Facial Expression Recognition Using Subspace Learning On LBP

Kazi Nuzhat Tasnem

ID: 2014-1-60-005

Tazin Ahmed

ID: 2014-1-60-105

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Department of Computer Science and Engineering
East West University
Dhaka-1212, Bangladesh

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Declaration

We, hereby, declare that the work presented in this thesis is the outcome of the research performed by us under the supervision of Dr.Taskeed Jabid , Assistant Professor, Department of Computer Science and engineering, East West University. We also declare that no part of this thesis has been or is being submitted elsewhere for the award of any degree or diploma.

Countersigned

.....

(Dr.Taskeed Jabid)

Supervisor

Signature

.....

(Kazi Nuzhat Tasnem)

(ID: 2014-1-60-005)

Signature

.....

(Tazin Ahmed)

(ID: 2014-1-60-105)

Abstract

There is different types of methods that can recognize the facial expression but none of them were able to generate the accurate result due to the lack of generalizability. This field has a huge possibilities and can open new doors to human machine interaction. As a result the demand of recognizing the human expression correctly is increasing day by day. So there are many ways to recognize the facial expression. Here in this paper, we are trying to analyze the facial expression on different sub space. First we applied a conventional method, LBP. Then we tried to apply Principal Component Analysis (PCA). We tried another subspace algorithm called Kernel Principal Component Analysis. Then we compared the results. We compared the accuracy of recognizing facial expression of these two algorithm using BSVM tool.

Acknowledgments

As it is true for everyone, we have also arrived at this point of achieving a goal in our life through various interactions with and help from other people. However, written words are often elusive and harbor diverse interpretations even in one's mother language. Therefore, we would not like to make efforts to find best words to express my thankfulness other than simply listing those people who have contributed to this thesis itself in an essential way. This work was carried out in the Department of Computer Science and Engineering at East West University, Bangladesh.

First of all, we would like to express my deepest gratitude to Allah for blessings on us. Next, our special thanks go to our supervisor,"Dr.Taskeed Jabid", who gave us this opportunity, initiated us into the field of "Facial Expression Recognition Using Subspace Learning On LBP ", and without whom this work would not have been possible. His encouragements, visionaries and thoughtful comments and suggestions, unforgettable support at every stage of our BS.c study were simply appreciating and essential. His ability to muddle us enough to finally answer our own question correctly is something valuable what we have learned and we would try to emulate, if ever we get the opportunity.

Last but not least, I would like to thank our family members for supporting us. There are numerous other people too who have shown me their constant support and friendship in various ways, directly or indirectly related to our academic life. We will remember them in our heart and hope to find a more appropriate place to acknowledge them in the future.

Kazi Nuzhat Tasnem

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Tazin Ahmed

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Chapter 1

Introduction

1.1 Facial Expression

One or more motions or positions of the muscles beneath the skin of the face is known as facial expression. [1] Facial expressions of a person express the emotional state of him. It is a form of nonverbal communication. It is the observable results of moving one or more facial muscles. The result of facial expression changes due to the different facial movement. [2]

1.1.1 Why Facial Expression recognition is important?

Facial expression recognition is important because facial expression can express a person's emotional state properly than using words to express it. It is very important in communication. If a person wants to make a good impression on someone using facial expression is an effective way. By using facial expression recognition by a machine, one can establish high security because there will be no error in recognition then because for every expression of that person the machine will detect him correctly. It can be also used to make yourself comfortable in your room by controlling the room temperature by the expression of a person. It plays an important role in sign language which helps the persons who can not talk. So facial expression recognition is important in all phase of life.

1.2 Different approaches of facial expression recognition

Facial expression recognition is a challenge for now a days. So there are some method that is used frequently for face recognition or facial expression recognition in image processing. There are 2 methods that are mostly used worldwide [19] [20]. Those are:

- Geometric Approach
- Global Approach

1.2.1 Geometric Method

Geometric method is a useful approach for facial expression recognition. In this approach the first step is to obtain a training set. After that it calculate the histogram of the images to detect the limit of the skin region. Then some pre-processing is needed like erosion, dilation, and filtering. After applying this the skin region of the face is found which describe the geometric shape of the face. After that we can find the edges of the head, to enter them to process of finding angles [21]. This method is quite effective but it needs a lot of pre-processing. After applying all those pre-work, only then we can apply this method. Also if we make any mistake in pre-process then the recognition system will fall apart if the Geometric algorithm is right though. For avoiding all those pre-processing the other method is preferable to use, that is Global method. One of them is Local Binary Pattern or LBP.

1.3 Local Binary Pattern

Local Binary Pattern (LBP) is an efficient texture operator which labels the pixel of an image by thresholding the neighborhood of each pixel and consider the result as a binary number. [3]

1.3.1 Process of LBP

- At first, we have to divide the whole image into cells. [1]
- Then for each pixel in a cell, we have to compare the pixel to each of its 8 neighbors. We have to follow the pixels along a circle for example clockwise or counter-clockwise. [1]
- "0" is written when the center pixel's value is greater than the neighbor's value,. Otherwise "1" is written. This gives an 8-digit binary number. [1]
- We have to compute the histogram, over the cell, of the frequency of each "number" occurring. This histogram can be seen as a 256-dimensional feature vector. [1]
- Then we have to concatenate histograms of all cells. This gives a feature vector for the entire window. [1]

Mathematically,

$$LBP_{R,P} = \sum_{P=1}^{P-1} s(g_P - g_c).2^P$$

Where g_P is neighborhood pixel in each block and it is threshold by it's center pixel value(g_c).P is a sampling point and R is radius.

Binary threshold function is,

$$S(x) = \begin{cases} 0, x \leq 0 \\ 1, x \geq 0 \end{cases}$$

In local binary pattern or LBP the size of features increases exponentially with the number of neighbors. This excessive number of features can be very tough to handle. It increases the complexity of the system. The structural information in here is limited because only pixel difference is used, magnitude information is ignored [22]. So for ignoring

a huge number of features and a large array in code we moved into another algorithm where a lot of features is not needed. The algorithm is called Principal Component Analysis or PCA in short.

1.4 Principal Component Analysis

Principal Component Analysis (PCA) is a technique which is used to accentuate variation and brings out strong patterns in a dataset. It's often used to make data easy to explore and apprehend. The number of distinct principal components is equal to the smaller of the number of original variables or the number of checking minus one. This transformation is specified in such a way that the first principal component has the largest possible divergence (that is, occurs for as much of the changeability in the data as possible), and each succeeding fundamental in turn has the highest variance possible under the restraint that it is orthogonal to the preceding fundamentals.A true eigenvector-based multivariate analysis is PCA.Often, its operation can be thought of as revealing the internal structure of the data in a way that best explains the variance in the data. If a multivariate dataset is visualized as a set of coordinates in a high-dimensional data space.PCA can supply the user with a lower-dimensional picture, a projection of this object when viewed from its most informative viewpoint. This is done by using only the first few principal components so that the dimensionality of the transformed data is reduced. Assume we have a matrix X,

$$X= \begin{pmatrix} X1 \\ X2 \\ . \\ . \\ . \\ Xp \end{pmatrix}$$

Then we should convert this as population variance-covariance matrix and should consider linear combinations like this:

$$Y_1=e_{11}X_1+e_{12}X_2+...+e_{1P}X_P$$
$$Y_2=e_{21}X_1+e_{22}X_2+...+e_{2P}X_P$$
$$.$$
$$.$$
$$.$$
$$Y_P=e_{P1}X_1+e_{P2}X_2+...+e_{PP}X_P$$

We thought each of this as a linear regression.We predict Y_i from X_1,X_2,...,X_p and we found regression coefficients as e_{i1},e_{i1},....,e_{ip}.So we get a function Y_i and it has a population variance like this:

$$var(Y_i) = \sum_{k=1}^{P}\sum_{l=1}^{P} e_{ik}e_{il}\sigma_{kl}$$

Then we will have Y_j as same as$Y_i$and both will have population covariance,

$$cov(Y_i, Y_j) = \sum_{k=1}^{P}\sum_{l=1}^{P} e_{ik}e_{il}\sigma_{kl}$$

Finally we will have a vector having all the coefficients,

$$e_{ij}= \begin{pmatrix} e_{i1} \\ e_{i1} \\ . \\ . \\ . \\ e_{ip} \end{pmatrix}$$

We select e_{i1}, e_{i2}, ... , e_{ip} to maximize like this:

$$var(Y_i) = \sum_{k=1}^{P} \sum_{l=1}^{P} e_{ik} e_{il} \sigma_{kl}$$

The sums of squared coefficients add up to one...along with the additional constraint We found that new component is uncorrelated with all the previously defined components.

$$\sum_{j=1}^{P} e_j^2 = 1$$

So we have,

$$e_i^l e_i = 1$$

$$\sum_{k=1}^{P} \sum_{l=1}^{P} e_{1k} e_{il} \sigma_{kl} = 0$$

$$\sum_{k=1}^{P} \sum_{l=1}^{P} e_{2k} e_{il} \sigma_{kl} = 0$$

At last we get,

$$\sum_{k=1}^{P} \sum_{l=1}^{P} e_{i-1,k} e_{il} \sigma_{kl} = 0$$

So the Covariance becomes, cov(Y_1,Y_i)=0, cov(Y_2,Y_i)=0, . . . cov($Y_i - 1$,Y_i)=0 So we find that all principal components are uncorrelated with one another.

PCA is an effective algorithm for facial expression recognition. It has less redundancy than featured LBP. Its complexity is also less than previous algorithms. This algorithm represent smaller database since the only trainee images are stored. It also can deduct noise. It is useful algorithm though it has some disadvantages too. Like the covariant matrix is difficult to evaluate in an accurate manner. It cant capture the simplest invariance. It is less sensitive for different dataset.it is an expensive algorithm for computation. The complexity rises if the size of data increases. It is also a time complex algorithm

[23]. So to cope up with those problems we tried another algorithm. It is also one kind of PCA but it is slightly different from PCA. This algorithm is called Karnel Principal Component Analysis or KPCA.

1.5 kernel Principal component Analysis

To overcome such limitation of PCA, a kernel-based PCA can be applied. In KPCA, input features are first transformed into a higher-dimensional feature space using a kernel. Then, typical PCA is performed in the high-dimensional space. The coveriance of the feature,we will have like this:

$$C = \frac{1}{N}\sum_{i=1}^{N}(\theta,(M_i).\theta(M_i)^T)$$

$$\theta(M_i) = \phi(M_i) - \phi$$

where N represents the total number of frames and suppose ϕ is a Gaussian kernel. Then, eigenvalue decomposition is done on the covariance matrix.Then we find the principal component like this:

$$\lambda E = CE$$

$$\text{C}=E^T\lambda E$$

Where E is a eigenvector and λ is a eigenvalue.And The feature vectors using KCPA for facial expression images will be like this:

$$\text{K}=\text{M}E_m^T$$

It gives better better result for facial expression recognition. So we have used this algorithm.

1.6 Support Vector Machine

A supervised machine learning algorithm that can be used to find both classification and regression is known as support vector machine(SVM). For most of the classification problem SVM is used. For classification or regression, it constructs a hyperplane or a set of hyperplanes in a high or infinite-dimension space. Hyperplane achieves a good separation for which the distance is larger to the nearest training data point of any class. The generalization error of the classifier is lower when the margin is larger. For image classification SVM is highly used algorithm because it gives accurate result than traditional query refinement schemes after just three to four rounds of relevance feedback [1] So we have used BSVM tool to calculate the accuracy rate of different algorithms.

1.7 Organization of the Thesis Works

We have structured our rest of the Thesis works as following: In Chapter 2 , we survey related work in facial expression image processing using various algorithms; Our working process is discussed broadly in Chapter 3; Chapter 4 introduces the experimental result of our working process;5 represents the conclusion of our work and proper references of our thesis works.

Chapter 2

Related Works

2.1 Introduction

At technological level, image processing is a new era of development. This field is so promising now a days. There are a lots of opportunities here. One field of image processing is face recognition. It has a huge opportunity in various field. One of them is facial expression recognition. There's a lot of scope in this field like improving human-computer interaction, mood detection using facial expression, controlling the uses of different kind of apps on the basis of anyone's mood or controlling the environment facilities in the basis of someone's mood. So this can make our life easy. With the help of this expression recognition system, if we can detect anyone's mood completely then we can introduce a clever home automation system which will provide all the modern facilities based on the mood. Like the color of the light or control of the air conditioner will change accordingly with mood. Our main motivation is to compare two types algorithm. Analysis the results and see which one gives better result in facial expression recognition. So, we have gone through some other research paper about image processing and facial expression detection to know about their models, works and techniques so that we can conclude a better result [14] [13].

2.2 Related Works

various authors tried to represent their thoughts and experiments about facial expression recognition which are as follows:

2.2.1 Facial expression recognition using image processing techniques and neural networks

In our regular life facial expression is an important things that helps people to interact with each another. So in this paper they focused on two things. One is face detection and another is facial expression recognition. For face detection they used traditional way. They first extracted the face area and then they extracted the eye, mouth and eyebrow outline to detect the face area. Then they extracted various features of the face. They used those features to create a set of vector. In here they have developed a single picture face detection method. This method has four parts such as knowledge-based, feature-based, template-based and appearance-based. Here the author AdaBoost classifier, and cascade classifier to find object or human faces more quickly. Once the feature is extracted then they applied neural network algorithm. In this paper the accuracy of face detection is 97.4% and then the experiment result is 96.2% and 92.8%[4].

2.2.2 Automatic facial feature extraction and expression recognition based on neural network

In [4], authors invented an approach to the problem of automatic extraction of facial features from a still and front posed image. They also gave a solution for classification of the image and recognition of facial expression. They used feed forward back propagation neural network to classify the expressions of supplied face into seven basic emotion category. Their working methodology is first they read the input image and then they localize the face from the image using morphological image processing operations. Then from the

whole image the face is cropped. Then they extract the features from the cropped image and try to find the facial feature vector. After that they used neural network. They train the neurons with as much data as possible. Then it can recognize whether the person is sad, happy, and angry or nothing. They also did a survey on previous methods of recognition of facial expression. They claim that their method has 100% accuracy training set and 95.26% accuracy for test data set [5].

2.2.3 Improving the Classification Accuracy of Emotion Recognition using Facial Expressions

In this paper the authors proposed a method of facial expression recognition which PCA and neural network. This paper is actually about the accuracy of classification of neural network with PCA for feature selection. Their proposed method contains four components: image preprocessing, feature selection, classification and expression recognition. In here image processing consists of scaling and rendering to prepare the face for recognition of expression. The image of the face will be taken as input and then the techniques of the process will be applied. For feature extraction they used PCA algorithm. It generates the Eigenfaces for each image [17]. Through this Eigenfaces the system generates Eigenvectors. Then they used the neural network with back propagation for classification. This is how they investigated the results and said that this process have 85% accuracy [6].

2.2.4 Face spoofing detection using LDP-Top

In here, the authors proposed an approach for face spoofing called high order Local Derivative Pattern from Three Orthogonal Planes (LDP-TOP). This method is simple rather effective. This method contains three steps mainly. The first step is to gray-scaled each frame and passed through a face detector. Then they normalized the faces geometrically. In the next step they applied LDP operators on three orthogonal planes

intersecting the XY, Xt and YT directions where T is the frame sequence. Then they concatenated the extracted histograms. In the last step, which is classification actually, they used SVM (support vector machine) to classify the extracted histograms. Then they determined if the input is spoofed or not. For face detection and normalization they used Viola-Jones method [7].

2.2.5 Facial Expression Recognition Using LBP Template of Facial Parts and Multilayer Neural Network

In this paper, the authors used LBP feature for face detection but first they extracted the features from the picture. They separated the different facial features like eyes, nose and mouth. Then they detect those features from the input picture. They matched the input image with the training dataset. In this paper the authors used the same process as in the previous paper. They used Viola-Jones method for normalizing the faces and then used LBP by extracting the features. After this they used convolutional neural network to recognize the facial expressions. They used fully connected layer network here. Their method gives 95.83% accuracy they claimed [7] [6].

2.2.6 A survey on facial expression recognition techniques

Here the authors described the process of facial expression recognition. They said that the primary need of expression recognition is the detection of face. The next step is to extract the features which will be used to select relevant features such as eyes, nose and mouth from face [9]. Then they used the LBP feature and after this they used CNN [8].

Chapter 3

Methodology

3.1 Taking inputs

We are here working on image processing. We exactly are doing facial expression recognition using subspace algorithm. But before using any subspace algorithm we used a general algorithm which is easy to understand. It is called Local Binary Patterns (LBP).For this reason we first read the images. So, we set the path of the folder which contains the images. Then we detect the size of the folder using a built in function. Then with the help of a loop which runs till the size of the folder we read the images. If there is any unreadable file then we put a zero value in the array in which we are putting the value of the images.

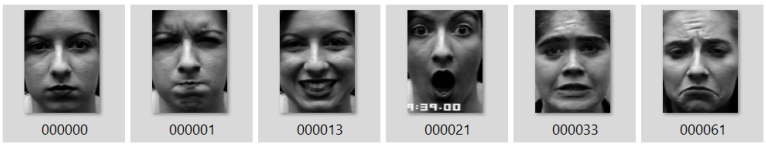

Figure 3.1: sample image of input such as normal,angry,happy,surprised,fear and sad

3.2 Applying LBP

Then we divide the image into cells (suppose 256*256). Then we compare each cells pixel value with its 8 neighbor cells either clockwise or anti-clockwise. If the center pixel value is greater than its neighbors value then we put 0 otherwise 1. By doing so we get

an 8 digit binary number and then we convert it into decimal and put it in the center cell. After doing this we get a 254*254 image. Then we calculate the histogram over the cell which is the frequency of each number occurring in the image.Then we put all the histogram value in a file and send it in SVM tool for testing.BSVM tool makes randomly training and testing data and gives us an accuracy rate after testing.

3.3 Creating blocks on LBP

At this point, now we are trying to work with features.Because we wants to improve the recognition system.For this we divide our images into 6 different blocks and then we apply the LBP algorithm on the blocks of images and get LBP histogram for the blocks on images.After that we put the histogram values along with images number in files again and check the accuracy rate in recognition by using the BSVM tool.

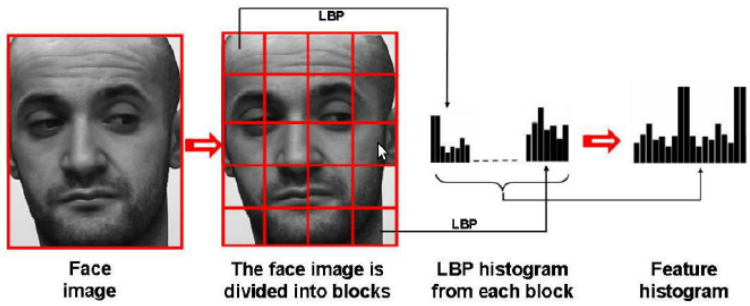

Figure 3.2: Local Binary pattern

3.4 Applying PCA on Blocks of LBP

After that we want to apply subspace learning on LBP.That's why we use principal component analysis algorithm on the LBP histogram which we gets for each of the block images.Then we restore the array values of new histogram gotten from the algorithm in

file,and send the file to the BSVM tool to see the accuracy of the recognition system.

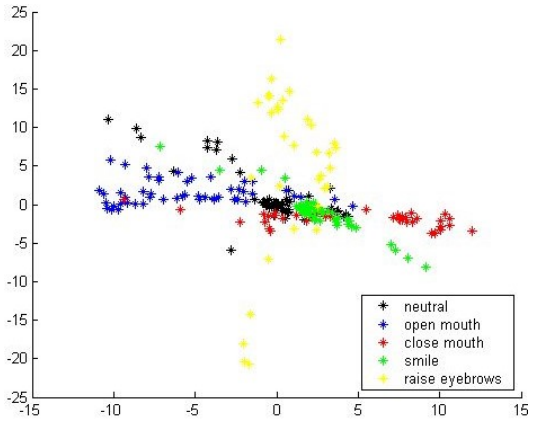

Figure 3.3: Plot of features using Principal Component Analysis on Facial Expression Images

3.5 Applying kernel PCA on Blocks of LBP

After that we want to apply another subspace learning on LBP because PCA is basically a lower order statistical method to map original high-dimensional data into a lower dimensional feature space.So we use kernel principal component analysis algorithm on the LBP histogram which we gets for each of the block images.Then we again restore the array values of new histogram gotten from the algorithm in file,and send the file to the BSVM tool to see the accuracy of the recognition system. Entire working process is given below:

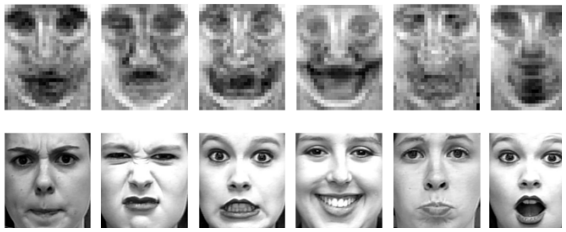

Figure 3.4: kernel Principal Component Analysis on Facial Expression Images

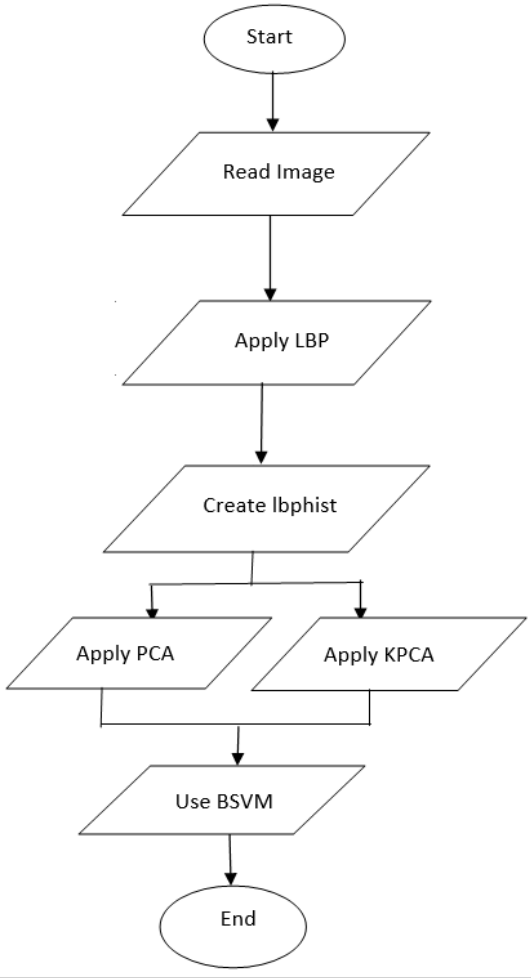

Figure 3.5: flow chart of facial expression image processing recognition

Chapter 4

Results

4.1 Results

4.1.1 Accuracy rate of LBP and Blocks on LBP

When we applied just LBP algorithm on the images we get 67.29% of accuracy in recognition of the expression of human face by using the SVM tool.Then we get 82.15% of accuracy of accuracy in recognition of the expression of human face by using the SVM tool after creating blocks on images.

Table 4.1: comparison between LBP and Blocks on LBP

Algorithm	Accuracy in percentage
LBP	67.29
Blocks on LBP	82.14

4.1.2 Accuracy rate of Blocks on LBP and PCA

After applying PCA algorithm on the blocks of images using LBP algorithm we get 84.56% accuracy rate.So at first using just LBP algorithm gives us very little perfection in recognition.But when we create the 6 Blocks on images and then apply the LBP algorithm we get more perfection in recognition.At last when we apply the PCA algorithm on the blocks of LBP we get an acceptable rate of accuracy in recognition.And we understands

that applying subspace learning on LBP gives us more accuracy in recognition.

Table 4.2: comparison between Blocks on LBP and PCA

Algorithm	Accuracy in percentage
Blocks on LBP	82.14
PCA	84.56

4.1.3 Accuracy rate of PCA and KPCA

After applying KPCA algorithm on the blocks of images using LBP algorithm we get 85.66% accuracy rate.So at first using just LBP algorithm gives us very little perfection in recognition.But when we create the 6 Blocks on images and then apply the LBP algorithm we get more perfection in recognition.Then when we apply the PCA algorithm on the blocks of LBP we get more perfection in recognition.At last after applying KPCA algorithm on the blocks of LBP we get an acceptable rate of accuracy in facial expressions recognition. And we understands that applying subspace learning on LBP gives us more accuracy in recognition.

Table 4.3: comparison between PCA and KPCA

Algorithm	Accuracy in percentage
PCA	84.56
KPCA	85.66

Chapter 5

Conclusion

5.1 Conclusion

In this thesis study, we applied subspace algorithm for facial expression recognition. First we showed the LBP feature and calculated its accuracy using BSVM tool. After that we applied block wise LBP feature and again calculated the accuracy. Then we applied a subspace algorithm called Principal Component Analysis (PCA).But it has some problems too.So we applied another a subspace algorithm called Kernel Principal Component Analysis (KPCA). We showed that these 4 approaches gives us 4 different accuracy and the accuracy is highest after we applied KPCA. Though we haven't able to attain 100% accuracy in this era but this paper can be helpful for the researchers who are trying to improve this. This field has a lot of scope so if we can attain 100% accuracy on facial expression then many technology can develop based on this including human computer interaction. If we can detect the facial expression correctly then we will be able to develop many automatic system which will develop their program based on facial expression. The whole world will be smarter than ever and our life will be a lot easier. So our study can be helpful for the researcher who are continuously working for the development of facial expression recognition and working for a better world.