A Study on Facial expression for Face detection

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Abstract

Human beings usually convey a lot of information using verbal and non-verbal communication methods. The most silent way of passing information is by hand movements, body language, facial expression and gestures. The use of facial expression is one of the prominent ways to communicate over verbal communication. The study on face detection process also considers facial expression feature analysis as one of the noteworthy factor taken into account by proposing five different classification models of facial expression. This paper mainly focuses on the various facial expressions studies applied to capture the human emotions by measuring its intensity in facial emotion recognition system.

Keywords: Face Detection, Face Recognition, Facial Expression, Face Emotion Recognition (FER), Principle Component Analysis (PCA), AdaBoost, Deep-Learning, Machine Learning (ML), Artificial-Neural Network (ANN), Convolutional neural network (CNN)

1. Introduction

The use of verbal and non-verbal communication system [1] helps in passing the thoughts or share meaningful information among humans. Face expressions are considered as one of the most striking attribute of body language which conveys the reaction & emotions in most comprehensive way [2]. An emotion is a powerful tool used by humans [3] for social communication [4]. The study of facial emotions and facial reaction is called as facial expression analysis. Various studies have been proposed by numerous authors [4] on facial expression recognition (FER) [3], gesture recognition and emotion recognition [5] which can be used interchangeably. Artificial

Intelligence and computer vision are designated as important areas for research on face recognition of human facial emotion [6].

Face recognition mechanism is used extensively in security surveillance systems for identification and verification. Its connected branch i.e. facial expression study [**5**] has emerged as an upcoming technology area to be applied in human machine interface and emotion detection system.

There are several techniques available for detecting the facial features viz. eyes, nose, lips, mouth, ears etc [7]. The term *facial expression* defines the study on the non-verbal communication symbols used for passing/sharing information. Each facial component is used to generate different facial expression or facial emotion (FER) [3]. Emotions are an important part of human existence [4] [8]. The instinctive action of our behaviours and rationales lead to reaction. Face is the best indicator of facial expressions conveying the message without saying even a word and is easily identified by others [1].

In this paper, we have focused on theoretical aspect as well as on designing the conceptual model for facial expression analysis to study human emotions. The study of existing research and literature review is shown in Section 2 followed by proposed classification model for facial expression in Section 3. To analyse the facial expressions each of the facial feature component has been categorised it into five different component methods to measure the accuracy of facial emotion shown in Section 4. Later the section 5 shows some of the recent face expression recognition based application available for mobile devices which is followed by conclusion in section 6.

2. Literature Review

Recently computer vision has upraised the level of evolution in the field of face recognition system and facial expression recognition to support automatic face recognition system [9]. In the field of face detection, many researchers [10] have progressed with many different approaches leading to different results for face expression analysis or facial expression recognition (FER) [3]. There is a common consensus outcome from the numerous researches conducted, that there are challenges in dealing with emotion detection methods [5] processing the information from various facial expressions taken from user as face input image. Many algorithms have been designed so far for expression detection using different deep learning based [11] and neural network approaches like back propagation algorithm [4], multilayer perception, PCA, Linear Regression Classification algorithm, Hidden Markov Models (HMM), Linear Discriminant and Self-organizing map (SOM) technique etc [12].

A comprehensive study covering the schemes and systems engaged for straightening out the subject of facial expressions analysis, starting from time of face detection to feature recognition and the final expression recognition system (ERS). However, ately different strategies from research worker in field of Facial Expression Recognition are discussed in [13].

The face recognition and facial expression covers the complete process from identification to verification and then finally analyzing the result. The most common and basic algorithm applied are Principle Component Analysis (PCA) and Viola-Jones algorithm used for identification or detecting facial expressions [14]. PCA algorithm is popular among all the algorithms used for identification process from input source face image and further corresponding to each facial expression Viola Jones algorithm is used to generate successive results [1].

Authors in [5] [6] [15] have composed conventional approach in three steps i.e. detecting face and facial components, extracting features and third the classification of facial expression. The input face image is processed to detect facial components like eyes, nose, mouth, cheeks etc it particularly focuses on the face region defining the component of face area. The facial features are extracted from the detected facial components and lastly it trains the classifier using support vector machine (SVM), AdaBoost, Random forest is employed to produce significant amount of accuracy for extracted features in result [16].

Facial expression recognition system goes through three steps to process any facial images stored in database. The steps are, starting with face acquisition, extraction of facial features and constructing a classifier [11]. Authors have been able to apply extraction and classification process effectively. Also author in [6] applied traditional approach as general approach with deep learning based method using machine learning algorithm. Out of several deep learning models [11], the most extensively used is Convolutional neural network (CNN) approach [11] and it is also used for defining convolution layers to filter the feature map networks. The performance of extracting facial expression reaches to 92.81% accuracy rate by applying CNN architecture [4].

Many authors in [6] [15] have classified facial expressions into categories such as Facial Action Coding System (FACS), Facial Landmarks (FL), Basic Emotions (BE), Compound Emotions (CE), Micro Expression (ME), Facial Action Units (AUs) [17], the expressions can be represented in the classification model. Mainly two approaches are discussed here for detection of action units and detection of each facial points. The main use of facial action coding system is to design a framework for characterizing movements in facial muscles which are 44 AUs on face. However, facial expression can be identified by AU detection and AU recognition [15].

Many different approaches proposed by few authors in [18] are related to diagnose of mental disease and also there are few applications in the field of traffic policing detecting the drowsiness of the driver for safety purpose.

Camera based smart phone devices supports with FER system follow basic three steps for facial expression recognition [5] i.e. pre-processing, facial feature extraction followed by detecting each face region [1]. So that highest amount of consistency in facial expression results can be achieved in the final steps.

Authors in [3] have demonstrated their study on FER system by considering variety of facial expression and aging group factors on FACES Image database and compared its performance with computation on JAFFE database. FER system has divided pattern recognition problem in two modules namely feature extraction and classification module. Gabor filter and Log Gabor filtration process used for extracting facial features. Whereas SVM Classifier is used for training the known input face images

and later unknown face images taken for processing. Whereas [19] has shown the FER process implemented feature extraction of each facial region using Histogram of oriented gradients (HOG) [20] and later SVM is performed for classifying the extracted features to its facial expression.

A brief methodological survey on facial expression conducted by researchers [5], the aim is to retrieve idea on various techniques developed in the area of emotion recognition [15], [21]. The technique discussed for automated facial emotion detection using Local Binary Pattern (LBP) with Cohn-Kanade, Berlin, JAFEE and other dataset to analyze different facial expression. The study in [21] has proposed for learning emotion recognition model defining different stages viz. facial feature extraction, subset feature extraction and lastly the emotion classifier. The Haar cascade method is applied for detecting facial features and on the extracted facial feature region Sobel-edge detection model is used to retrieve the characteristics value of each of the extracted feature. All such stimulations are performed to demonstrate the distance learning process of emotion recognition on facial expression system [21]

Wide variety of datasets like Extended Cohn Kanade database contains more than ten thousand face images on different subjects available over the internet for research purposes. The robust and automated facial expression and emotion recognition system divides the basic emotions on the basis of properties of facial images into six classes namely “happy, sad, surprise, fear, disgust and angry” [15]. These are universally recognised emotional classes as basic emotions [20]. In addition to that it can recognize a “neutral” state and analyze “contempt”. It also computes “Action Units”, “valence”, “arousal”, “gaze direction”, “head orientation”, and personal attributes such as gender and age. Authors in [17] have proposed a Facial Expression Recognition theory for Combined Emotions algorithm (FERCE) grouping basic emotions into set of emotion classes and nearly 37 emotions have been identified as combination of two or more emotions simultaneously, out of which 16 are added new for statistical analysis employed for validating FACS.

3. Classification Model of Facial Expressions

Based on the facial features extracted, different level of facial expression can defined as under

- ***Single Component Method***: This method shows the changes on facial muscle which reflects distinct change in facial expression.
- ***Basic Component Method***: This method depicts the basic set of human emotions like happy, sad, anger, fear etc.
- ***Hybrid Component Method*:** This hybrid method defines the combination of above two methods
- ***Micro Component Method:*** This method indicates the subtle or little movement in facial expression.
- ***Macro Component Method:*** This macro based method defines the change in group of muscles along with the frequent change in emotions.

Hence, for the above listed classification models here we have considered only two facial features components such as eyes and mouth for explaining & are described in brief as below:

EYES are frequently engaged while in dialogue with other person; taking notice of eye movements is important part of the communication process. Few common things worth noticing include if there is a unmediated eye contact or averting gaze, how many times the eyes blinked, the status of pupil dilation. While evaluating body language attention should be paid to the following eye signs.

- "Eye Gaze": When a person looks straight into the eyes while having a conversation, it shows that they are interested and paying due attention. However, longer eye contact may give a feeling of threatening. Other than that, breaking the eye contact and often looking away might point to that the person is not paying attention, not comfortable or trying to hide the real feelings.
- "Eye Blink": Blinking is natural phenomena, but one should give attention to whether a person is blinking too frequent or too less. People generally blink more rapidly when they are under stress or not comfortable. Inconsistent blinking indicates that a person is deliberately trying to control the eye movements.
- "Pupil Size": Pupil size can be taken as a very subtle gestural communication signal. While exposure to light in the environment controls the pupil dilation and sometimes emotions can also cause to happen minor changes in pupil size.

MOUTH expressions along with the movements are also considered important component while reading the body language. For example, biting on the bottom lip could indicate that the individual is experiencing worry, fear, or insecurity. Covering the mouth could be an attempt to be gracious and if the person is yawning or coughing it may also be an effort to cover up disapproval. Smiling is one of the greatest body language symbols, but smiles can also be understood in many ways. A smile could be genuine, or it could be used to convey false happiness, sarcasm, or sometimes cynicism. While accessing body language, attention should be paid to the following signal for mouth and lips:

- "Pursed lips": Tighten up the lips could be an indicator of distaste, disapproval or distrust.
- "Lip biting": Sometime people bite their lips when there is an emotion of worry, anxiety or stress.
- "Covering the mouth": On occasions when people want to conceal an emotional reaction, they might cover their mouths so as to avoid displaying smile or smirks.
- "Turned up or down": Minor changes to the mouth can also be small indicators of a person's feelings. When the mouth is marginally turned up, it could mean that the person is feeling happy or is optimistic. On the contrary, a marginally down-turned mouth can indicate sadness, disapproval, or even a twisted emotional state.

To analyse the emotion type, Table 1 has listed most of the expression modes [15] with their respective features [22] and movement detected on eyes and mouth (lip) movement accordingly.

4. Measure emotions accurately

To measure facial emotions from an input face image, the feature selection and template matching algorithm is applied. In order to capture facial feature geometry of a specific component, the selected component details will be extracted & fed into the detailed logical structure of that specific facial component. Facial features can be obtained with the help of

face detection techniques which is already carried out in our previous research work [**7**]. The facial component is extracted using bounding box property by defining number of blobs in a face image. The bounding box on each face input image covers the area around the facial component region like both the eyes in which eyebrows also included, complete nose with nostrils, mouth in which lower and upper lips are properly included. From the previous step the highlighted component's dimension (coordinates), position & formation are extracted & the resultant data is compared with master input-image data to compute the differences in turn finding the emotion type.

5. Application of Facial Expression Recognition

In recent years, we have observed that extensive use of smart phones in both personal & corporate domains has led to substantial developments in this area. The smart phone based mobile applications are enabled with the face recognition supporting features. The human face identification feature and face detection function is in-built for secure access of authorized personnel only to the mobile device. Some of the most commonly used mobile application utilizing the face recognition technology to a great extent are snapchat, Google Lens, Face Recognition & Face Detection App, FaceSDK, FaceMatchR, Face2gene, Faceapp, Applock Face, Facephi, Facefirst etc.

With all such applications installed it widely supports in strengthening the cyber security and also help law enforcement officers in preventing the secure systems from unusual activity.

Table 1: Emotion Expression Identification [13, 17, 22 and 23]

S. No.	Type of Expression	Key Features	Motion of facial part	Visibility factor	Accuracy Rate
1.	Happy [15]	• Eyes muscle gets tightened and crow's feet wrinkles [13] • Corners of lips raised diagonally [23]	• Brightened Eyes • Corner of eyes crinkled [13] • Corner of Mouth turned into a curve [23]	Prominently visible	96.38% [15]
2.	Sad [15]	• Inner corner of eyebrows raised and Eyelids loose [13] • Lip corners pulled down [23]	• Eyes filled with tears • Lower lip trembled or quivered • Cover eyes from his/her hand [17]	Prominently visible	91.15% [15]
3.	Surprise [15]	• Eyebrow and Eyelids both gets pulled up [13] • Mouth hangs open [23]	• Eyebrow raised • Lips form upper and lower curve	Explicitly visible	98.09% [15]
4.	Fear [15]	• Upper eyelids and eyebrows pulled up together [13] • Mouth Stretched [23]	• Chew bottom lip • Jaw clenched • Jaw tightened	Explicitly visible	91.75% [15]
5.	Disgust [15]	• Eyebrows pulled	• Lips tightened	Unambiguously	93.46%

		down and Upper lip pulled up [23] • Lips loose [13]	• Eye blinked tightly		[15]
6.	Anger [15]	• Eyebrows gets straightened [23] • Upper and lower eyelids pulled up [13] where as margins of lips rolled in [17]	• Eyes wide open • Mouth set in a hard line • Presses lips under teeth	Clear visible	87.73%. [15]

6. Conclusion

Emotions are the elementary blocks for understanding human behaviour as these play critical role in non-verbal communication. Facial expression study extracts the emotion data to provide deep perception that permit researchers to gain insight in complex human behaviour.

From the literature study it infers that the performance of the system secured to 92.81% accuracy rate by applying CNN architecture. The average 92.81% accuracy rate achieved while testing. After investigating wide range of facial expression recognition techniques, artificial neural network (ANN) based approach provides considerable training set of optimistic results. Here it's concluded that face expression analysis is an interestingly complex & challenging field after face detection and face recognition process. However, a lot more further research is required in this specific domain of facial expression interpretation.

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