

# Side View Face Identification Based on Wavelet and Random Forest

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**Abstract** – This paper provides a novel side-view face authentication method based on discrete wavelet transform and random forest. A subset selection method that increases the number of training samples and allows subsets to preserve the global information is presented. The authentication method can be summarized to have the following steps: profile extraction wavelet decomposition, subset splitting and random forest verification. The new method takes the advantage of wavelet's localization property in both frequency and spatial domains, while maintaining the generalized properties of random forest. The implementation of the proposed method is computationally feasible and the experimental results show that the performance is satisfactory.

**Keywords**—Face Recognition, Human-Machine Interaction, Pattern Recognition, Video Surveillance ‘

## I. INTRODUCTION

Face Recognition is one of the most relevant and intelligence applications of image analysis. It's a main challenge is to build an automated system which equates human ability to recognize faces. Although humans are quite so good in identifying known faces, we must deal with a large amount of unknown faces when we are not very skilled. The computers, with an almost limitless, intelligence memory and fast computational speed, should overcome human's limitations up to certain level. Face Recognition remains as an unsolved problem and a demanded technology. In fact, the earliest works on this subject were made in the 1950's in psychology [1]. They came attached to other issues like interpretation of faces, emotions or perception of face gestures.

Engineers started to show interest in Face Recognition in the 1960's. One of the first researches on this subject was Woodrow W. Bledsoe. In 1960, Bledsoe, along other researches, started Panoramic Research in Palo Alto, California. During 1964 and 1965, Bledsoe, along with Charles Bisson and Helen Chan, worked to recognize human faces on using computers [2], [3], [4], and [5]. Because the funding of these researches was provided by an unnamed intelligence agency, little of the work was published. He continued his researches later at Stanford Research Institute [5]. Bledsoe designed and implemented a semi-automatic system. He described most of the problems that even 50 years later Face Recognition still suffers - variations in head rotation, illumination, facial expression and facial aging. In 1973, Fischler and Elschanger tried to

measure similar features automatically [6]. Their algorithm used local template matching and a global measure of fit to find and measure facial features.

There were other approaches back on the 1970's. Some researchers tried to define face as a set of geometric parameters and then perform some pattern recognition based techniques on those parameters obtain from face. But the first one that developed a fully automated Face Recognition system was Kenade in 1973 [7]. The algorithm extracted sixteen facial parameters automatically. He got a correct identification rate of 45-75%. He demonstrated that better results were obtained when irrelevant features were not used. In the 1980's there were a diversity of approaches actively followed by other researchers, most of them continuing with their previous tendencies. Some works tried to improve the methods used measuring subjective features. For instance, Mark Nixon presented a geometric measurement for eye spacing [8]. The template matching approach was improved with strategies such as "deformable templates". This decade also brought with new approaches for recognition. Some researchers build Face Recognition algorithms using artificial neural networks [9].

The first mention to Eigen faces in image processing, a technique that would become the prevalent approach in coming years, was made by L. Sirovich and M. Kirby in 1986 [10]. Their methods were based on the PCA i.e. Principal Component Analysis. Their goal was to make up an image in a lower dimension without losing no such information, and then reconstructing it in new faces [11]. The 1990's saw the broad recognition of the mentioned Eigen face 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 used Eigen faces for recognition [12]. Their algorithm was able to locate, track and classify a subject's head.

## II. FACE RECOGNITION SYSTEM

Face recognition system is a complex image-processing problem in real world applications with complex effects of illumination, occlusion, and imaging condition on the live images. These images have some known properties like; same resolution, including same facial feature components, and similar eye alignment. These images will be referred as "standard image" in the further sections. Recognition applications uses standard images and detection algorithms

detect the faces and extract face images which include eyes, eyebrows, nose, and mouth.

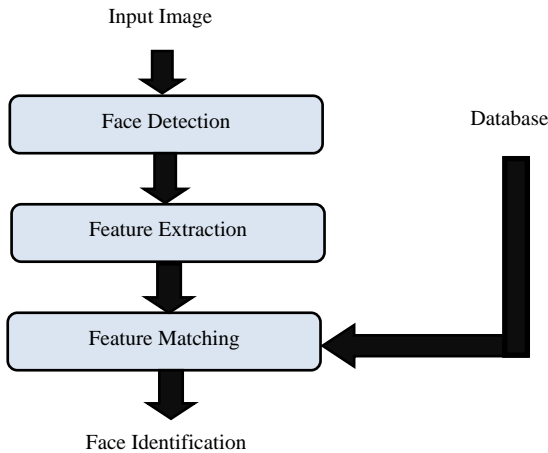


Figure 1: Basic flow of face recognition [13]

Figure 1 exhibits basic flow of face recognition system. The first step for face recognition system is to acquire an image from a camera or dataset. Second step is face detection from the acquired image. As a third step, face recognition that takes the face images from output of detection part. Final step is person identity as a result of recognition part.

### III. PROBLEMS ARISE DURING FACE RECOGNITION

Due to the multi dynamic nature of face images, a Face Recognition system can suffer from various problems during the Face Recognition process. It is possible to mention a Face Recognition system as either “robust” or “weak” depend on its recognition performances under these situations. The purposes of a vigorous Face Recognition system are given below:

#### A. Scale Invariance

The same face can be presented to the system at diverse measures. This may occur due to the focal distance between the camera and the face. As this distance gets closer, the face image gets larger.

#### B. Shift Invariance

The same face can be presented to the system at different perspectives and alignments. For example, face images of the similar person could be taken from frontal and profile views. Besides, head orientation may change due to translations and rotations.

#### C. Illumination Invariance

Face images of the similar person may be occupied under different illumination conditions such as, the position and the strength of the light source can be modified.

#### D. Emotional Expression and detail Invariance

Face images of the same person can differ in expressions when smiling or laughing. Also some details such as beards, moustaches or dark glasses can be present.

#### E. Noise Invariance

A robust Face Recognition system should be insensitive to noise generated by cameras or frame grabbers. Correspondingly, it should function under partially occluded images.

### IV. LITERATURE REVIEW

Face Recognition has been an interesting issue for both neuroscientists and computer engineers dealing with artificial intelligence (AI). A healthy human can detect a face easily and identify that face, whereas for a computer to recognize faces, the face area should be detected and recognition comes next. Hence, for a computer to recognize faces the photographs should be taken in a controlled environment; a uniform background and identical poses makes the problem easy to solve. The history of studies on human face perception and machine recognition of faces are given under this heading.

When building artificial Face Recognition systems, scientists try to understand the architecture of human Face Recognition system. Focusing on the methodology of human Face Recognition system may be useful to understand the basic system. However, the human Face Recognition system utilizes more than that of the machine recognition system which is just 2-D data. The human Face Recognition technique uses certain data obtained from some or all of the senses; auditory, visual, tactile, etc. All these data is used either individually or collectively for storage and memorizing of faces. In most of the cases, the ambiances also play an important role in human Face Recognition system. It is hard for a machine recognition system to handle so much data and their combinations. However, it is also hard for a human to remember many faces due to storage limits. An important potential advantage of a machine system is its memory capacity [14], whereas for a human Face Recognition system the important feature is its parallel processing capacity.

#### Machine Recognition of Faces

Although studies say human Face Recognition were expected to be a reference on machine recognition of faces, research on machine recognition of faces has developed by the independent of studies on human Face Recognition. During 1970’s, typical pattern classification techniques, which use measurements between features in faces or face profiles, were used. During the 1980’s, work on Face Recognition was nearly stable. Since the early 1990’s, research take interest on machine recognition of faces has grown enormously. The explanations may be;

- An increase in emphasis on commercial / civilian/research projects.
- The researches on neural network classifiers with highly emphasis on real-time computation and adaptation for Face Recognition.
- The obtain ability of real-time hardware.
- The growing need for surveillance applications.

The basic question relevant for face classification is that; what form the structural code (for encoding the face) should take to achieve Face Recognition. Two foremost methods are used for machine identification of human faces; geometrical local feature based methods, and holistic template matching based systems. Also, combinations of these two approaches, viz. hybrid methods, are used. The first approach, the geometrical local feature based one, extracts and measures discrete local features (such as hair, nose, mouth, eye, etc.) for recovering and recognizing faces. Then, standard statistical pattern recognition methods and/or neural network approaches are employed for matching faces using these measurements [15]. One of the well-known geometrical-local feature based methods is the Elastic Bunch Graph Matching (EBGM) technique.

The other approach, the holistic one, theoretically associated to template matching, endeavours to recognize faces using global face representations [16]. Holistic methods approach the face image as a whole face and extract features from the whole face region. In this holistic approach, as in the previous approach, the pattern classifiers are applied to classify the image after extracting the features of face. One of the methods to extract features in a holistic system is applying statistical methods such as PCA i.e. Principal Component Analysis) to the whole image. The most important problem in Face Recognition is the curse of dimensionality problem. Appropriate methods should be applied to reduce the dimension of the studied face space. Also, computational complexity would be an important problem when working on large databases.

In the given following sections, the main studies shall be summarized. The Face Recognition techniques are grouped as statistical and neural based approaches.

#### A. Statistical Approaches

Statistical methods include template matching based systems where the training and test images of faces are matched by measuring the respective correlation among them. Furthermore, statistical methods contain the projection based methods such as Linear Discriminant Analysis (LDA), Principal Component Analysis (PCA), etc.

**Template Matching:** Brunelli and Poggio [17] suggest that the optimal strategy for Face Recognition is holistic and corresponds to template matching. In their research, they associated a geometric feature based technique with a template matching based system. In the simplest form of template matching, the image (as 2-D intensity values) is compared with a single template representing the whole face using a distance metric. Although recognition by matching raw images has been successful under limited conditions, it agonizes from the usual shortcomings of straightforward correlation-based approaches, such as variable lighting conditions, sensitivity to face orientation, size, and noise. The reason for this vulnerability of direct matching methods lies in their attempt to carry out the required classification in a space of extremely high dimensionality. In order to overcome the curse of dimensionality, the connectionist corresponding of data

compression approaches is active first. Though, it has been successfully argued that the resulting feature dimensions do not necessarily retain the structure needed for classification, and that more common and influential approaches for feature extraction such as projection based systems are required.

#### B. Neural Network Approaches

Neural Network approaches plays major role in Face Recognition generally in a geometrical local feature based manner, but there are also some methods where neural networks used holistically means for whole face.

**Feature Based Back Propagation NN:** Temdee et al. [15] presented a frontal view Face Recognition method by using fractal codes which are determined by a fractal encoding method from the edge pattern of the face region covering eyes, eyebrows, and nose. In their Face Recognition system, the obtained fractal codes are fed as inputs to a Back-propagation Neural Network for identifying an individual features. They tested their system performance on the ORL face database. They performance report as 85 % correct recognition rate in the ORL face database.

**Dynamic Link Architectures (DLA):** Lades et al.[18] proposed an object recognition system based on Dynamic Link Architectures, which was an extension of the Artificial Neural Networks (ANN). The DLA uses correlations between the fine-scale cellular signals to group of neurons dynamically into higher order entities can be used to code high-level objects, such as a 2-D face image. Sparse graphs are used to represent face images, whose vertices are labelled by a multiresolution description in terms of local power spectrum, edges are labelled by geometrical distance vectors. Face Recognition can be done using elastic graph matching.

**Elastic Bunch Graph Matching (EBGM):** Wiskott et al. [19] proposed a geometrical local feature based Face Recognition system for single images out of a large database containing one image per person, which is known as Elastic Bunch Graph Matching (EBGM). In this system, faces are represented by labelled graphs, based on a Gabor Wavelet Transform (GWT). Elastic Graph Matching process extracts Image graphs of new faces and can be compared by a simple similarity function. In this recognition system, phase information is used for accurate node positioning and object-adapted graphs are used to handle large rotations of depth. The image graph extraction is totally based on the bunch graph, which was created from a small set of sample image graphs. In contrast to different neural-network systems, no extensive training was required for new faces or object classes. Only a small number of typical examples have to be inspected to build up a bunch graph, and individuals could be recognized after storing a single image.

The system inhibits most of the variance caused by size, positions, and expression of image graphs. In these image graphs, some predetermined points on the face (eyes, nose, mouth, etc.) are described by sets of wavelet components (jets). The image graph extraction is totally

based on the bunch graph, which was constructed from a small set of image graphs.

### Literature Review of Recent Papers

Rizk et al. provides an analysis of multilayer perceptron back propagation neural networks (MLP/BP NN), radial basis function neural networks (RBF NN), and multilayer cluster neural networks (MCNN) applications in different Face Recognition systems. Feature extraction based methods involved in the analysis are the discrete wavelet transforms (DWT), discrete radon transforms (DRT), and discrete cosine transforms (DCT) and the principal component analysis (PCA) technique. These algorithms were developed for using MATLAB and tested on the ORL i.e. Oracle Research Laboratory database. Also, a new proposed 2-stage Face Recognition system based on eye localization and a windowed face area for recognition [20].

Liu et al. presented an independent Gabor features (IGFs) method and its application to Face Recognition. IGF method first extracts a Gabor feature vector from a set of sampled Gabor wavelet representations of face images, then reduces the dimensionality of the vector by the use of PCA i.e. principal component analysis, and finally proposed the independent Gabor features based on the independent component analysis i.e. ICA. The independence property of these Gabor features facilitates the application of the PRM method for features classification. Gabor transformed face images exhibit strong characteristics of orientation selectivity and spatial locality. These images can, thus, produce salient local features that are most suitable for Face Recognition. While, ICA further reduces redundancy and represents independent features explicitly. These independent features are become very useful for other subsequent pattern discrimination and associative recall. Experiments done on Face Recognition using the FERET i.e. Face Recognition Technology and the ORL database sets, where the images vary in expression, scale, illumination, and pose, show the feasibility of the IGF method. In particular, the IGF method gain 98.5% correct Face Recognition accuracy when using 180 features for the FERET dataset, and 100% accuracy for the ORL dataset using 88 features [21].

Rida et al. presented a paper demonstrates how a Face Recognition system can be designed with artificial neural network. Note that the training process did not consist of a single call to a training function. Instead, the network was trained several times on various input ideal and noisy images, the images that contents face. In this case training a network on different sets of noisy images forced the network to learn how to deal with noise, a common problem in the real world [22].

Rasied et al. presented a developed Face Recognition system. The method used singular valued decomposition as images feature extractor and back propagation neural networks as its classifier. The back propagation training parameters are varied in order to find the best parameter with the highest performance accuracy. The results from experiments have showed that combinations of both

methodologies give good recognition rate and therefore considered as an effective Face Recognition system [23].

Variations in pose, expression and illumination situations make Face Recognition an even more challenging and difficult task. Wang et al. presented a Face Recognition approach by using image enhancement and Gabor wavelets transformation. Logarithm transformation and normalization are performed in face images captured under various lighting conditions for Face Recognition. This includes convolving a face image with a series of Gabor wavelets at diverse locations, scales and locations and extracting features from Gabor filtered images. Note worthy developments are also observed when the preprocessing and Gabor filtered images are used for feature extraction instead of the original images. The approach achieves 94.4% recognition accuracy using only 160 features of a face image. Results show that this method advances Face Recognition performance using this scheme when training and testing on images captured under variable illumination and expression [24].

Song et al. have proposed an efficient shaded-face pre-processing technique using front-face symmetry. The existing Face Recognition PCA technique has a shortcoming of making illumination variation lower the recognition performance of a shaded face. The study has aimed to improve the performance by using the symmetry of the left and right face. In order to evaluate the performance of the proposed Face Recognition method, the study experimented with the Yale face database with left/right shadows. The experimental methods for this are as following: the existing PCA, PCA with first three Eigenface excluded, histogram equalization and the proposed method [25].

Boualleg et al. proposed a new hybrid method for the recognition of faces combines the neural networks with the principal component analysis. By using the geometrical approach, a preliminary classification of the faces is carried out by PCA before using a neuronal classifier (PMC) [26].

Face Recognition is a challenging task in computer vision and pattern recognition. It is well-known that attaining a low-dimensional feature representation with enhanced discriminatory power is of paramount importance to Face Recognition. Furthermore, current investigation has shown that the face images reside on a possibly nonlinear multifarious. Thus, how to efficiently feat the hidden structure is a key problem that significantly affects the recognition results. In this paper, Wang et al. proposed a new unsupervised nonlinear feature extraction method called spectral feature analysis (SFA). The main advantages of SFA over traditional feature extraction methods are: (1) SFA does not suffer from the small-sample-size problem; (2) SFA can extract discriminatory information from the data, and they show that linear discriminant analysis can be subsumed under the SFA framework; (3) SFA can effectively discover the nonlinear structure concealed in the data. These pleasing belongings make SFA very suitable for Face Recognition tasks. Results on three yardstick face

databases illustrate the superiority of SFA over traditional methods [27].

Study demonstrated that color information makes contribution and enhances robustness in Face Recognition. However, utmost of the methods to Face Recognition still use gray-scale images, mostly due to the additional dispensation and storing charges of the larger input size for color images. Multi-layer neural networks (MLNs) have been widely used in Face Recognition applications and yielded highly competitive results. Youssef et al. proposed a new method that makes a full use of color information without noteworthy additional dispensation charge and validates that the neural network in the proposed method is compatible with the existing MLN training algorithms based on error back propagation (EBP) [28].

The face is a complex multidimensional visual model and it is difficult for Face Recognition to develop a computational model. Mu-chun presented a novel approach for Face Recognition that associates fast independent component analysis (Fast-ICA) and Radial Basis Function neural networks. Initially, to reduce the image data, low-frequency sub-band images are extracted from original face images by 2D wavelet transform. After, Fast-ICA is applied to extract features from the low-frequency sub-band image which contains most discriminated information of face image. For decreasing computational charge, the enhanced Fast-ICA method is presented. Then, RBF neural networks classifier is considered [29].

The Face Recognition is an active subject in the area of computer pattern recognition that has been an emphasis in reach for the last couple of decades because of its widely potential applications. Wang presented a Face Recognition approach which is put forward based on the RBF neural network. The problem of feature of a face image vector, the problem of training algorithm of hidden layer neural nodes and the difficulty of standardization of the image-size are also discussed. Experiments have been conducted on ORL face database [30].

Youyi et al. presented a Face Recognition algorithm based on wavelet neural network. This procedure rest on the multi-resolution property of wavelet and the robustness and memorization features of neural network, as well as syndicates with the wavelet neural network step modification algorithm, a wavelet neural network is intended for the use of Face Recognition. Its efficiency and correctness are verified by some experiments [31].

Pritha et al. proposed a method, comprising of Laplacian of Gaussian (LoG) filter for intricate facial detail enhancement, Singular Value Decomposition (SVD) for holistic feature extraction and Feed forward Neural Network (FFNN) for classification. Applications of LoG filter best part, else concealed facts such as moles, wrinkles, etc. The principal components from SVD form a basis for the unique dataset. The unique dataset is then predictable onto the condensed subspace, the outcome of which is weight vectors that are fed as input to the FFNN for the training module. The FFNN uses gradient descent batch mode, back propagation algorithm with adaptive

supervised learning. The technique is launched L-SVD-NN and is tested on the Yale face dataset achieving an accuracy of 84.85% [32].

Hussein developed a Face Recognition system for personal identification and verification using Principal Component Analysis with different distance classifiers. The test results in the ORL face database produces interesting results from the point of view of recognition achievement rate, and robustness of the Face Recognition algorithm. Different classifiers were used to match the image of a person to a class (a subject) obtained from the training data. These classifiers are: the Euclidian distance classifier, the City-Block Distance Classifier, the Squared Chebyshev distance Classifier and the Squared Euclidian Distance Classifier. The Euclidian Distance Classifier produces a recognition rate higher than the City-Block Distance Classifier which gives a recognition rate higher than the Squared Chebyshev Distance Classifier[33].

Singh et al. developed a Face Recognition system which is based on the modified PCA algorithm by using some components of the LDA algorithm of the Face Recognition. This algorithm is based on the measure of the principal components of the faces and also to find the shortest distance between them [34].

Face Recognition involves comparing an image with a database of stored faces in order to identify the individual in that input image. The images can be examined and faces can then be recognized, earlier they can be recognized. There are different approaches of Face Recognition which involve a series of steps that serve to apprehending, examining and associating a face to a database of stored images. Zainudin et al. covered comparative study of image recognition between Linear Discriminant analysis (LDA) and Principal Component Analysis (PCA). In this study, the result of PCA and LDA is analyzed in term of its accuracy, measurement of accurate recognition, time execution and database used [35].

Prof. V.P. Kashisagar proposed new technique for Face Recognition consisting on the concept of information based theory i.e. coding and decoding of different face images. He used PCA i.e. Principal Component Analysis for feature extraction and Neural Network for recognition and introduced new results [36]. Bashir proposed a new method for Face Recognition. After a preprocessing and normalization stage to the image, PCA (Principle Components Analysis) is applied to recognize a specified face. If the face not recognized correctly, then more features are extracted face color and moment invariant. The face is recognized again using Decision Tree. Applying two stage recognition process increased the recognition accuracy by 2% [37].

Ding et al. provides a novel side-view face authentication method based on discrete wavelet transform and random forest. A subset selection method that increases the number of training samples and allows subsets to preserve the global information is presented. The authentication method can be summarized to have the following steps: profile extraction, wavelet decomposition, subset splitting and

random forest verification. The new method takes the advantage of wavelet's localization property in both frequency and spatial domains, while maintaining the generalized properties of random forest [38].

## V. CONCLUSION

Carrying out literature review is very significant in any research work as it clearly establishes the need of the work and the background development. It generates related queries regarding improvements in the study already done and allows unsolved problems to emerge and thus clearly define all boundaries regarding the development of the research project. Plenty of literature has been reviewed in this paper in connection with Face Recognition techniques.

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