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Efficiency Improvement in Recognition of Human Facial Expression

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ABSTRACT

Face recognition has been very important issue in computer vision and pattern recognition over the last several decades. One difficulty in face recognition is how to handle the variations in the expression, pose and illumination when only a limited number of training samples are available. Here we used two databases, one is an Indian database which is not a standard database and second one is a JAFFE (Japanese Female Facial Expression). When we implemented facial expression recognition system using Indian database then we got accuracy of the algorithm is 68%. Then we implemented same system with JAFFE database then we got accuracy of the algorithm is about 70-71% which gives quite poor Efficiency of the system. Then we implemented facial expression recognition system with Gabor filter and principal component analysis. Here Gabor filter we have selected because of its good feature extraction property. Then the output of the Gabor filter we have used as an input for the PCA. Principal Component Analysis has a good feature of dimension reduction so we choose it for that purpose. In this system we used JAFFE database for training and testing purpose and we got good results. We got efficiency of the system is about 76-77% which higher than the previous system.

Keywords : Human Facial Expression, JAFFE, fingerprint, face recognition, DNA, iris recognition, ICA, Principal Component Analysis, Linear Discriminant Analysis, PCA

I. INTRODUCTION

Important motivation of facial expression recognition is that expression itself is an efficient way of communication: it's natural, non-intrusive, and has shown that, surprisingly, expression conveys more information than spoken words and voice tone. To build a friendlier Human Computer Interface, expression recognition is essential.

Facial Expressions provide important communicative cues, which constitute 55 percent of the effect of a communicated message; hence recognition of facial expressions became a major modality in Human Computer Interaction. For example, in a HumanComputer Interface if the Computer can sense and understand the users' intentions from their facial expressions, it might be possible for the system to assist them by giving suggestion and proposals according to sensed situation.

People exchange their emotional state nonverbally by reading information from other faces. Thereby, the opportunity is given to draw a conclusion between the facial expressions and their related emotions. Being aware of the emotion of others, people are able to better judge the situation, which makes them adapt their own behavior. The challenge for humans is to not incorrectly interpret the facial expressions and thus to misjudge the situation. Emotion recognition represents an essential means for improving the communication between man and machine.

A possible purpose would be the invention of a learning software which reacts on the learners mood by asking easier or more difficult questions or cheering up the user with a learning-game. One could as well imagine a board computer which realizes when the driver of a car or bus gets tired or stressed and then advises to take a break from driving. Therefore, a lot of research is spent on developing algorithms for facial expression recognition, and great achievements have been made during the last decade.

II. METHODS AND MATERIAL

2.1 Biometrics

Biometrics is the science and technology of measuring and analyzing biological data. In information technology, biometrics refers to technologies that measure and analyze human body characteristics, such as DNA, fingerprints, eye retinas and irises, voice patterns, facial patterns and hand measurements, for authentication purposes.

Biometrics consists of methods for uniquely recognizing humans based upon one or more intrinsic physical or behavioral traits. In computer science, in particular, biometrics is used as a form of identity access management and access control. It is also used to identify individuals in groups that are under surveillance.

Biometric Technology

Today, a wide variety of applications require reliable verification schemes to confirm the identity of an individual .The term biometric comes from the Greek words bios (life) and metrikos (measure). Biometric technology is a ways to secure human society and to extend knowledge about human nature and behavior. It refers to an automatic recognition of individuals based on a feature vector(s) derived from their physiological and/or behavioral characteristic.

Need of Biometrics

- ✓ Authentication – the process of verifying that a user requesting a network resource is who he, she, or it claims to be, and vice versa.
- ✓ Conventional authentication methods
- ✓ Something that you have – key, magnetic card or smartcard
- ✓ Something that you know – PIN or password

Pattern Recognition

A biometric system is essentially a pattern-recognition system that recognizes a person based on a feature vector derived from a different biometric characteristic that the person possesses. Biometric characteristics can be divided in two main classes

1. Physiological are related to the shape of the body. Examples include, fingerprint, face recognition, DNA, Palm print, hand geometry, iris recognition.
2. Behavioral are related to the behavior of a person. Examples include, typing rhythm, gait, and voice.

A biometric system can operate in the following two modes

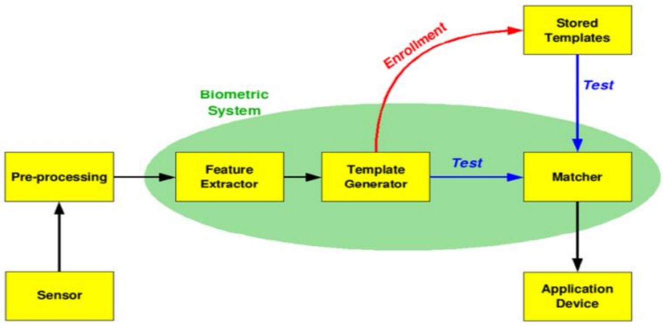

Figure 1

2.1 Biometric System Process Flow

Identification – A one-to-many comparison of the captured biometric against a biometric database in attempt to identify an unknown individual. The identification only succeeds in identifying the individual if the comparison of the biometric sample to a template in the database falls within a previously set threshold.

2.5 Types of Biometrics:

There are numerous types of biometric methods in use. The most widely applied methods include:

2.5.1 Face Recognition

The identification of a person by their facial image can be done in number of different ways such as by capturing an image of the face in the visible spectrum using an inexpensive camera or by using the infrared patterns of facial heat emission. Face Recognition generally involves two stages, Face detection & face recognition. Some facial recognition algorithms identify faces by extracting landmarks, or features, from an image of the subject's face. For example, an algorithm may analyze the relative position, size, and/or shape of the eyes, nose, cheekbones, and jaw. These features are then used to search for other images with matching features. Other algorithms normalize a gallery of face images and then compress the face data, only saving the data in the image that is useful for face detection. In face localization, the task is to find the locations and sizes of a known number of faces.

2.5.2 Iris Recognition

Iris recognition is an automated method of biometric identification that uses mathematical pattern-recognition techniques on video images of the irises of an individual's eyes, whose complex random patterns are unique and can be seen from some distance. It is a method of biometric authentication that uses pattern-recognition techniques based on high-resolution images of the irises of an individual's eyes. Iris recognition uses camera technology, with subtle infrared illumination reducing seculars reflection from the convex cornea, to create images of the detail-rich, intricate structures of the iris. Converted into digital templates, these images provide mathematical representations of the iris that yield unambiguous positive identification of an individual.

Iris recognition efficacy is rarely impeded by glasses or contact lenses. Because of its speed of comparison, iris recognition is the only biometric technology well-suited for one-to-many identification.

Figure 2. Iris Scanner

A key advantage of iris recognition is its stability. An iris-recognition algorithm first has to identify the approximately concentric circular outer boundaries of the iris and the pupil in a photo of an eye. The set of pixels covering only the iris is then transformed into a bit pattern that preserves the information that is essential for a statistically meaningful comparison between two iris images. The mathematical methods used resemble those of modern loss compression algorithms for photographic images. The result is a set of complex numbers that carry local amplitude and phase information for the iris image.

To authenticate via identification (one-to-many template matching) or verification (onetoone template matching), a template created by imaging the iris is compared to a stored value template in a database. The key advantage of Iris recognition is that it is an internal organ that is well protected against damage and wear by a highly transparent and sensitive membrane.

2.5.3 Fingerprint Recognition

One of the most commercially available biometric technologies, fingerprint recognition devices for desktop and laptop access are now widely available from many different vendors at low cost. Finger prints are unique for each finger of a person including identical twins. With these devices, users no longer need to type passwords instead; only a touch provides instant access. Fingerprint systems can also be used in identification mode.

Figure 3. Fingerprint Scanner

2.5.4 Signature Recognition

The technology is based on measuring speed, pressure and angle used by the person when a signature is produced. This technology uses the dynamic analysis of a signature to authenticate a person. One focus for this technology has been e-business applications and other applications where signature is an accepted method of personal authentication.

Biometric signature recognition systems will measure and analyze the physical activity of signing, such as the stroke order, the pressure applied and the speed. An application of face biometrics includes Access to documents, contract / agreement execution, acknowledgement of goods or services received, and banking services.

2.5.5 Voice Recognition

Voice recognition is "the technology by which sounds, words or phrases spoken by humans are converted into electrical signals, and these signals are transformed into coding patterns to which meaning has been assigned". The difficulty in using voice as an input to a computer simulation lies in the fundamental differences between human speech and the more traditional forms of computer input. While computer programs are commonly designed to produce a precise and well-defined response upon receiving the proper (and equally precise) input, the human voice and spoken words are anything but precise. Each human voice is different, and identical words can have different meanings if spoken with different inflections or in different contexts.

III. FACIAL EXPRESSION RECOGNITION APPROACHES

3.1 Knowledge based Method

In this approach, face detection methods are developed based on the rules derived from the researcher's knowledge of human faces. It is easy to come up with simple rules to describe the features of a face and their relationships. For example, a face often appears in an image with two eyes that are symmetric to each other, a nose, and a mouth.

The relationships between features can be represented by their relative distances and positions. Facial features in an input image are extracted first, and face candidates are identified based on the coded rules.

A verification process is usually applied to reduce false detections. One problem with this approach is the difficulty in translating human knowledge into well-defined rules. If the rules are detailed (i.e., strict), they may fail to detect faces that do not pass all the rules. If the rules are too general, they may give many false positives. Moreover, it is difficult to extend this approach to detect faces in different poses since it is challenging to enumerate all possible cases. On the other hand, heuristics about faces work well in detecting frontal faces in uncluttered scenes. Yang and Huang used a hierarchical knowledge-based method to detect faces. Their system consists of three levels of rules.

At the highest level, all possible face candidates are found by scanning a window over the input image and applying a set of rules at each location. The rules at a higher level are general descriptions of what a face looks like while the rules at lower levels rely on details of facial features.

3.2 Feature based Method

In contrast to the knowledge-based top-down approach, researchers have been trying to find invariant features of faces for detection. The underlying assumption is based on the observation that humans can effortlessly detect faces and objects in different poses and lighting conditions and, so, there must exist properties or features which are invariant over this variability. Numerous methods have been proposed to first detect facial features and then to infer the presence of a face.

Facial features such as eyebrows, eyes, nose, mouth, and hair-line are commonly extracted using edge detectors. Based on the extracted features, a statistical model is built to describe their relationships and to verify the existence of a face. One problem with these feature-based algorithms is that the image features can be severely corrupted due to illumination, noise, and occlusion. Feature boundaries can be weakened for faces, while shadows can cause numerous strong edges which together render perceptual grouping algorithms useless.

In a Gaussian skin color model is used to classify skin color pixels. To characterize the shape of the clusters in the binary image, a set of 11 lowest-order geometric moments is computed using Fourier and radial Mellin transforms. For detection, a neural network is trained with the extracted geometric moments. Their experiments show a detection rate of 85 percent based on a test set of 100 images. The symmetry of face patterns has also been applied to face localization Skin/non skin classification is carried out using the class-conditional density function in YES color space followed by smoothing in order to yield contiguous regions. Next, an elliptical face template is used to determine the similarity of the skin color regions based on Hausdorff distance.

Finally, the eyes centers are localized using several cost functions which are designed to take advantage of the inherent symmetries associated with face and eye locations. The tip of the nose and the center of the mouth are then located by utilizing the distance between the eye centers. One drawbacks is that it is effective only for a single frontal-view face and when both eyes are visible. In contrast to pixel-based methods, a detection method based on structure, color, and geometry was proposed.

3.3 Template based Method

In template matching, a standard face pattern (usually frontal) is manually predefined or parameterized by a function. Given an input image, the correlation values with the standard patterns are computed for the face contour, eyes, nose, and mouth independently. The existence of a face is determined based on the correlation values. This Approach has the advantage of being simple to implement. However, it has proven to be inadequate for face detection since it cannot effectively deal with variation in scale, pose, And shape. Multi-resolution, multistage, sub templates and deformable templates have subsequently been proposed to achieve scale and shape invariance. They used several sub Templates for the eyes, nose, mouth, and face contour to model a face. Each sub template is defined in terms of line segments. Lines in the input image are extracted based on greatest gradient change and then matched against the sub templates. The correlations between sub images and contour templates are computed first to detect candidate locations of faces. Then, matching with the other sub templates is performed at the candidate positions.

3.4 Appearance based Method

Contrasted to the template matching methods where templates are predefined by experts, the “templates” in appearance- based methods are learned from examples in images. In general, appearance-based methods rely on techniques from statistical analysis and machine learning to find the relevant characteristics of face and non-face images.

The learned characteristics are in the form of distribution models or Discriminant functions that are consequently used for face detection. Meanwhile, dimensionality reduction is usually carried out for the sake of computation efficiency and detection efficacy. Many appearance-based methods can be understood in a probabilistic framework.

IV. FACIAL EXPRESSION RECOGNITION ALGORITHM

The input of a facial Expression recognition system is always an image or video stream. The output is an identification or verification of the subject or subjects that appear in the image or video. Some approaches define a facial Expression recognition as a mainly four step process fig 4.

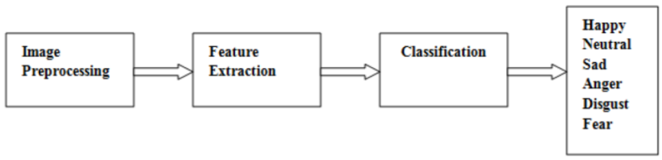

Figure 4. Block Diagram of Facial Expression Recognition System

4.1 Image Pre-processing

The image is first processed in order to extract the features, which describe its contents. The processing involves filtering, normalization, segmentation, and object identification. The output of this stage is a set of significant regions and objects. Image pre-processing often takes the form of signal conditioning (such as noise removal, and normalization against the variation of pixel position or brightness), together with segmentation, location, or tracking of the face or its parts. Expression representation can be sensitive to translation, scaling, and rotation of the head in an image. To combat the effect of these unwanted transformations, the facial image may be geometrically standardized prior to classification.

4.1.1 Face Space and Its Dimensionality

Computer analysis of face images deals with a visual signal (light reflected of the surface of a face) that is registered by a digital sensor as an array of pixel values. The pixels may encode color or only intensity. After proper normalization and resizing to a fixed m-by-n size, the pixel array can be represented as a point (i.e. vector) in an mndimensional image space by simply writing its pixel values in a fixed order. A critical issue in the analysis of such multi-dimensional data is the dimensionality, the number of coordinate necessary to specify a data point.

4.1.2 Image Space Vs Face Space :

In order to specify an arbitrary image in the image space, one needs to specify every pixel value. "Thus nominal" dimensionality of the space, dictated by the pixel representation, is mn-a very high number even for images of modest size however, much of the surface of a face is smooth and has regular texture.

Therefore, per-pixel sampling is in fact unnecessarily dense. The value of a pixel is typically highly correlated with the values of the surrounding pixels. Moreover, the appearance of faces is highly constrained, for example, any frontal view of a face is roughly symmetrical, has eyes on the sides, nose in the middle, etc. A vast proportion of the points in the image space do not represent physically possible faces. Thus, the natural constraints dictate that the face images will in fact be confined to a subspace, which is referred to as the face space.

4.2 Feature Extraction Techniques:

Feature extraction- involves obtaining relevant facial features from the data.

These features could be certain face regions, variations, angles or measures, which can be human relevant (e.g. eyes spacing) or not. This phase has applications like facial feature tracking or emotion recognition. Finally, the system does recognize the facial expression.

There are Several Algorithms are used for Feature Extraction of Image.

Table 1 Feature Extraction Algorithms

Method	Notes
Principal Component Analysis (PCA)	Eigenvector-based, linear map
Kernel PCA	Eigenvector-based , non-linear map, uses kernel methods
Eigenvector-based , non-linear map, uses kernel methods	Eigenvector-based, supervised linear map
Independent Component Analysis (ICA)	Linear map, separates non-Gaussian distributed features
Neural Network based methods	Diverse neural networks using PCA, etc.
Active Appearance Models (AAM)	Evolution of ASM, uses shape and texture
Gabor wavelet transforms	Biologically motivated, linear filter

4.2.1 INDEPENDENT COMPONENT ANALYSIS

Independent Component Analysis (ICA) has emerged recently as one powerful solution to the problem of blind source separation while its possible use for face recognition has been shown by Bartlett and Sejnowski.ICA searches for a linear transformation to express a set of random variables as linear combinations of statistically independent source variables. The search criterion involves the minimization of the mutual information expressed as a function of high order cumulants. Basically PCA considers the 2nd order moments only and it uncorrelates data, while ICA accounts for higher order statistics and it identifies the independent source components from their linear mixtures. ICA thus provides a more powerful data representation than PCA. As PCA derives only the most expressive features for face reconstruction rather than face classification, one would usually use some subsequent discriminant analysis to enhance PCA performance.

As PCA considers the 2nd order moments only it lacks information on higher order statistics. ICA accounts for higher order statistics and it identifies the independent source components from their linear mixtures (the observables). ICA thus provides a more powerful data representation than PCA as its goal is that of providing an independent rather than uncorrelated image decomposition and representation. ICA of a random vector searches for a linear transformation which minimizes the statistical dependence between its components.

Independent component analysis is an unsupervised learning method based on high order statistics. Briefly, ICA is the separation of independent sources from their observed linear mixtures (Hyvarinen and Oja, 2000). The system model of ICA is given as

$$X = AS$$

where A denotes the mixing matrix, S denotes the source matrix containing statistically independent source vectors in its rows and X denotes the data matrix. In the ICA method, the only information we possess is the observations, and neither the mixing matrix nor the distribution of the sources is known. Under the assumptions that the sources are statistically independent and non-Gaussian (atmost one of them can have Gaussian distribution), we find the unmixing matrix W by maximizing some measure of independence. In other words, a separation matrix, W, is estimated, which, under ideal conditions, is the inverse of the mixing matrix A.

$$Y = WX \text{ and } W = A^{-1} \text{ and } Y = S$$

4.2.2 LINEAR DISCREMINENT ANALYSIS

Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) are two commonly used techniques for data classification and dimensionality reduction.

Linear Discriminant Analysis easily handles the case where the within-class frequencies are unequal and their performances have been examined on randomly generated test data.

This method maximizes the ratio of between-class variance to the within-class variance in any particular data set thereby guaranteeing maximal separability.

The use of Linear Discriminant Analysis for data classification is applied to classification problem in speech recognition. The prime difference between LDA and PCA is that PCA does more of feature classification and LDA does data classification. In PCA, the shape and location of the original data sets changes when transformed to a different space whereas LDA doesn't change the location but only tries to provide more class separability and draw a decision region between the given classes. This method also helps to better understand the distribution of the feature data.

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4.2.3 PRINCIPAL COMPONENT ANALYSIS

Principal Component Analysis is a standard technique used in statistical pattern recognition and signal processing for data reduction and Feature extraction. Principal Component Analysis (PCA) is a dimensionality reduction technique based on extracting the desired number of principal components of the multi-dimensional data. The purpose of PCA is to reduce the large dimensionality of the data space (observed variables) to the smaller intrinsic dimensionality of feature space (independent variables), which are needed to describe the data economically. This is the case when there is a strong correlation between observed variables. The first principal component is the linear combination of the original dimensions that has the maximum variance; the n-th principal component is the linear combination with the highest variance, subject to being orthogonal to the n -1 first principal components. The main idea of the principle component is to find the vectors that best account for the distribution of face images within the entire image space. These vectors define the subspace of face images, which we call "face space".

STEPS OF PCA

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- ✓ Acquire the initial set of face images (the training set).
- ✓ Calculate the eigenfaces from the training set, keeping only the M images that correspond to the highest eigenvalues. These M images define the face space. As new faces are experienced; the eigenfaces can be up-dated or recalculated.
- ✓ Calculate the corresponding distribution in M-dimensional weight space for each known individual, by projecting his or her face images onto the "face space".

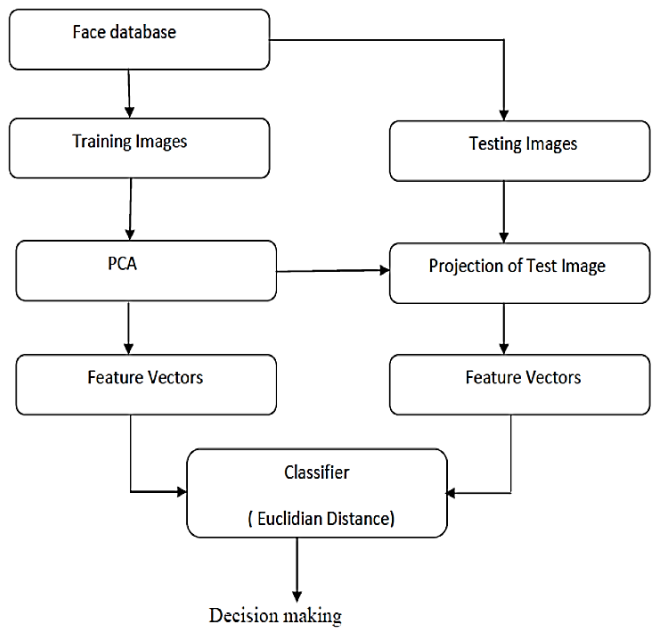

Figure 5. PCA Flowchart

The basic steps of PCA are:

1. Collect xi of an n dimensional data set x , i=1,2,,3………,m
2. Calculate mean mx and subtract it from each data point , xi - mx
3. Calculate Covariance Matrix C=(xi - mx)(xi - mx)T
4. Determine eigenvalues and eigenvectors of Holistic methods the matrix c
5. Sort Eigen values and corresponding eigenvectors in decreasing order
6. Select first d <= n Eigen vectors and generates data set in new representation.
7. Projected test image is compared to every projected training image and result is the training image closest to the test image.

V. RESULTS AND DISCUSSION

GABOR FILTER

Gabor filters are often used in image processing and are based on physiological studies of the human visual cortex [12]. Gabor filter is one of the most successful approaches for processing images of the human face (Fasel et al., 2002). Lyons et al. (1998) proposed a Gabor wavelet based facial expression coding system and show that their representation method has a high degree of correlation with the human semantic ratings. In Zhang etal. [13], Gabor filter banks based facial expression coding for feature extraction and multilayer perception(MLP) based feature classification is reported to have performed better than geometric feature based facial expression recognition.

Face feature extraction represents the first part of the identification process. Before describing the featuring process, we must mention another important operation related to face recognition. A proper image face registration is essential for a good face-expression recognition performance. Also, some image pre-processing operations may be necessary. First, the original face images have to be converted to the grayscale form. Then, some contrast and illumination adjustment operations are performed. All face images must be processed with the same illumination and contrast. So for that some histogram equalization operations are performed on these images, to obtain a satisfactory contrast. Also, the facial images are often corrupted by various types of noise. So, we process them with the proper low-pass filters, for noise removal and restoration [14]. The enhanced face images are then ready for the featuring process. We try to obtain some feature vectors which provide optimal characterizations of the visual content of facial images. For this reason we will have to do the two-dimensional Gabor filtering, a widely used image processing tool, for feature extraction.

The Gabor filter (Gabor Wavelet) represents a band-pass linear filter whose impulse response is defined by a harmonic function multiplied by a Gaussian function. Thus, a bi dimensional Gabor filter constitutes a complex sinusoidal plane of particular frequency and orientation modulated by a Gaussian envelope. It achieves an optimal resolution in both spatial and frequency domains.

$$\psi_{f,\theta}(x,y) = \exp\left[-\frac{1}{2}\left\{\frac{x_{\theta_n}^2}{\sigma_x^2} + \frac{y_{\theta_n}^2}{\sigma_x^2}\right\}\right]\exp(2\pi f x_{\theta_n}),$$

$$\text{where, } \begin{bmatrix} x_{\theta_n} \\ y_{\theta_n} \end{bmatrix} = \begin{bmatrix} \sin\theta_n & \cos\theta_n \\ -\cos\theta_n & \sin\theta_n \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

σx σy are the standard deviations of the Gaussian envelope along the x- and y- dimensions, f is the central frequency of the sinusoidal plane wave, and θn the orientation. The rotation of the xy plane by an angle n θ will result in a Gabor filter at the orientation θn.The angle θn is defined by:

$$\theta_n = \frac{\pi}{p}(n-1),$$

$$\text{for } n=1,2,\ldots,p \text{ and } p \in \mathbf{N}, \qquad (5)$$

The input image I (x, y) is convolved with the Gabor filter bank (x, y, f ,θ) to obtain Gabor feature representation Qm,n (x, y).

$$Q_{m,n}(x, y)\,(x, y) = I(x, y) * \psi(x, y, f, \theta) \qquad (6)$$

The phase of $Q_{m,n}(x, y)$ changes linearly under small displacement in the direction of the sinusoid, but the magnitude of it changes slowly with displacement. Hence we used the magnitude of the convolution outputs.

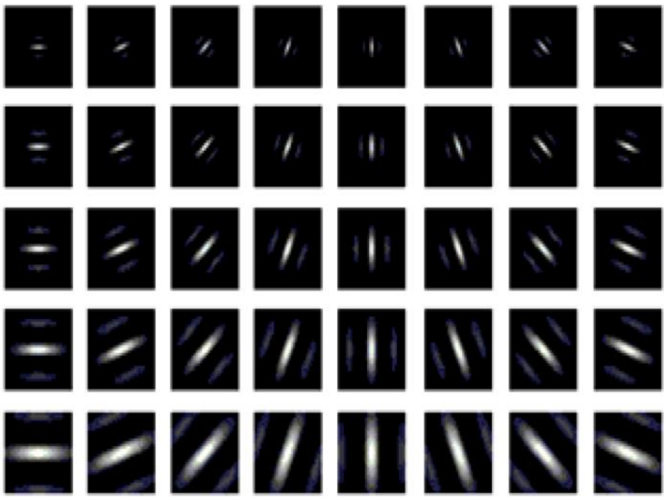

Figure 6. The real part of the Gabor filters with five frequencies and eight orientations for $f_{max} = \pi/2$, the row corresponds to different frequency f_m, the column corresponds to different orientation θ_n

VI. CONCLUSION AND FUTURE WORK

In this paper we discussed how PCA actually works and how it is use for facial expression recognition which is a novel and effective subtle facial expression analysis approach. By using different frequencies and orientations we can get batter result of feature extraction of the face using Gabor filter. We can use the different database and we can see the result comes by using that database. This method gives significant results. But in case of luminance variations in image it will not give satisfactory results.

So for best results we have to enhance this PCA method and also we have to combine different methods to get good results. Other feature extraction methods is ICA, LDA, kernel PCA and many more. As facial expressions plays important role in human-to-human communication, our future work is to develop a facial expression recognition system with better efficiency, which combines body gestures of the user with user facial expressions.

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