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Face expression recognition using Scaled-conjugate gradient Back-Propagation algorithm

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ABSTRACT: *Since decades, face recognition has become an active area of research in computer vision and psychology. The rapid developments of face recognition are being fueled by numerous advances in computer vision. An ongoing challenge in this field is to design an effective human-computer interaction (HCII). In this paper we will study the latest work done that has been done in the field of facial expression recognition and analysis. In our work we have recognized six different expressions using Cohn-kanade database and system is trained using scaled conjugate gradient back-propagation algorithm. In proposed methodology we have used MATLAB's computer vision toolbox for face detection & cropping the images and neural network toolbox. In our work we have achieved 100% training accuracy and 87.2% overall testing accuracy of six different expressions.*

Keywords: *FACS (Face action coding system), neural network, Action units (AU), SVM (Support vector machines).*

I. INTRODUCTION

Human-computer interaction such as voice, gesture, and force-feedback are emerging. Despite important advances, one necessary ingredient for natural interaction is still missing that is emotions. Emotions play an important role in human-to-human communication and interaction, allowing people to express themselves beyond the verbal domain. The ability to understand human emotions is desirable for the computer in several applications. The facial expressions are one of the most powerful channels of non-verbal Communication. Facial expression provides information about emotional response, regulates interpersonal behavior, and communicates aspects of psychopathology. Facial expressions can reveal what people are thinking and feeling, it is only recently that the face has been studied scientifically and has the great potential for human-computer interaction.

Several approaches have been used for automatic facial emotions recognition from static images or video sequences. In all these approaches, the first step is to detect the face and once the face is detected the next step is to extract the features from the detected face that are relevant to display of emotions and classified into a predefined set of facial actions or furthermore to emotion related expressions. Most of the facial emotion or expression analyzers recognize expressions corresponding to the basic emotions, i.e happiness, anger, fear, surprise, disgust and sadness. Fig. 1 explains basic steps that are used for facial expression analysis system.

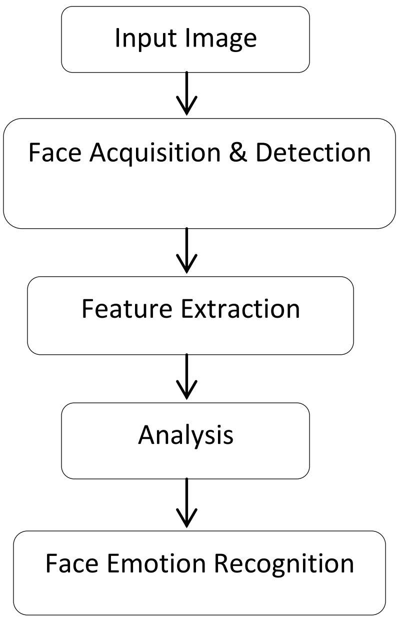

Fig 1:- Basic Face expression analysis system

First step is the input image with different expressions play an important role in the facial expression analysis. Properties of the image like its resolution, sizes etc are important and usually, the facial image in the frontal or near frontal view is used to recognize facial expression. Once we have the image the next step is to cut and crop the image and detect face using the face detector. Now after second step we got the balanced image whose feature should be fed to the system.

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The facial features are mainly of two types: geometric and appearances features [3]. Geometric features measures the variation in shape, location, distance of facial components in different expressions. The appearance features can be extracted on either whole face or specific regions in a facial image. The last and most critical step is the expression classification. The classification systems classify the emotions into different categories according to the mood.

In the next section we will study about the related work that has been done in the field of face expression recognition and analysis.

II. LITERATURE REVIEW

Research on human perception and cognition has been conducted for many years, but it is still unclear how humans recognize facial expressions. Which types of parameters are used by humans, and how are they processed? By comparing human and automatic facial expression recognition we may be able advance our understanding of each and discover new ways of improving automatic facial expression recognition. Although it is often assumed that more fine-grained recognition is preferable, the answer depends on both the quality of the face images and the type of application. Ideally, an automatic face expression system should recognize all action units and their combinations. In high quality images, this goal seems achievable; emotion-specified expressions then can be identified based on emotion prototypes identified in the psychology literature. For each emotion, prototypic action units have been identified. In lower quality image data, only a subset of action units and emotion specified expression may be recognized. Recognition of emotion-specified expressions directly may be needed. We seek systems that become 'self-aware' about the degree of recognition that is possible based on the information of given images and adjust processing and outputs accordingly. Recognition from coarse-to-fine, for example from emotion-specified expressions to subtle action units, depends on image quality and the type of application.

Two main streams in the current research on automatic analysis of facial expressions consider facial effect (emotion) interference from facial expressions and facial muscle action detection [1]. In this section, we also evaluate the various frameworks for emotion detection. The objective is to assess the relevance of different framework to deal with a different kind of data.

2.1 Facial Action Coding System (FACS)

The Facial Action Coding System (FACS) is a comprehensive, anatomically based system for measuring nearly all visually discernible facial movements [4]. FACS describes facial activity on the basis of action units (AU), as well as several categories of head and eye positions and movements. Action Units (AU) are the fundamental actions of individual muscles or groups of muscles. FACS is recognized as the most comprehensive and objective means for measuring facial movement currently available, and it has become the standard for facial measurement in behavioral research in psychology and related fields. Since FACS deals with the movement, not with other visible facial signs, it limits a full understanding of the psychology of facial behavior. Thus the person performing the classification has to be trained to interpret the expression from the action units obtained.

2.2 Neural network based analysis

Neural network learning methods provide a robust approach to approximating real-valued, discrete-valued, and vector-valued target functions. For certain types of problems such as learning to interpret complex real-world sensor data, artificial neural networks are among the most effective learning methods currently known. For example, the BACKPROPAGATION has proven surprisingly successful in many practical problems such as learning to recognize handwritten characters (Lecunn et al. 1989), learning to recognize spoken words (Lang et al 1990) and learning to recognize faces (Cottrell 1990).

Padgent [5], Hara and Kobayashi [6, 7], Zhang [8] and Zhao [7] used neural network approach for expression classification. They classified images into six or seven emotional categories. Padgett et al., [5] trained neural networks from the data of 11 subjects and tested with the data from one subject. The training and testing dataset was interchanged and new networks were trained and tested. A classification accuracy of 86% was achieved in this study. Hara and Kobayashi [6, 7] also used neural networks approach. The training dataset consisted of from data of 15 subjects (90 images) and these networks were tested using data from another 15 subjects. The classification accuracy achieved was 85 %. Zhang et al., [8] used the JAFFE data base which consists of 10 Japanese female subjects. Although an accuracy of 90.1% was achieved; same data was used for training and testing.

2.3 EMG based methods

Facial EMG measures the electrical activity of the facial muscles [9]. Facial expression analysis using EMG based techniques requires invasive insertion of electrodes into the facial muscle fiber for accurate result. The major disadvantage of using EMG based methods is that it may alter the normal behavior of the subjects due to attachment of electrodes and confuse the subject.

Various teams have worked on the face expression recognition and analysis systems using FACS AU.

The results analysis work is done in two categories:

A) Person Independent:- Person independent category means in such systems, during training few images are not shown to the system and we will use those images to check how many images the system identify based on the mood correctly.

B) Person Specific: - Person specific category means the faces that we have trained or shown to the system and testing is done on the same faces.

Teams	Emotion Detection		Overall
	Person Independent	Person Specific	
ANU [16]	0.649	0.838	0.734
KIT [1]	0.658	0.944	0.773
MIT-Cambridge [1]	0.448	0.433	0.44
Montreal [1]	0.579	0.870	0.700
NUS [21]	0.636	0.730	0.672
Riverside [2]	0.752	0.962	0.838

Table 2:- Emotion recognition using SVM and their accuracies by different teams.

III. EXPERIMENTATION

In this section we will explain the implementation of our proposed work. Our proposed work is divided into four main steps explained below:

Step 1:-Collection of different face expression images

First step is to collect different images of different facial expressions. So for that we have used cohn-kanade database. It consists of six basic emotions that we need to classify.

Step 2:- Creation of dataset

Step 3:- Selection of neural network

Once the dataset is created the next step is to select the neural network. It means we need to decide about input layer, hidden layer and output layer. For our work, we have used 50*50 images it means our input layer consist of 2500 features. We have used 200 hidden layer and since we want to classify six different emotions hence our output layer consist of 6 classes.

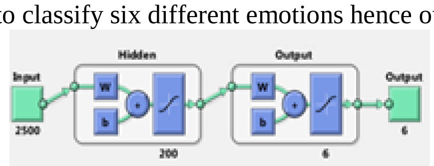
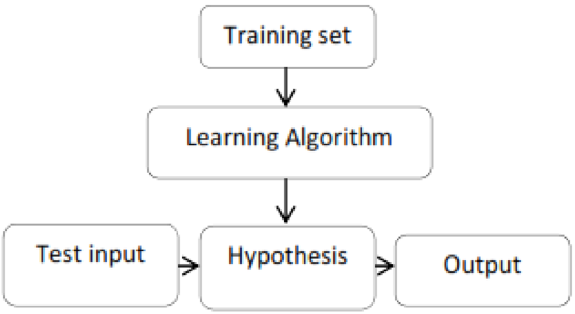


Fig: Neural network used

Step 4:- Training the system using Scale conjugate gradient back propagation algorithm.



Once the network architecture is decided the next step is to train this network. For that we have used scale conjugate gradient back-propagation as learning algorithm

Step 5: Testing the system using unseen images.

Once the system is trained, Test input i.e. unseen images that are not shown to the system is provided to the system and according to hypothesis the image is classified accordingly.

IV. Results

In this section, we will evaluate the proposed method. We have implemented our face recognition system using MATLAB. We have used Cohn-Kanade database for emotion recognition which contains six different emotions. Classification rates [1] by the baseline method for the emotion detection sub-challenge are shown in Table V. After simulating, we have got good training and testing accuracies as shown in table 3.

Training accuracy	100%
Testing Accuracy	87.2%

Table 3: - Overall Training and testing accuracy

We have also measure performance of our system by estimating mean square error and % Error.

Mean squared error is the average squared difference between outputs and targets. Lower values are better. Zero means no error.

Percent Error indicates the fraction of samples which are misclassified. A value of 0 means no misclassification, 100 indicates maximum misclassification.

	Mean square error	Error(%)
Training	1.16455e-5	0
Testing	4.04047e-2	12.76595e-0

Table 4:- Mean square error and Error (%)

In addition, we have provided confusion matrices for the for emotion recognition of the overall test dataset. Rows are predicted results, columns the ground truth.

	Angry	Disgust	Fear	Happy	Sad	Surprise
Angry	**3**	0	0	0	0	0
Disgust	0	**5**	1	0	0	0
Fear	0	0	**7**	0	1	0
Happy	0	2	0	**12**	0	0
Sad	2	2	1	0	**5**	0
Surprise	0	0	0	0	0	**9**

Table 5:- Confusion Matrix for emotion recognition of the overall test dataset.

V. Conclusion

This paper describes the different techniques that are employed in face expression recognition and analysis. With respect to machine learning techniques, we noticed a strong trend to use SVMs. Most of the teams result that we have already shown in Table 2 used SVM, such techniques have proven very popular in recent literature. But in our work we have used scale conjugate gradient back propagation algorithm and we are getting overall testing accuracy up to 87.2% which is better than the as compared to the work done using SVM explained in table 2.

In our future work, we can improve our recognition rate by using LBP histogram, equalization techniques & PCA techniques before training the system.

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