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FACIAL EXPRESSION DETECTION USING NEURAL NETWORK

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ABSTRACT: The human identification and emotion recognition is one of the significant fields in human-machine relationship. It is a considerably challenging task to generate an artificial intelligent computer that is able to recognize and understand human emotions for important purposes, e.g. security, entertainment, society. Several studies and researches have been done for building an accurate and effective machine for Identification and emotion recognition system. Identification and emotion recognition methods have been divided into two different categories along a number of dimensions: speech emotion recognition vs. facial emotion recognition; machine learning method vs. statistic method. Facial expression method can also be classified based on input data to dynamic or static images. This research focuses on emotion identification to identify six universal human behaviour: disgust, smile, sad, normal, surprise and angry. Principal Component Analysis (PCA) and the Support Vector Machine (SVM), KND algorithms are used to extract unique facial expression feature among emotions using the public database of "Japanese Females Facial Expression" (JAFFE). The experiment results demonstrated that the emotion recognition system has been successful and that is working well with the experimental databases.

INTRODUCTION

BACKGROUND AND MOTIVATION

From past few years, the relation between human and computer interaction with computer vision play an important role in the study of Artificial intelligence. Lot of study and research has been conducted for improvement and developing a interactive relationship between human and computer. One of the main factors that play an important role for increasing and developing of the relationship between the computer and human is the studying of computer ability to find out the behaviour of humans. By the help of machine ,we are able to assess the human behaviour depending on their affective state(mood) in the same way that human's senses do .The artificial intelligent machine will be able to sense, interpret and respond to human intentions, emotions and moods .

The Identification and emotion recognition having applications that can be use in different areas of life; for instance, in security and surveillance, they can predict the offender or criminal's behaviour by analysing the images of their faces that are captured by the control-camcorder. Even, the Identification and emotion recognition system has been used in communication to make the machine more interactive with people by answering the queries. The identification and emotion recognition system had a considerable impact on the game and entertainment field besides its use to increase the efficiency of robots for specific tasks such as me-caring services, military tasks, medical robots, and manufacturing servicing. Generally, the intelligent computer with the emotion recognition system has been used to improve our daily lives.

Scientists restrict the emotions of people in seven different feelings: Anger, Disgust, Fear, Happiness, Neutral, sad, and surprise. Generally, scientists have analysed the human emotions and realized that Human

emotion recognition can be achieved by the facial expressions. Facial expression analysis deals with the changes in the movement of the facial muscles. According to GovindUkhandrao **Kharat** ; Sanjay V. **Dudul** (2008) , speech contributes to an effects the emotions of the speaker by 7% for the spoken word and by 38% for the voice; whereas, the facial expression is affected by 55%. Hence, there are many algorithms which analyse the speech or the facial expressions in order to recognise the emotion. Hence, many studies tend to use a hybrid system for facial expressions which yielded the most accurate results as the case with an accuracy of the hybrid system that is used for facial expressions recognition.

AIMS AND OBJECTIVES

The main aim of this project is to recognise the facial expression and emotions. This project can be developed with the use of machine learning algorithm which include two stages:-

1) Training
2) Testing

Machine learning includes PCA, KND algorithm and SVM techniques.

Focused objective of this research is to identify the emotion and features of facial expression with the use of principal component analysis (PCA) and (SVM) i.e. support vector machine for hybrid classification and to classify the emotion KND algorithm is examined. Static image data base is used in the project to train and test.

LITERATURE REVIEW

Emotion recognition is the significant application of image processing. it is based on facial expression.
Here in emotion recognition technique we try to identify emotions by extracting spatial features from the image that differ from one another. Since 1997 many methods of facial recognition have been developed to achieve accurate approaches towards classifying emotions and features.

The procedure that every emotion recognition method uses to follow is:-

1) Input data
2) Pre-processing data
3) feature extraction and filtered
4) filtered feature classification
5) Result

THE INPUT DATA STAGE

Emotion recognition methods are classified into different categories along with number of dimensions. For example, they can be divided into two parts based on the data input (Images). The first part is sequence video and the second is static image. Each category has a different suitable feature extraction. For instance, for video sequence and the utilized Optical Flow method that has been used by to follow the dynamic movement of the facial features. Then used of the results of the facial feature movements to classify the motions into six expressions: smiling, sad, normal, surprised, angryand disgust. Whereas, the other method used both the Optical Flow andPrincipal Component Analysis (PCA). The most widely used method for tracking
Emotion Recognition System based on Facial Expression.

THE PRE-PROCESSING STAGE

The next stage after the input stage is Pre-processing. The main work of this is to classify the data for the processing stages (extracted feature and classifier) based on the different situation that differs between

methods. The most important data that we required is position of the face. There are various techniques for detecting the face. In addition, some methods require Specific data, for example, mouth position, eye with brows position, eye without brows position, and face without hair and shoulders. The other methods used two kinds of data. The first is a set of images that contains face without hair and shoulders. The following data can be used for extracting the features: Full image is sized 80x80, eye image sized 80x20 and mouth image sized 45x30 .we have some techniques that have been used for the identification of the face, eyes and mouth.

FACE AND FACIAL PART DETECTION

There are many different algorithms for face detection/recognition based on the face color or shape of the face. We can categorize the face detection methods into two categories. The first category is based on different facial features which mean extracting the feature from the image than classifying the region on the image into a facial region and non-facial region. There are two method based on chrominance color information. First one is Adapted Chain Code (ACC) to detect the face by finding a boundary and then using the Modified Golden Ratio (MGR) to detect Emotion Recognition System based on Facial Expression.
the facial parts; for example, eyes, eyebrows, mouth and nose. Firstly, MGR extracted the eye position then decided the eyebrows, mouth and nose based on that position. The other category includes the features extracted from the image to recognize the facial region they belong to a single pattern .In this the template-matching method we can used Six templates extract the features of the face; one template for the mouth, two for the eyes, two cheek templates and one for the chin. The most important method is PCA by this we can extract the features of the face very easily.

FILTERING AND FEATURE EXTRACTION STAGE

These stages help in developing a successful emotion recognition system. Here in this stage features are extracted and filtered from the set of raw data. Many researches on image processing are done to produce effective features to differentiate between the facial expressions. Some approaches are based on geometric feature i.e. feature information and some are based on static features .The acquired feature are called Appearance feature. In many cases multiple techniques and filtering of extracted feature are together to increase the performance and achieve better result and accuracy.

Analysed data is then minimized into small set of information called feature space. For the efficient and effective analysis better quality of feature space is needed.

Some of the filtering techniques that are used for extracting feature from an image are:-

1) Principle Component Analysis (PCA)
2) Independent Component Analysis (ICA)
3) Discrete Cosine Transform (DCT)
4) Gabor Filters
5) Fast Fourier Transform (FFT)
6) Singular Value Decomposition (SVD). Etc…….

FILTEREDFEATURE CLASSIFICATION

It is one of the most important stages in an emotion recognition system. Here the difference between the changes occurred in a facial expression while the movement of muscles is required to analyse the emotion. Sadness and disgust are one the confusing emotions where the human mostly confuse to recognise it. In some cases sadness also contain the emotions of farness. Angry, Natural, Happy, Sad, Surprise, Disgust and

Fear. Here while filtering feature classification two problems comes one is confusion rate and the difference in lightning and brightness of the images. The emotions like Angry, Surprise and Happy have strong negative and positive values thus has less confusion rate.

In order to build the accurate emotion recognition system many number of classifying approaches are used. Two main ones are:-

1) Non-machine learning
   EX. Euclidean and linear discrimination analysis.
2) Machine learning.
   EX. Feed forward Neural Network (FNN), Hidden Markov Model (HMM), Multilayer Perceptron (MLP), Improved Kernel Canonical Correlation analysis (IKCCA), Radial Basis Function Network (RBFN) and Support Vector Machine (SVM) etc.

Stages of machine learning:-

1) Training
2) Testing

REQUIREMENTS AND ANALYSIS

Introduction

To get the best results while using the emotion recognition system there are some points that needs to be analysed first. Here focus is given on identifying the aim of the project. Along with that it describes the set of data that is used in each stage of the experiment and explaining the environment in which the project is carried out.

ANALYSING THE PROJECT AIM

The main aim of the project is to build a System that recognises the emotion of a person by using facial features that are derived from the still images of the same person. This project is basically used to differentiate between 6 types of expression:- smiling,sad,normal,angry,disgust,surprised.The major task of the project can be divided into subtasks. They are classified as:-

1) Creating the database of the image whose expression is needed to be derived.
2) Secondly the system to recognize the expression can be built by using two techniques. They are:-
   A) Machine Learning
   B) Non-machine Learning

Here machine learning techniques are used to build the system.

SYSTEM REQUIREMENT AND ASSUMPTION

The system is required to detect the expressed emotion whether it is smiling, sad, angry, surprised, disgust, normal with the help of Principle Component Analysis (PCA) method which is used for extracting facial features of the image. The amount of facial region to be used is identified in a particular image. Those parts of the image are particularly used to differentiate among the different expressions of the face.

3.4 The Experiment Database

For implementing this project two open source database are used for extracting facial expression. They are:-

1) Japanese Female Facial Expression (JAFFE)- This works for the greyscale images. There are a total of 215 images of different facial expression. Ten Japanese women faces are used to represent all the six different emotions. Each face is used to represent 2-3 examples of each emotion.

2) FACES- This works for the colour images. It was used in the period 2005-2007.The database consists of a total of 72 images of mixed age people i.e. young, middle aged and old. It is used to represent six emotions with the help of six common facial expressions. To represent each emotion there are 12 images expressed in different expressive forms.

3.5 Environment and usage tool

The environment that is used to carry out the research in this project is Visual Studio 2015.Visual Studio provided appropriate accessibility and implementation environment to carrying out this project. It provides tools to modify the requirements of emotion recognition system.

DESIGN

Here the architecture and design of emotion recognition system and the implementation of stages along with functionality is explained. The algorithm which is supposed to be used for the implementation of project will be clarified in detail.

EMOTION RECOGNITION SYATEM AND ARCHITECTURE

The architecture of emotion recognition system is divided into 4 Stages-

1) Creating database
2) Pre-processing data
3) Feature extraction
4) Classification

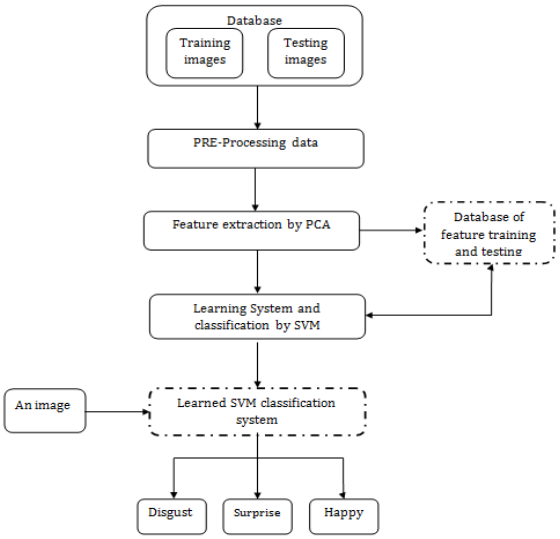

Fig:- emotion recognition system architecture

DATABASE

Here in this stage the database is divided into 2 stages-

1) Training data:-

To find out the optimal hyper-plane AdaBoost and SVM classifier is used and the training data is needed for training AdaBoost and SVM classifier.

2) Testing:-

During training data optical hyper-plane has been discovered and to test these testing data is used.

In the database there were different faces representing different emotions. In this stage 8 forms are chosen for training the database. And 2 forms representing the testing data. Because of the unequal characterization of frames the training data and testing data are not divided by frames in the database. For the correct observation in the division the database is not divided randomly. In the SVM classification stage that is so called verification stage the training data is used for testing.

THE PRE-PROCESSING DATA

For obtaining the accurate result this stage is very important as this stage is not considered as a main stage. This stage need to perform three steps:-

1) Detecting the region of face
2) Recognise the brightness and dullness i.e. lighting in the image
3) Removing the noise

FEATURE EXTRACTION BY PCA

Here in this stage the recognition of extraction of facial expression by principal component analysis algorithm. The unique features in the different human emotions are tried to recognise by the system. For extracting the important data when the data set are compared in themselves PCA is a powerful algorithm.

Steps performed by PCA algorithm for extracting the data-

Step 1- convert the N*N image matrix to N2*1 vector matrix.

Step 2- calculating the mean-adjusted data by subtracting the mean of each image dimension by Image vector.

Step 3- calculating the covariance matrix from the above resulted matrix.

Step 4- from the covariance calculating the eigen values and eign vector.

Step 5- form a feature matrix by collecting the eigenvectors in one matrix.

Step 6- resulting a final data i.e. one data set.

Final data (feature of the image)=feature vector*mean adjusted data

LEARNING SYSTEM BY SVM AND AdaBoost

By machine learning approach here the features of the facial expression will be classified. SVM and AdaBoost are the most successful machines designed for facial emotion recognition.

To separate two classes in the feature space we find out the optimal-hyper plane with the help of SVM machine learning algorithm.

RESULTS AND DISCUSSION

This chapter is dedicated to conduct experiments that examine the efficacy of the emotion recognition system based on the facial expressions. The result of each stage in the system is presented. Then the findings of the whole experimented system will be discussed and analyzed. Furthermore, the data set that has been provided to test and evaluate the emotion recognition system is described in this chapter. Finally, the some suggestions that might improve the work are presented.

USAGE DATA SET FOR EVALUATION

A set of 120 images has been used for testing purposes. This data set is a mixture of person images depicting happy, disgust and surprise emotions. Two different kinds of database have been used to examine the efficacy of the emotion recognition system. Fist, the Japanese Female Facial Expression (JAFFE) database has been used while building and training system. This data base contains 30 images of each emotion that disgust, happiness and surprise. This data

set has been described previously: Requirements and analysis. Figure 6.1: sample of grayscale images from first group (JAFFE) database

The second database that has been obtained from WWW2 is FACES database (see Figure). It has used 36

images which are distributed as 12 images for each emotion expressing disgust, happiness and fear that has been used instead of surprise because this data base does not contain any image that depicts the surprise emotion. These images are colour images and this database has been also described previously in Chapter3: Requirements and analysis

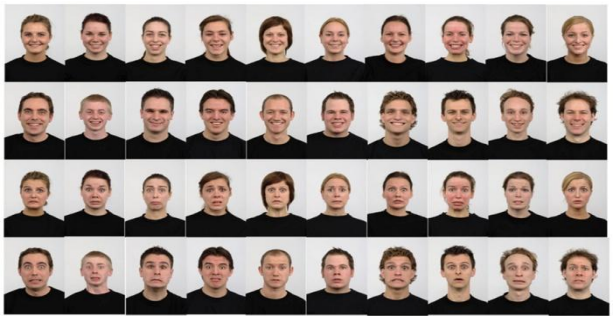

Figure: sample of colour images from second group (FACES) database

TOOLS USED FOR EVALUATION

The main useful statistical measurements that were utilized to evaluate the emotion recognition system are: recall, precision and accuracy. These measures are useful in that they help judge the performance of the emotion recognition system. The recall rate measures and studies the relation between the correct

Classification rates of specific emotions and the wrong classification of this specific emotion whereas precision measures the relation between the correct classification rate of specific emotions and the wrong classification of other emotions that are classified as special emotions. Finally, the accurate rate measures the relation between the correct classification rate of specific and other emotions and the total number of testing images, i.e. the following convert of these relations into a symbolic equation.

Recall=true positive/(true positive +false negative) (Equation 6.1)

Precision=true positive/(true positive +false positive) (Equation 6.2)

Accuracy=(true positive+ true negative)/(false positive+true negative + true positive +false negative) (Equation 6.3)

Where *true positive* for specific data set of emotions (A) is the correct classification rate of emotion; while, *false positive* of A emotion is the wrong classification rate of other data set of emotions that are classified as A type whereas false *negative* is the wrong classification of emotion A. Finally, *true negative* of emotion A is the correct classification for images whose label is not A. Additionally, it is noticed that the summation of true *positive*, *false positive*, *false negative* and *true negative* is the total number of the testing images.

EXPERIMENTAL RESULTS

The performance of PCA feature extracted algorithm with AdaBoost and SVM classification and the algorithm has been examined. The performance is evaluated by examining the system's capability to distinguish between three different emotions based on analyzing the facial expressions. The system has been

tested over the grayscale and color images. The two previous sources have been used separately. To avoid confusion, firstly, the emotion recognition system has been tested using grayscale images JAFFE database. In this testing, the system has examined its ability to distinguish between three types of emotion: happiness, disgust and surprise. Secondly, the system has examined the use of the color image and thus, tested the three emotions that were classified as happy, disgust and fear. It is noticed that it has separated the images that may have incorrect labels from the original images in both sets of data. Additionally, for both data sets, the database has been partitioned into two files without overloading the training file and the testing file. Then, after training the system, it has selected images of different expressions randomly to test the system ten times. The result of this testing will be stored in the external ten files. The following tables display the results that are collected from the ten external files. Table 1 demonstrates system results of the first group testing "grayscale images" whereas able 2 reveals the system results of the second group "colored images"

Target / Recognition result	Disgust (25)	Happy (33)	Surprise (20)	Average
Disgust	17	5	2	
Happy	4	23	2	
Surprise	6	5	17	
Recall	62.96%	69.7 %	80.95%	71.20%
Precision	70.83%	79.31%	60.71%	70.28%
Accuracy	79.01%	80.25%	81.48%	80.25%

Table 6.1: system performance results for random testing grayscale images

Target / Recognition result	Disgust (10)	Happy (8)	Fear (10)	Average
Disgust	8	1	0	
Happy	0	7	1	
Surprise	2	0	9	
Recall	80%	87.5%	91.0%	86.16%
Precision	88.88%	87.5	81.81	86.06%
Accuracy	89.28	92.85	89.28	90.47%

Table 6.2: system performance results for random testing color images

It is noticed that the numbers of the testing images for each emotion are not equal because the image testing has been selected randomly from the test file. Moreover, it may test an image more than once.

Moving to more accurate results, the tables below illustrate the results of the system over the database file that contains whole image training and testing images without overloading. The system behaviour over three groups of data has been examined. The first group is the original grayscale images without applying the pre-processing stage on this group of data. Secondly, the grayscale images after applying the pre-processing stage. The third group is the colour image group obtained after the pre-processing stage because it cannot use the original data directly to extract their features. The following tables demonstrate the system performance with each group of data.

Target / Recognition result	Disgust	Happy	Surprise	Average
Disgust	22	0	3	
Happy	3	29	1	
Surprise	4	2	26	
Recall	75.86%	93.55%	86.67%	85.33%
Precision	88%	87.88%	81.25%	85.71%
Accuracy	88.89%	93.33%	88.89%	90.37%

Table 6.3: system performance results for original grayscale images

Target / Recognition result	Disgust	Happy	Surprise	Average
Disgust	19	9	0	
Happy	4	13	3	
Surprise	6	11	27	
Recall	65.52%	41.94%	90%	65.82%
Precision	73.10%	65.00%	61.36%	66.48%
Accuracy	81.11%	72.22%	77.77%	77.03%

Table 6.4: system performance results for re-processed grayscale images

Target / Recognition result	Disgust	Happy	Fear	Average
Disgust	1	1	3	
Happy	11	11	5	
Surprise	0	0	3	
Recall	8.33%	91.66%	27.27%	42.42%
Precision	20.00%	40.74%	100%	53.58%
Accuracy	57.14%	51.42%	77.14%	61.9%

Table 6.5: system performance results for color images

THE EXPERIMENT RESULTS DISCUSSION

In this sub-section, the experiment results will be evaluated. It can be observed evidently from the previous sub-section Experiment results that the outcomes formed an emotion recognition system according to the products of the PCA extracted feature algorithm and the AdaBoost & SVM classier. The system achieves satisfactory results. During the training on the system, the system has achieved the highest accuracy performance of emotion recognition observed obviously in Table 6.1 and Table 6.2: 80.25% and 90.47% respectively. The system can detect the 17 disgust images out of 25 in the first kind of data. In contrast, it can detect 8 disgust images out of 10. However, the emotions that have the highest recall are the surprise for the grayscale images and the fear images: 80.95%, 91.00%. This means that the surprise and fear emotions have the lowest confusing rate against the disgust and happy emotions. But these results are not stable. Moreover, these results are turned upside down when the expert of the emotion recognition system is applied to the whole database. Tables 6.1 and 6.2 confirm that the development emotion recognition system is more robust than the color image or the grayscale images whereas Tables 6.3, 6.4 and 6.5 prove the opposite of the last results.

As stated previously, the last three tables: 6.3, 6.4 and 6.5 have exhibited the system performance based on three groups of data: original grayscale images, re-processed grayscale images and colure images. Firstly, the system proves its robustness for classifying the emotions in table 6.3 since the accuracy rate has reached 90.37%. In this case, the system achieves the highest recall and precision rate in the happy emotion when it can detect 29 happy images out of 31. Furthermore, the two images are miss-classified with the surprise emotion while the disgust and surprise emotions could achieve equal accuracy rate 88.89%. Secondly, it has improved the system by developing the pre-processing stage to increase the proportion of the system performance accuracy. These stages verified the requested information and they could detect 27 surprise images out of 30 (90%). But it has led to disappointing results for detecting happy and disgust emotions since they confuse the rate of happiness and disgust emotions as the surprise emotion was very high. Precision statistic measures the relations between emotions that are related to the distinction between emotions. Thus, table 6.4 shows the surprise emotion that has the lowest precision rate (66.48%) and this result is important in that it has detected 6 disgust images and 11 happy images as surprise images. Therefore, the average of the recognition system accuracy performance rate was decreased to 77.3%. On the other hand, if we compare the performance of the emotion recognition system that is based on PCA, AdaBoost and SVM with the two used database colour or greyscale images, one can observe clearly that the system is effective in achieving a higher accurate performance rate 90.37% over the greyscale images whereas it has achieved 61.9% accuracy rate over the colour images, (see Table 6.3 and Table 6.5). These results were unexpected because of the colour images that had been converted to greyscale images in the pre-processing stage before extracting their feature and learning the system. Consequently, the significant question is what the most important potential factors that may have considerable effect on the system performance are. To answer this question, one potential factor is suggested; it may be significantly responsible for changing the system performance. It is that the age of persona on the picture. For instance, the wrinkles on the forehead of a happy old person smiling look like the wrinkles on the forehead of an angry mid-age persona.

Generally, one has to notice that it is standard that the PCA feature extracted algorithm is very robust and efficient against any slight change. Thus, it was efficient to extract important features that verify the effective emotion recognition system over the JAFFE database that has women in the mid-age. In contrast, the PCA algorithm is not adequate to achieve the optimal emotion recognition system that is appropriate for all kinds of statistic images. It is suggested to construct a hybrid emotion recognition system that is based on PCA and other efficient extracted feature algorithm as what it has been performed in the classification stage. Hybrid SVM and AdaBoost algorithm can be used to obtain the optimal classifier system.

FUTURE DIRECTIONS

Although the emotion recognition system is successful and it has achieved its goal, there are many suggestions for developing the system to improve the percentage of accuracy. First, it can extract features form the special part of the face rather than apply the ACP for the whole facial part. For example, it can divide the facial part to eyes region, mouth region, eyebrows and forehead region. Then apply the PCA algorithm for each part individually. Afterwards, learn the system. In this way, the percentage of accuracy will be improved because the number of the extracted facial features will be few and the system will be more important, stronger and more sufficient to learn the classifier system.

Secondly, the use of the hybrid system is suggested for the extracted features. For instance, it might be so effective that it can apply the DCT algorithm before the CPA whereas the DCT is an image compression technique, (see chapter 2: literature review).

Thirdly, it can also develop the emotion recognition system and make it more complicated and capable of distinguishing between the basic seven emotions: happiness, sadness, disgust, surprise, anger, fear and neutrality. The emotion recognition system is satisfactorily flexible; it can improve the processes easily.

CONCLUSIONS AND DIRECTIONS FOR FURTHER RESEARCH

The research made in this project is very vital and contribute in future .In this first thing, is to examine that weather segments of face yield higher accuracy to recognise the facial expression .The Japanese database we have used is much more efficient as the images used in the dataset lead to superior recognition due to strong co-relation between images . The key processes that are applied are the Principal Component Analyses (PCA), Support Vector Machine (SVM) and KND algorithm for extracting the facial feature to recognise the

emotion. The techniques have been selected after going through all the recognition technique that are mentioned in chapter 2: literature review. During training period a lot of problems were faced in the machine learning stage, further these issues had been resolved. During the testing stage it has been completely ensured that the system successfully recognizes the given expression and is built according to the requirements.

The experimentation in the project uses two kinds of statistic images that is, greyscale images JAFFE database and colour images FACES database. The result of the system is explained in chapter 6. After various attempts, it became clear that the percentage of accuracy of greyscale images (90.37%) is higher than that of the colour images (61.9%), and the system provides satisfactory results with both kinds of images. Furthermore, to increase the accuracy of the system other useful ideas have been suggested to make it more efficient to distinguish between six emotions.

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