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Facial Expression Recognition: A Survey

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***Abstract*- Face Expression plays an important role in human communication. Facial Expression Recognition (FER) is process performed by computers which consist of detect the face in the image and preprocess the face region, extracting facial expression features from image by analyzing the motion of facial features or change in the appearance of facial features and classifying this information into facial expression categories like prototypic facial expression such as fear, happy, sad or Action Units(AU) such as eye open or mouth stretched. Face Expression Recognition techniques have always been a very challenging task in real life applications because of the variations in the illumination, pose and occlusion. This paper presents a methodology for face expression recognition.**

***Keywords:* Facial Expression Recognition (FER), Feature Extraction, Feature Classification, Prototypical Facial Expression, Action Units (AU).**

I. INTRODUCTION

Human face is a very useful and powerful source of communicative information about human behavior. It provides information about human personality, emotions and thoughts. Facial expression provides sensitive cues about emotional response and plays a major role in human interaction and nonverbal communications [2]. It can complement verbal communication, or can convey complete thoughts by itself.

Researcher says that the verbal part or spoken words of a message contributes only for 7 percent to the effect of the message as a whole, the vocal part contributes for 38 percent, while facial expression of the speaker contributes for 55 percent to the effect of the spoken message. This implies that the facial expressions form the major modality in human communication.

With the development of artificial intelligence and pattern recognition, people pay more and more attentions to facial expression recognition which is an important technology of intelligent human-interactive interface [3]. Different people may have different appearance for different expressions. But human can still recognize a wide range of different expressions. If we are not familiar with someone's face we can recognize the person's facial expression due to the universality of expressions. However it is a challenging task for a computer vision system to recognize an individual across different expressions or to classify the basic facial expression across different persons.

Facial expression analysis has wide range of applications in areas such as in social psychology, video conferencing, user profiling, image retrieval, psychological area, face animation etc .Facial expressions help coordinate conversation, and have considerably more effect on whether a listener feels liked or disliked than the speaker's spoken words [1]. Facial expressions have been studied by cognitive psychologists, social psychologist, neurophysiologists, cognitive scientist and computer scientists. Computer vision based approaches to facial expression analysis discriminate among a small set of emotions.

Challenge in face expression recognition system.

It has already been stated that face expression recognition techniques have always been a very challenging task for researches because of all difficulties and limitations. Facial expression analysis and recognition is a complex task because faces vary from one person to another due to different age. The challenges associated with face expression recognition can be attributed to the following factors:

Pose: The images of a face vary due to the relative camera-face position such as frontal or non-frontal. Face may have a different angle so some of facial features such as an eye or the nose may become partially or wholly occluded. To overcome this challenge implements good pre-processing techniques which are invariant to translation, rotation and scaling. As shown in fig 1 image which is used for feature extraction having different pose is complex.

Fig 1: Different Pose in an image

Occlusion: Faces may be partially occluded by other objects. In an image if face is occlude by some other faces or objects such as mask, hair, glasses as shown in fig 2. For that image extraction of expression features are complex.

Fig 2: Occluded Face

Illumination: If the images are taken in different lights. Then expression feature can be detected inaccurately and hence recognition rate of facial expression is low. Face image taken with different lights is shown in fig 3. This factor would typically make feature extraction more difficult. To compensate the variation of illumination in an input image, image preprocessing methods like DCT normalization, Histogram Equalization, Rank Normalization can be applied before feature extraction.

Fig 3: Illuminated Face

This paper gives an overview of the methodology to be followed for facial expression recognition. The rest of this paper is organized as follows. Section 2 describes the facial expression recognition methodology with necessary steps to be followed. Section 3 provides conclusion of the study.

II. FACIAL EXPRESSION RECOGNITION METHODOLOGY

Facial Expression Recognition consists of three main steps. In first step face image is acquired and detect the face region from the images and preprocessed the input image to obtain image that have a normalized size or intensity. Next is expression features are extracted from the observed facial image or image sequence. Then extracted features are given to the classifier and classifier provides the recognized expression as output. The block diagram of methodology used in facial expression recognition is given in fig 4:

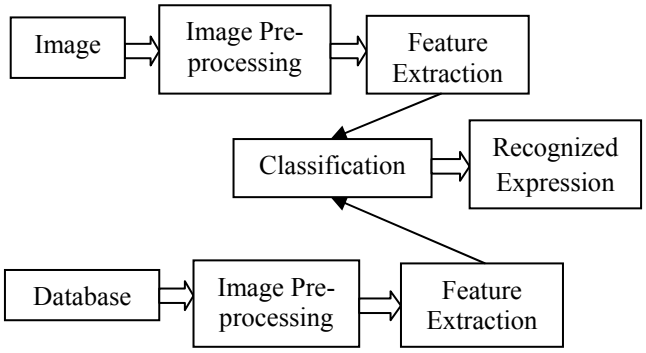

Fig 4: Block Diagram of Facial Expression Recognition Methodology

The input image can be represented in various ways. If face image can be represented as a whole unit then it is called holistic representation. If face image can be represented as a set of features then it is called analytic representation. Face can also be represented as a combination of these two then is called hybrid approach.

Facial features are prominent features of the face-eyebrows, eyes, nose and mouth. The face model features are the features used to represent model the face. Facial Expression are formed by deformation of facial features or features appear temporarily appear in the face.

In the case of static images, the process of extracting the facial expression information is referred to as localizing the face and its feature in the scene. In the case of facial image sequences, this process is referred to as tracking the face and its features in the scene. Face representation and the kind of input images determine the choice of mechanisms for automatic extraction of facial expression information.

A. Face Detection and Pre-processing

Face Detection step is used to obtain the face region from images. This step is require because images having a different scales and orientation. The Face detection process is also not easy because scale and the orientation of the face can vary from image to image. If the shots are taken with a fixed camera, faces can occur in images at various sizes and angles due to the movements of the observed person. So it is difficult to search for fixed pattern in the image. Presence of noise and face images are occluded to perform this task is difficult.

Input image having a complex backgrounds and variety of lightning conditions can be also quite confusing in localizing or tracking. Face expression recognition tends to fail if the test image has a different lighting condition than that of the training images. If illumination is non-uniform, facial point can be detected inaccurately for that preprocessing step is required.

B. Expression Feature Extraction

After the face has been located in the image or image sequences, it can be analyzed in terms of facial features. There are two types of features that are usually used to describe facial expression: Geometric Features and Analytic Features.

1) *Geometric Features:* The features measure the displacements of certain parts of the face such as eyebrows or mouth corners. The facial components or facial feature points are extracted to form a feature vector that represents the face geometry. Geometry based method is that expressions affect the relative position and size of various features and that by measuring the movement of certain facial points the underlying facial expression can be determined. The task of geometric feature measurement is usually connected with face region analysis, especially finding and tracking crucial point in the face region. Various methods exist which can extract feature for expression based on motion of the feature such as Optical Flow [3], Active Appearance Model [1] which is statistical model of shape and gray scale information. Relationship between AAM displacement and the image difference is analyzed for expression detection.
2) *Appearance Features:* The Features describe the change in face texture when particular action is performed such as wrinkles, bulges, forefront, regions surrounding the mouth and eyes. Image filters are used, applied to either the whole-face or specific regions in a face image to extract a feature vector. Appearance-based algorithms are wide-range and include Principal Component Analysis (PCA) [5], Independent Component Analysis (ICA) [7], Locality Preserving Projections (LPP) [8], Linear Discriminate Analysis

(LDA) [7], Gabor wavelets [6], Local Binary Pattern (LBP) [7].

C. *Expression Classification*

After the set of features are extracted from the face region are used in classification stage. The set of features are used to describe the facial expression. Classification requires supervised training, so the training set should consist of labeled data. Once the classifier is trained, it can recognize input images by assigning them a particular class label. The most commonly used facial expressions classification is done both in terms of Action Units, proposed in Facial Action Coding System (FACS) [12] and in terms of six universal emotions: happy, sad, anger, surprise, disgust and fear defined by Ekman [13].

1) *Facial Action Coding System (FACS)*: Facial Action Coding System (FACS) was developed by Paul Ekman and Wallace Friesen in 1976 is a system for measuring facial expression. FACS is based on the analysis of the relations between muscle contraction and changes in the face appearance. It is a common standard to systematically categorize the physical expression which has been useful to psychologists and to animators. The Face can be divided into Upper Face and Lower Face Action units [12] and the subsequent expressions are also identified. The fig 5 shows some of the combined action units.

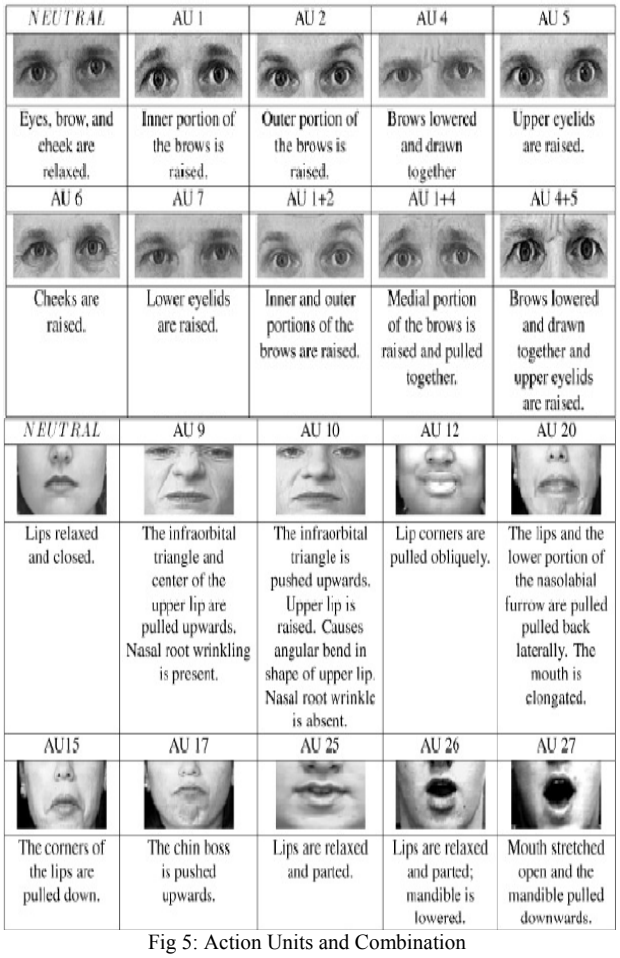

Fig 5: Action Units and Combination

Contractions of muscles occurred because of some expression are marked as an Action Unit (AU).Action Units are changes in the face caused by one muscle or a combination of muscles. The task of expression analysis with use of FACS is based on decomposing observed expression into the set of Action Units. There are 46 AUs that represent changes in facial expression and 12 AUs connected with eye gaze direction and head orientation. Action Units are highly descriptive in terms of facial movements, however, they do not provide any information about the message they represent. AUs are labeled with the description of the action.

2) *Prototypical Facial Expression:* Instead of describing the detailed facial features most facial expression recognition system attempt to recognize a small set of prototypical emotional expressions. According to the Ekman's theory [13], there are six basic emotion expressions that are universal for people of different nations and cultures. Those basic emotions are anger, neutral, disgust, fear, happy, sad and surprise as shown in fig 6.

Fig 6: Six Universal Emotions

There are a lot of different machine learning techniques for classification task, namely: K-Nearest Neighbors [10], Artificial Neural Networks [11], Support Vector Machines [3], Hidden Markov Models [3] and Boosting Techniques like Adaboost classifier [2].

III. CONCLUSION

Human detect and identify faces and facial expressions in a scene with little or no effort. Still, development of an automated system that accomplishes this task is rather difficult. Various approaches have been made towards robust facial expression recognition, applying different image acquisition, and feature extraction, analysis and classification methods. This paper has briefly overviewed the methodology of facial expression recognition.

Feature extraction is important stage for expression recognition system because extracted features are used for Classification stage. Feature extraction for expression recognition using geometric features is more difficult because it depends on the shape and sizes of features so appearance based features are easier to extract.

Extracted Facial features are used to detect the Action Units occurrences and then AU combinations were translated into emotion categories. This process required much effort because the analysis was done manually and more training time is require for building a FACS coder. So develop Facial Expression Coding System that classify expression as provided by Ekman into six categories using any of the neural network technique is easy to develop and efficient.

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