interest on face recognition. Its narrow initial application area is being widened.

V. FACE RECOGNITION APPROACHES/METHODS:

During the last decade different approaches towards the face recognition system that have been proposed, can be classified into four main categories.



A. Holistic Methods:

In holistic approach, the complete face region is taken into account as input data into face catching system [31]. These methods use the whole face region as the raw input to a recognition system. One of the most widely used representations of the face region is eigenpictures [32], which are based on principal component analysis [33]. Shermina presented a face recognition technique which is based on multilinear principal component analysis and locality preserving projection to improve the performance of face recognition system [34]. The low face recognition rate is due to the background just at the back of the face. Similarly, Grudin reveals that correlation of entire face does not show

reasonable results. However, illumination normalization is essential to deal with Eigenfaces.

B. Template Based:/Feature Based

Template based face recognition, where face template has been extracted and used for face recognition [35]. Typically, in these methods, local features such as the eyes, nose, and mouth are first extracted and their locations and local statistics (geometric and/or appearance) are fed into a structural classifier [36]. A template-based approach to detecting the eyes and mouth in real images was presented in [37]. In Zhengya et al. a feature based scheme for fast face recognition is presented [38]. The technique comprises of shape feature based reference control, facial feature extraction technique and method to compute the difference between two faces using extracted set of features. Along with countering face recognition problems as expression, pose and illumination, the presented approach is robust with high performance factor for face recognition systems. A big challenge for feature extraction methods is feature "restoration", this is when the system tries to retrieve features that are invisible due to large variations, e.g. head Pose when we are matching' a frontal image with a profile image.

C. Model Based Methods:

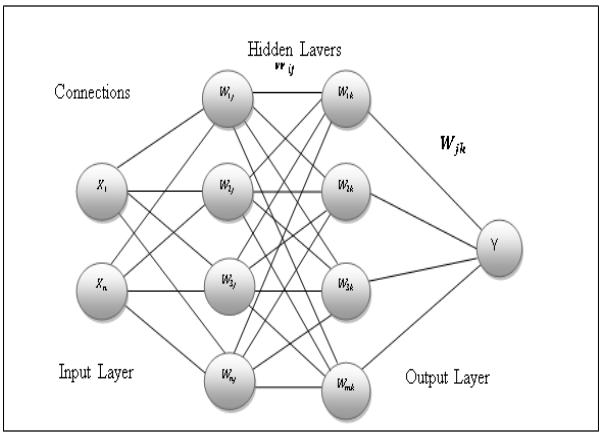
These can employ texture of the face and shape, along with the 3D depth information. Model-based approaches can be 2-Dimensional or 3 Dimensional [39]. These algorithms try to build a model of a human face. These models are often morphable. A morphable model allows classifying faces even when pose changes are present. 3D models are more complicate, as they try to capture the three dimensional nature of human faces [40]. Examples of this approach are Elastic Bunch Graph Matching or 3D Morphable Models. The image of a person's face is caught in 3D, allowing the system to note the curves of the eye sockets, for example, or the shapes of the chin or forehead. Even a face in profile would serve because the system uses depth, and an axis of measurement, which gives it enough information to construct a full face. The 3D system usually proceeds thus: Detection, Position, Measurement, Representation and Matching. Detection- Capturing a face either a scanning a photograph or photographing a person's face in real time. Position- Determining the location, size and angle of the head. Measurement- Assigning measurements to each curve of the face to make a template with specific focus on the outside of the eye, the inside of the eye and the angle of the nose. Representation- Converting the template into a code - a numerical representation of the face and Matching- Comparing the received data with faces in the existing database.

In Case the 3D image is to be compared with an existing 3D image, it needs to have no alterations. Typically, however, photos that are put in 2D, and in that case, the 3D image need a few changes. Utsav et al presented a face recognition system based on 3D generic elastic model for tackling the problem of pose variation during recognition of face [41]. The presented 3D model comprises a database of 2D pose views which are further adjusted for matching process. Muhammad et al. represents the 3D face recognition method using horizontal and vertical stripes [42]. However, none of them is free from limitations and is able to fully solve the pose problem [43].

D. Neural Networks:

Dr. Robert Hecht-Nielsen defines a neural network as: "...a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs" [44]. Neural Networks are more reliable as compared to linear methods like Karhunen-Loeve technique [45].

Neural networks are algorithms which are inspired by the types of computational structures found in the brain, enabling computers to learn from experience. Such networks incorporate processing elements known as "units", which are analogous to neurons. These are sorted as input units, hidden units, and output units. One unit connected to another implies that activity of one unit directly influences the activity of the other; the tendency of activity in one unit to induce or inhibit activity in the other is called the "weight" of the connection between these units. Networks learn by modifying these connection strengths or "weights".



Artificial neural networks are a popular tool in face recognition [46]. They have been used in pattern recognition and classification. One approach is to use decision-based neural networks, which classifies pre-processed and sub sampled face images [47]. Lawrence et al used self-organizing map neural network and convolutional networks [48]. Self-organization capacity approach is proposed based on SOM which mapped image samples in to a topological space in which input mapping is same for original and output space [49]. So, it encapsulates dimensional reduction as well

unvarying to minor changes in image sample. Victor emilNeagoe has presented concurrent SOM for face recognition [50]. Concurrent SOM is assembling of small SOM in which each SOM is developed individually for efficient and good result for one class [51]. A.S. Raja has proposed face recognition algorithm based on SOM following supervised learning approach. Gregoire Lefebvre and Christophe Garcia, have aimed probabilistic approach for face recognition [52]. Local feature is extracted from Region of interest then feed in to SOM Neural Network then face recognition is executed using probabilistic approach. The SOM seems to be computationally costly and can be substituted by a PCA without loss of accuracy.

Zhang and Fulcher presented an artificial neural network Group-based Adaptive Tolerance (GAT) Tree model for translation-invariant face recognition in 1996. Their algorithm was developed with the idea of implementing it in an airport surveillance system. The algorithm's input was passport photographs. This method builds a binary tree whose nodes are neural network group-based nodes. So, each node is a complex classifier, being a MLP the basic neural network for each group-based node.

Lin et al. developed face detection and recognition algorithm using probabilistic decision based neural networks (PDBNN). They applied it to face detection and feature extraction.

On the basis of architecture Neural Networks can be classified into two groups:

1. Based on one architecture, different methods of ANN are: Multilayer Perceptron (MLP); BackPropagation Neural Networks (BPNN); Retinal Connected Neural Network (RCNN); Rotation Invariant Neural Network (RINN); Fast Neural Networks (FNN); Convolutional Neural Network; Polynomial Neural Network (PNN).

2. Based on ANN on combination with other techniques, different methods are: Principal Component Analysis with ANN (PCA & ANN); Evolutionary Optimization of Neural Networks; Gabor Wavelet Faces with ANN; and finally Skin Color and BPNN.

VI. SELF-ORGANIZING MAP (SOM)

SOM has been proposed by Kohonen in the early eighties [53]. The SOM provides an orderly mapping of an input high-dimensional space while preserving the most important topological and metric relationships of the primary data items; it can be thought to produce some kind of abstractions of information. So it can be utilized in a number of ways in complex tasks such as pattern classification, process analysis, machine perception, control, and communication.

The overview of this method is described as follows.

a) Localizing The Face Image:

The original face image is firstly divided into M non-overlapping sub blocks with equal size. Then the M low dimensional local feature vectors (LFVs) are obtained by concatenating the pixels of each sub block.

b) SOM Projection:

SOM network is then trained using all the obtained sub blocks from all the available training images irrespective of classes. After the SOM map has been trained, each sub block R of the same face image I are mapped to its corresponding best matching units (BMUs) by a nearest neighbor strategy, whose location in the 2D SOM topological space is denoted as a location vector $l_{ii} = \{x_{i,}\ y_{i,}\}$.

All the location vectors from the same face can be grouped as a set, which is called SOM-face.

c) Identifying Face Based On SOM-Face:

A soft nearest neighbor (soft -NN) ensemble decision method, which can effectively exploit the outputs of the SOM topological space and can avoid the closing of information, is used to identify the unlabeled subjects.

VII. CONCLUSION

This paper has demonstrated the effectiveness of biometric system recognizing faces using a view based approach implemented with neural networks (SOM). Neural based Face recognition is robust and has better performance. Moreover fusion of multiple neural networks classifiers improves the overall performance of face recognition. Combined with other neural networks methods, SOM gives better results & recognition rate is increased. Further research is possible to increase performance issues and measurement and comparisons of other algorithms as described in the presented framework.

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