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Facial Emotion Recognition using Eye

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Abstract

The next generation concept evolving in the field of Artificial Intelligence is how to improve *Machine Perception and Social Intelligence* by making a smarter system capable of reading and understanding human behavior. Human beings communicate with each other through mutual conversations and they process this information by one of the following medium: speech and vision. Therefore, *facial emotion recognition* can be considered as a vital and useful visual based tool for building systems which can identify, interpret, process, and simulate human emotions. The traditional approach for performing facial emotion recognition is tracking changes in the facial muscles which are defined as Action Units(AU)[1]. Although Action Units has proven to be a quite successful approach in the process of identification of facial expressions, there are a total of 7000 AUs combinations of different AUs characterized to distinguish the emotions which can prove to be really a very extensive and time consuming procedure]. In this paper we provide an alternative approach of using feature points instead of action units to develop a faster and efficient recognition method. In this paper we attempt to achieve higher efficiency in recognizing human emotions accurately by using minimal number of geometrical feature points. We first take pre-processed dataset of JAFFE image database as our input, then we perform extraction of the feature points of only two features: Eyes and Eyebrows of human face. In the final stage, we classify this extracted dataset through Decision Tree Algorithm and are able to achieve 78.4% recognition rate when we run it across for 213 images in overall.

Keywords: Artificial intelligence, facial emotion recognition, feature points, JAFFE, Decision Tree Algorithm.

OBJECTIVE AND RESEARCH SCOPE

A person's face plays an important role in delivering a message while communicating in a group or with an individual. The face is an implicit part of body language which is considered to be one of the key forms of communication. Therefore reading facial expressions correctly is crucial to interpret the feelings of a person hidden within his message. With the changing expressions of people, the shape of different facial components such as eyes, mouth, eyebrows etc. tend to change accordingly. In this study we focus on two of such features i.e. eyebrows and eyes and to determine how the variation in these two components help us to differentiate the 7 basic emotional states of a human i.e. happiness, fear, anger, sadness, disgust, surprise and normal (neutral).

LITERATURE SURVEY

Facial Action Coding System is the most commonly used research tool in tracking the changes in the facial muscular activity. FACS helps in translating the varying changes in facial muscles to the appropriate Action Units. It is an anatomically based system for describing all notable facial movements in detail[2]. Each notable component of facial movement is called an Action Unit or AU. All facial expressions can be compartmentalized into their constituent AUs[2]. According to Ekman and Friesen, these changes can be transformed into 46 action units by combinations of which we can cover all the basic emotions.

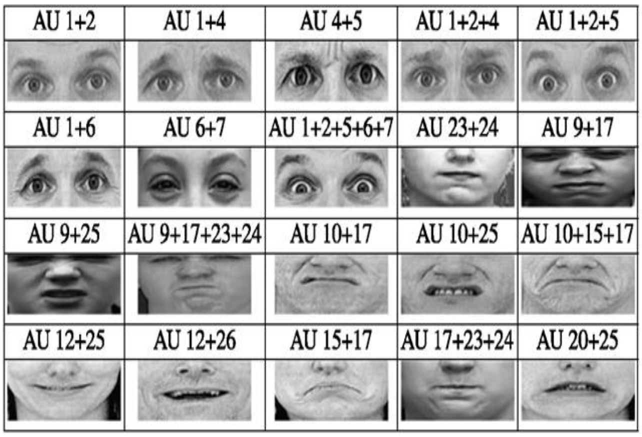

Figure 1: AU Combinations for upper and lower face

Maja Pantic and Ioannis Patras[8] took up the challenge of automatic analysis by recognizing facial muscle actions which are generated through different expressions. They performed particle filtering to obtain 15 fiducial or feature points on sequence of profile face images and were able to obtain recognition rate of 87%. The selection of these 15 facial points are shown in fig. 2.

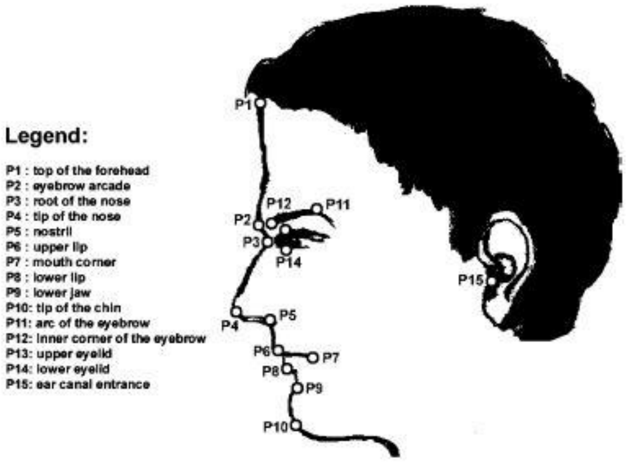

Figure 2: Facial points obtained through Particle Filtering

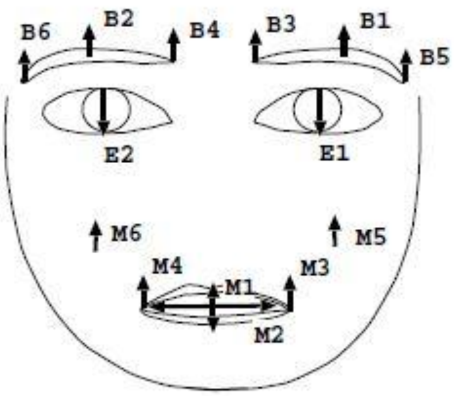

Figure 3: Facial Features classified by Bayesian Network

Guided Particle Swarm Optimization (GPSO) algorithm[4], a variation of PSO algorithm implemented by Bashir Mohammed Ghandi, R. Nagarajan and Hazry Desa for facial emotion detection by tracking the relevant points, which here are considered as Action Units (AUs) and is able to detect the six emotions in real time. But a drawback of GPSO algorithm encountered was that image preprocessing needed to be performed, hence its application was limited to pre-recorded images only. Therefore they improved the system by implementing Lucas-Kanade (LK) [4] optical flow algorithm. LK Algorithm helped in keeping track of the positions AUs in real time which eliminated the requirement of pre-processing. However they observed that the Back-Propagation Neural Network (BPNN)[7] has proven more successful in classification based problems. After comparing both the approaches they concluded that BPNN is better than GPSO in terms of speed however the accuracy of results by BPNN was slight less than GPSO. Yoshihiro Miyakoshi, and Shohei Kato[5] gave an another approach of using Bayesian Network for emotion detection system with facial features. Bayesian network classifiers infer from the dependencies among the target attribute and explanatory variables. The system proposed by them tries to learn Bayesian Network in two phases: internal and external phase. The internal phase uses K2 algorithm to construct casual relations among the facial features whereas the external phase constructs casual relation between facial features and emotions using feature selection. The facial features constructed by the K2 algorithm are depicted in fig. 3. A facial components detection method proposed by Byung-Hun Oh, Kwang-Seok[6] Hong uses the histogram method, the blob labeling method, and the MMGC image for face detection with an accuracy of 81.4%. Tie Yun and Ling Guan[3] proposed an alternative by introducing fiducial points localization using scale invariant feature based Adaboost classifiers and were able to achieve 90.2% average recognition rate using Support Vector Machines (SVM). These 26 fiducial points as per classification of AUs[2] can be described as per given table. According to Tie Yun and Ling Guan, these feature points extracts most important characters of the face and these points must be selected as minimum as possible.

Points No.	Fiducial Points Description
1	Top of the head
2	Tip of the chin
3	Left of the head
4	Right of the head
5	Left eye inner corner
6	Top of the left eye
7	Left eye outer corner
8	Bottom of the left eye
9	Right eye inner corner
10	Top of the right eye
11	Right eye outer corner
12	Bottom of the right eye
13	Left eyebrow inner corner
14	Top of the left eyebrow
15	Left eyebrow outer corner
16	Right eyebrow inner corner
17	Top of the right eyebrow
18	Right eyebrow outer corner
19	Top of the nose
20	Left nose corner
21	The medial point between left and right nostril centers
22	Right nose corner
23	Left corner of the mouth
24	Top of the upper lip
25	Right corner of the mouth
26	Bottom of the lower lip

Figure 4:. Facial Fiducial Points selection through Adaboost Classifiers

MODULES OF PROPOSED WORK

The method adapted by Tie Yun and Ling Guan[3] of using feature points better and quicker in comparison to the Action Units[2] which is considered to be a standard approach for facial detection. Still accounting all the features in the process of detection will lead to the same problem encountered in case of action units i.e. large no. of possible combinations formed by the 26 feature points. Our aim is to carry out the process of emotion recognition by choosing minimum features using only two features of facial structure i.e. eyes and eyebrows. The first step involved in this process is image pre-processing. The processed images will contain fiducial points for each section of the face viz. nose, eyes, eyebrows, mouth and outline of the face as shown in fig. Once we obtain these feature points, the next step is to isolate the feature points for the facial features we require to analyze in our system. Thereafter we examine these feature points extensively and try to find which points could prove crucial in the process of determining different expressions. Once we narrow down the feature points we run it through classification algorithm and its outcome will give information about the correctness of these selected feature points in identifying the seven emotions: happy, sad, angry, disgust, surprise, and neutral (normal). This whole process is outlined in fig. 5:

IMPLEMENTATION ARCHITECTURE

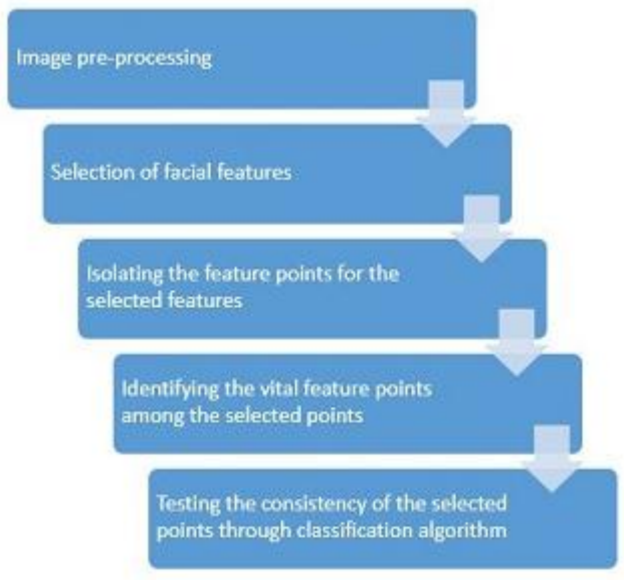

Figure 5: Process Flow for the proposed system

IMPLEMENTATION TOOLS

For implementing this system, we utilize the JAFFE (Japanese Female Facial Expression) image database to show our results. The dataset which is taken as input here has already been pre-processed to obtain the required feature points for each facial component for all the images present in the set. The mapping of these feature images is shown in the fig, below:

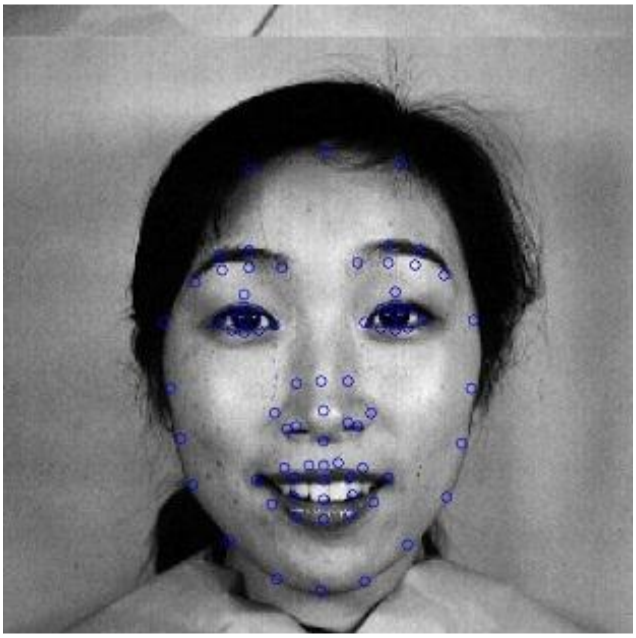

Figure 6: Feature Points Extraction for a pre-processed image in JAFFE Database in Matlab

As we can infer from the fig. 6 we achieve 12 feature points covering the eyebrows (6 for each eyebrow) and 20 feature points covering the eyes (20 for each eye). The eyebrow is further divided into two components: inner brow and outer brow. Maja Pantic and Ioannis Patras[8] mentioned 15 fiducial points in total for profile image (side face) out of which points P1(eyebrow arcade), P11(inner corner of the eyebrow), P12(arc of the eyebrow), P13(upper eyelid) and P14(lower eyelid) for a single eyebrow and eye. This directly makes assumption of anatomically theory of equality of the two sides of the face. Though there is a debate among physcologists claiming this theory to be incorrect, it is a safe assumption as it proves to be true in most of the cases. The K2 algorithm implemented by Yoshihiro Miyakoshi, and Shohei Kato[5] yields 14 feature features for the entire face among which total of 8 features covering the eyes and eyebrows viz. E1(Blinking of right eye)l, E2(Blinking of left eye), B1(Vertical movement of right brow), B2(Vertical movement of left brow), B3(Vertical movement of right brow left corner), B4(Vertical movement of left brow right corner), B5(Vertical movement of right brow right corner) and B6(Vertical movement of left brow left corner). Another method of feature points selection proposed by Tie Yun and Ling Guan[3] lists 26 fiducial points spread all over the face listed in the table as follows: 5 (Left eye inner corner), 6 (Top of the left eye), 7(Left eye outer corner), 8(Bottom of the left eye), 9(Right eye inner corner), 10(Top of the right eye), 11(Right eye outer corner), 12(Bottom of the right eye), 13(Left eyebrow inner corner), 14(Top of the left eyebrow), 15(Left eyebrow outer corner), 16(Right eyebrow inner corner), 17(Top of the right eyebrow), 18(Right eyebrow outer corner) making a total of 12 feature points selection comprising of eyes and eyebrows. All these approaches were able to achieve accuracy of more than 75% on an average which illustrates effectiveness of facial points over action units in obtaining higher recognition rates.

By the analysis of these previous approaches we perform the selection of these 7 feature points for our experiment as follows:

Figure 7: Selection of key feature points in left eye and eyebrow

a. Left Inner Brow
b. Apex point of Left Brow
c. Left Inner Brow Corner
d. Left Eye left corner
e. Left Eye right corner
f. Left Eye apex point
g. Left Eye base point

In our discussion we will follow the assumption of the theory about both the sides of the face being anatomical equal for reduction of the feature points. MatLab has been used as a software tool in our experiment for extraction and manipulation of these selected feature points. The processed images from the JAFFE database comprises of 77 detected facial points for each one of the 213 images in the database. Here we isolate these 7 selected feature points for each image and merge them to create a new minimal dataset.

RESULTS

Each image in the JAFFE database has a label assigned to it. This label provides the description of the emotion corresponding to all individual images in the database. After accomplishing the task of extraction of the necessary feature points, we analyze results through classification with algorithms like J48 which is a Decision Tree based algorithm with the help of Weka software tool which predicts how much matching occurs between the selected features of the images and all the corresponding emotions associated to them specified in the label. The results obtained through the experiment are as shown in the fig. 8 and 9. As we can observe from the figure we successfully identify all the seven basic emotions with recognition rate of 78.4% by using just 7 feature points out of a total of 77 originally defined points in the image dataset that we have taken as input. The confusion matrix demonstrates how many instances (images) we were correctly able to guess for each different categories of emotions.

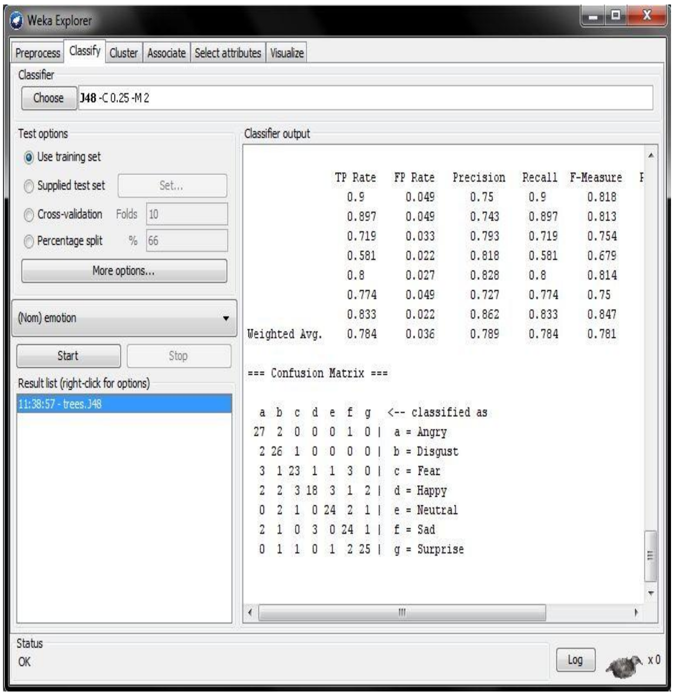

Figure 8: Confusion Matrix exhibited by Weka displaying no. of correctly identified instances for each different emotion

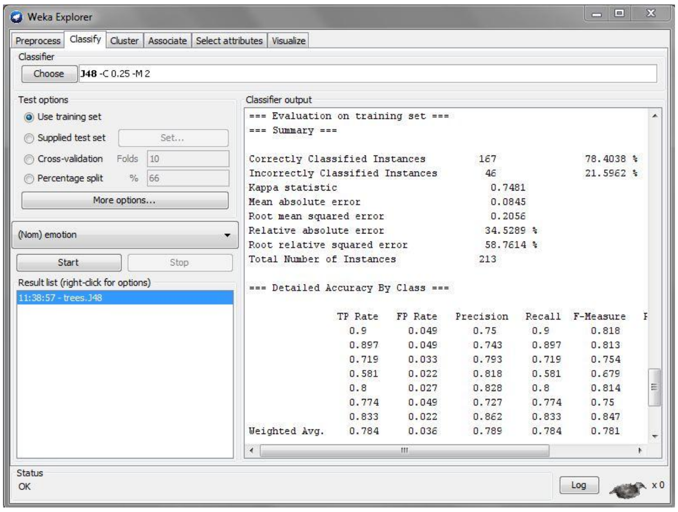

Figure 9: Total no. of correct instances identified and accuracy or recognition rate given by Weka

CONCLUSION

The result of our experiment and the previous studied approaches all lead to the conclusion that facial features can be considered as a more effective measure while performing facial emotion detection. Also limiting the feature points for a no. of specified features can give us a speedy and higher recognition rate. However the recognition rate achieved here is standard but not exceedingly higher than some of the existing methods. However, with some modifications we can surely increase the chances of achieving better accuracy.

FUTURE SCOPE

The modifications that can be further applied to the proposed system in this system are: mathematical transformations applied to the finally selected and extracted feature points for correcting the inconsistent results that we achieved during the experiment or implementing a new alternative image processing method for obtaining highly related geometrical feature points thereby leading to improvement in results. A new algorithm can also be devised for better classification of the emotions through pattern matching or some other method.

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