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RESEARCH ARTICLE

PARAMETRIC ANALYSIS OF FACIAL EXPRESSIONS BASED ON THE STATISTICAL APPROACH

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ABSTRACT

Recognition of facial expression was studied in this paper using several properties associated with the face it self. Actually, as the facial expression changes, the curvatures developed on the face and the dimensions of the objects such as eyebrows, lips and the area of the mouth change. Naturally there exist changes in the intensity of the pixels corresponding to these objects. Therefore it was found that the natural eye could distinguish these sharp changes and understand the facial expressions accordingly. The percentage changes were computed with regard to certain parameters related to different expressions associated with the face and that of the neutral face of the same person. The experimental results predicted a definite change in every trail. These results can also be used as a tool to design intelligent systems which recognizes different objects in the given environment. The results are found to be of immense scientific interest.

INTRODUCTION

Facial expression recognition and analysis has been an active research topic in the field of computer vision system and machine learning. Facial analysis and recognition have received substantial attention from researchers in biometrics, pattern recognition, and computer vision communities. They applications are quite large such as security, communication, and entertainment. Although a great deal of efforts has been devoted to automated face recognition systems, it still remains a challenging uncertainty problem. This is because human facial appearance has potentially of very large intra-subject variations of head pose, illumination, facial expression, occlusion due to other objects or accessories, facial hair and aging. These misleading variations may cause classifiers to degrade generalization performance. A study on facial expression analysis concentrates on (i) facial muscle analysis (ii) Action unique (Aus) (iii) facial expression data extraction and (iv) facial models. Human faces contain abundant information of human facial behaviours (Cohn *et al.,* 1999). According to Johansson's point-light display experiment (Johansson, 1973) (Johansson, 1976), facial expressions can be described by the movements of points that belong to the facial features such as eye brows, eyes, nose, mouth and chin and analyzed by the relationships between those features in movements (Pantic and Rothkrantz, 2000b). Hence, point-based visual properties of facial expressions can then be used for facial gesture analysis. It is important to note that facial features such as eyes, eyebrows, mouth, facial lines and bulges will change human facial appearances when their facial muscles are contracted. The contracted muscles will deform those features temporarily and the change of the muscular movements can only last for a few seconds (Fasel and Luettin, 2003; Pantic and Rothkrantz, 2004). Those facial muscles include frontalis, corrugator, procerus, depressor supercilli, orbicularis oculi, levator labii superioris, nasalis, zygomatic minor, zygomatic major, caninus, depressor labii, buccinators, orbicularis oris, masseter, depressor labii, mentalis, triangularis, platysman, and risorius. The FACS is called Facial Action Coding system, which is used to describe facial movements/motions/actions of facial muscles in behavior science (Ekman and Friesen, 1975) (Donato *et al.,* 1999) (Essa and Pentland, 1997). This system is based on action units (Aus). Each AU represents some facial movement. For example, AU1 stands for upward pull of the inner portion of the eyebrows. There are 44 AUs in total. Different sets of combinations of AUs accur in different facial expression categories; for example, the combination of 'surprise' consists of AUs1+2. These action units can also be used to detect subtle changes of facial expression (Pantic and Rothkrantz, 2004, Tian *et al.,* 2001). Actually detection of feature points of a still image is very important in facial expression analysis because by knowing which expression the current image is and which facial muscle actions produce such an expression (Pantic and Rothkrantz, 2004, Vukadinovic and Pantic, 2005). There are three types of face representation for analyzing

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facial expressions (Donato *et al.,* 1999). They are template-based (holistic), feature-based (analytic), and hybrid (analytic to holistic) methods (Pantic and Rothkrantz, 2000a). About 55% of human ommunication relies on facial expressions. There are prototypic (Six basic emotional expressions: sadness, happiness, anger, disgust, fear and surprise) and non-prototypic (blended emotional expression) expressions (Ekman and Friesen, 1975, Pantic and Rothkrantz, 2000b). In addition, *facial fiducial points* are the special facial points such as the corners of the eyes, corners of the eyebrows, and the tip of the chin etc. (Vukadinovic and Pantic, 2005). Examples using facial feature points are (Pantic and Rothkrantz, 2004) which used 19 fiducial facial feature points and (Valstar and Pantic, 2006). A detailed analysis of a research works on the facial expression recognition over the last decade is found in (Fasel and luettin, 1999). Recognition of face using eigen space projection methods (Turk and Pentland, 1991) was very well explained which had concentrated on the pixel levels. Each image is treated as a one dimensional vector and compared to detect the correct one. Later this method was improved using fisher space (Yang and Frangi, 2003). Then facial features are extracted using haar classifiers (Wilson and Fernandez, 2006). Eigendecomposition method was developed (Randy and Hoover, 2009) to recognise the sub spaces in a face which was based on the spectral theory. Even the facial features are analysed on the wrapped images (Hui Li, Hui Lin and Guang Yang, 2006). Face recognition process has two phases, representation and learning, both of which are recurring topics in computer vision. The primary task of representation is to find efficient salient features from raw face images. There are various methods, by which one can recognize faces accurately, but the recognition of emotions became a topic of high attention as we failed to put a line of demarcation between one expressions with the other. Of course, it is subjective and the level of understanding the emotions has changed as the new and sophisticated models and algorithms are developed. For security reasons, the focus is diverted even to understand the true and false expressions in the face. The wide range of potential applications of the present research includes, image understanding, synthetic animation, psychological study and intelligent human computer interaction and has lead to more attention on the facial expression recognition systems. Through this paper we would like to discuss some of the key parameters which can help in classifying the facial expressions.

A through survey of the literature pertaining to this topic reveals that no work is available in this direction. Therefore the present investigation is undertaken in order to predict qualitative as well as quantitative results pertaining to the subject. It is quite amazing to see how our mind is able to put a line of demarcation between two expressions of the same face. Visual perception may be dependent solely on the curvatures and the resultant geometry and shapes developed on the face. It is unimaginable that the calculations we implement are also happening in our mind before distinguishing different facial expressions. To verify these aspects we used the following parameters

Entropy: It is a measure of the amount of information that can be derived from the image i.e.,

$$E = \sqrt{\sum_{i=0}^{255} P(i)\log_2 P(j)}$$

It can be noted that the image having uniform histogram will have entropy value = 8.

Skewness: It is a measure of the degree of asymmetry or the departure from symmetry of the histogram. Its value lies between -1 and +1 and is represented by $\gamma_1 = \sqrt{\frac{\mu_3}{\sigma_3}}$

where μ_3 = third one dimensional moment and σ is the standard deviation

Kurtosis: It is a measure of the degree of peakiness of a histogram and is represented by K and is calculated as follows.

i.e., $\sigma_T^2 = \sum i(i-\mu_T)^2 Pi$

σ_T^2 = is the total variance of levels K= $(\frac{\mu_4}{\sigma_4}) - 3$

K= 0 , the curve is normal and if K= -ve the curve is more flat tapped.

If K = +ve the curve is more peaked

EXPERIMENTS AND RESULTS

It consists of comparing the changes in certain parameters corresponding to the same components such as eyes, nose and mouth of different facial expressions. In the following sections we discuss about the obtained features. Facial expression database and calculation of different parameters. We have used the Japanese female Facial expression (JAFFE) database. It is downloaded from the site http://www.kasrl.org/jaffe.html. This is used for extraction of components in each face and the variations in them with respect to entropy, skewness and kurtosis.

Fig 1. Japanese female Facial expression (JAFFE) database

It contains 213 grayscale images of 6 facial expressions (happiness, anger, sadness, fear, disgust and surprise) plus one neutral face posed by 10 Japanese women. The size of each image is 256X256. We have extracted the portion of these images such as mouth, eyes and nose and tested for the changes in each one of these components with different expressions using VC++ software. The extracted portion of eyes is having size of 115x50 and mouth is 65x35 and that of nose is 60x30. As we know that maximum or appreciable changes happen with only the aperture of mouth and the eyes with changes in expressions, we have taken at present only these portions and the data thus obtained is plotted with the help of origin software which is as follows.

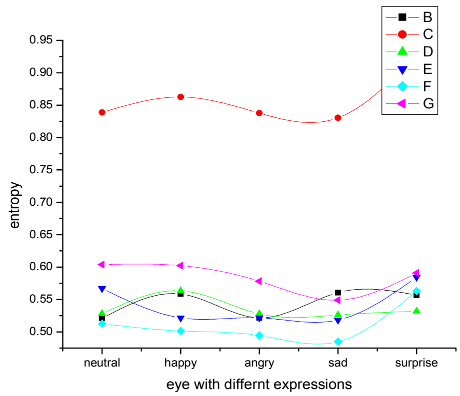

Fig 2. Entropy vs eye variations

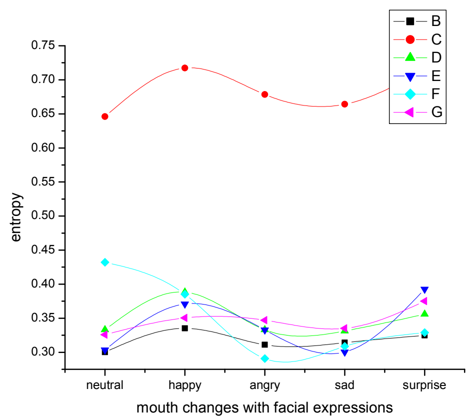

Fig 3. Entropy vs mouth variations

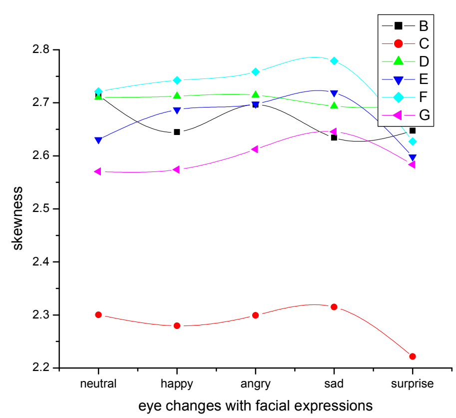

Fig 4. Skewness vs eye variations

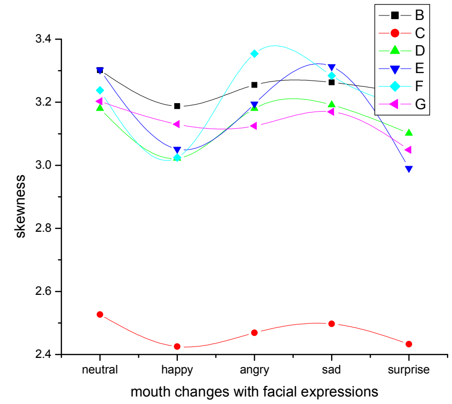

Fig 5. Skewness vs mouth variations

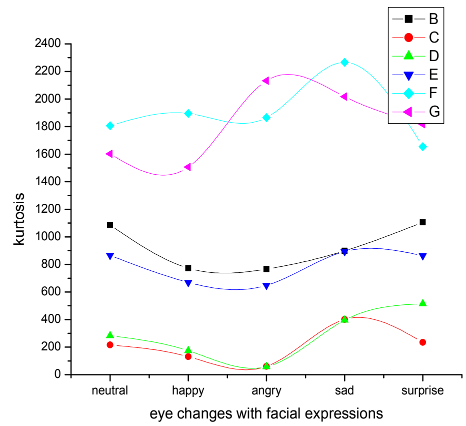

Fig 6. Kurtosis vs eye variations

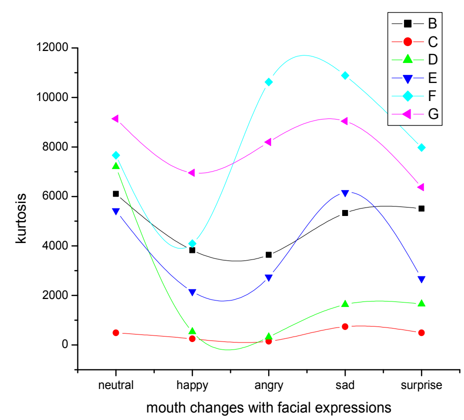

Fig 7. Kurtosis vs mouth variations

Fig. 2 represent the variation of entorpy of eyes with changes in expression on the face. From the graph it is clear that variations in entropy is same for face B and C. Where as the Fig. 3. represents the variation of entropy of mouth as the expression on the face changes. In this case, the face C and F exhibit similar varitions. Figure 4. and Figure 5. Represent the variations of skewness in eyes and the mouth as the facial expression change. Variation of skew ness of eyes and mouth are found to be same in case of faces C and G but not in others. Fig. 6. and Fig. 7. Represent the variations in kurtosis of eyes and the mouth respectively as the facial expression change. In this case also, two faces have shown similar changes. From the above experiments it was clear that the entropy and the skewness are inversely proportional to each other. The component with greater entropy will have lesser skewness. I.e., if the information in the image is more, then the image is less asymmetric. From the graphs six out of ten are plotted, two of them show similar changes as the facial expressions changes. For the remaining there is no resemblance. The same was observed with face as a whole also. That is just 30% of the human faces will have similar variations with respect to different facial expressions. This shows that human brain does not depend on only the mathematical expressions that are used here but on something else. Certainly this plays a vital role in the designing of an intelligent system.

Conclusions

Human faces contain abundant information of human facial behaviors. According to Johansson's point-light display experiment, facial expression can be described by the movements of points that belong to the facial features such as eye brows, eyes, nose mouth and chin and analyzed by the relationships between those features in movements. Hence point based visual properties of facial expressions can then be used for facial gesture analysis. About 55% of human communication relies on facial expressions. The experiments were conducted with regard to facial recognition under expression changes by using parametric analysis based on statistical approach. The interesting examined experimental results predicted that (i) Entropy and skewness of any image are inversely proportional to each other. (ii) Higher the entropy value the lesser is the value of skewness and vice versa. (iii) Two out of the six graphs plotted shown exact variations in all parameters such as entropy, skewness and kurtosis. (iv) Thirty percent of the human faces posses similar changes with respect to these set of faces as their expression changes. It was concluded that facial behaviors could also be used as another behavioral biometric for human identification and verification. The experimental results showed that a face recognition system with optimal design may eventually be developed, which is robust to the problem of facial expression changes. There is a scope to find algorithms and methods which can help to design intelligent system.

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