A novel fuzzy facial expression recognition system based on facial feature extraction from color face images

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ABSTRACT

Emotion recognition plays an effective and important role in Human–Computer Interaction (HCI). Recently, various approaches to emotion recognition have been proposed in the literature, but they do not provide a powerful approach to recognize emotions from Partially Occluded Facial Images.

In this paper, we propose a new method for Emotion Recognition from Facial Expression using Fuzzy Inference System (FIS). This novel method is even able to recognize emotions from Partially Occluded Facial Images. Moreover, this research describes new algorithms for facial feature extraction that demonstrate satisfactory performance and precision. In addition, one of the main factors that have an important influence on the final precision of fuzzy inference systems is the membership function parameters. Therefore, we use a Genetic Algorithm for parameter-tuning of the membership functions. Experimental results report an average precision rate of 93.96% for Emotion Recognition of six basic emotions, which is so promising.

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1. Introduction

Emotion Recognition is an important step in Human–Computer Interaction (HCI). For establishing emotional interactions between humans and computers, a system to recognize human emotion is of a high priority. There are many applications that use "emotion recognition" such as customer services, intelligent automobile systems, game and entertainment industry, automated systems that provide aid to psychologists, behavioral and neuroscience researchers and the like. These applications are built based on automated human emotion recognition. It is noted that in this paper we use "Emotion Recognition System" and "Facial Expression Recognition System" synonymously.

Several various works using different approaches for emotion recognition have been proposed in the literature recently (Chakraborty et al., 2009; Maglogiannis et al., 2009; Pantic and Rothkrantz, 2000; Cowie et al., 2005; Esau et al., 2005; Guo and Gao, 2007; Ioannou et al., 2005; Jamshidnejad and Jamshidined, 2009; Ko and Sim, 2009; Pantic and Rothkrantz, 2004; Bashyal and Venayagamoorthy, 2008; Kharat and Dudul, 2008; Zeng et al., 2006; Muthukaruppan et al., 2007; Khan and Bhuiyan, 2009). Table 1 summarizes the aforementioned methods and their main characteristics.

For example, a fuzzy relational approach to human emotion recognition from facial expressions was proposed by Chakraborty et al. (2009). One major drawback of mentioned article is that only three distinct fuzzy sets: HIGH, LOW, and MODERATE for fuzzification were used. Moreover, only three facial features (eye opening, mouth opening, and the length of eyebrow constriction) were considered, and the FCM clustering algorithm that was employed for detecting the lip region is highly time-consuming. In this paper, we solve these drawbacks using more than three fuzzy sets with different types of membership functions, we also use more facial features for emotion recognition, and also new facial features extraction algorithms with high precision and accuracy are proposed.

Maglogiannis et al. (2009) presented an integrated system for emotion detection in which they used only eye and mouth expressions for detecting five emotions (Happy, Sad, Neutral, Surprise, and Angry). The main part of their algorithm is the utilization of an edge detection technique to determine the lines of the eyes and mouth, curves and gradients. It is mentioned that they did not use fuzzy inference system for emotion recognition.

Note that in Table 1, most of the previous works reported their precision and accuracy on different and/or non-standard image databases. This may cause the results to be incomparable and also somehow unreliable. Besides, a robust approach to recognize emotion from partially occluded facial images has not been proposed yet.

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Table 1
A brief review of the recent works for emotion recognition.

Authors	Used methods and algorithms	Principal characteristics	Number of recognized emotions	Average recognition rate
Chakraborty et al. (2009)	Fuzzy relational approach to human emotion recognition from facial expressions	Three distinct fuzzy sets: HIGH, LOW, and MODERATE for fuzzification were used. Moreover, only three facial features (eye opening, mouth opening, and the length of eyebrow constriction) were considered.	6 basic emotions	Average recognition rate for adult males, adult females and children in age group 8–12 years are 89.11%, 92.4%, and 96.28%, respectively.
Maglogiannis et al. (2009)	Detect the emotions pictured in the eyes and mouth, using edge detection and measuring the gradient of eye's and mouth's region figure	Only two facial features (eye and mouth expressions) were considered.	4 basic emotions and Neutral	Average of features detections and emotion recognition rate: 82.14%
Pantic and Rothkrantz (2004)	Rule-based reasoning	An automated system that was developed to recognize facial gestures in static, frontal- and/or profile-view color face images	32 individual facial muscle actions (AUs)	86.3%
Kharat and Dudul (2008)	Support Vector Machine (SVM)	Various feature extraction techniques such as Discrete Cosine Transform (DCT), Fast Fourier Transform (FFT), and Singular Value Decomposition (SVD) are used to extract the facial features.	6 basic emotions and Neutral	92.86%
Khan and Bhuiyan (2009)	The facial features, especially eyes and lip are extracted and approximated using Bézier curves representing the relationship between the motion of features and changes of expressions	In this research, four different facial expressions of 200 individual persons pictures have been analyzed. In this paper, 3rd order Bézier curve has been used to identify the face outlines and expressions.	4 basic emotions and Neutral	94.4%
Rizon et al. (2009)	Genetic Algorithm	Lip and eye features are employed to classify the human emotion through a set of irregular and regular ellipse fitting equations using Genetic Algorithm.	6 basic emotions and Neutral	83.57%
Khanum et al. (2009)	Hybrid system comprising a blend of Fuzzy logic (FL) and Case-Based Reasoning (CBR)	This hybrid system comprising a blend of FL and CBR can lead to a solution where the two approaches cover each other's weaknesses and benefit from each other's strengths	6 basic emotions	90.33%
Gomathi et al. (2009)	Multiple Adaptive Neuro-Fuzzy Inference System (MANFIS)	Initially facial image is segmented into three regions from which the uniform Local Binary Pattern (LBP) texture features distributions are extracted and represented as a histogram descriptor.	6 basic emotions	94.29%
Esau et al. (2007)	Fuzzy Classification	Proposed the fuzzy video-based emotion recognition system VISBER that allows analyzing facial expressions in video sequences	4 basic emotions and Neutral	72%