Advances in Intelligent Systems and Computing 425

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Sanghamitra Bandyopadhyay
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Sergey Mosin
Maode Ma *Editors*

Advances in Signal Processing and Intelligent Recognition Systems

Proceedings of Second International Symposium on Signal Processing and Intelligent Recognition Systems (SIRS-2015), December 16–19, 2015, Trivandrum, India

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Preface

This Edited Volume contains a selection of refereed and revised papers originally presented at the second International Symposium on Signal Processing and Intelligent Recognition Systems (SIRS-2015), December 16–19, 2015, Trivandrum, India. SIRS-2015 provided a forum for the sharing, exchange, presentation and discussion of original research results in both methodological issues and different application areas of signal processing and pattern recognition.

Credit for the quality of the symposium proceedings goes first and foremost to the authors. They contributed a great deal of effort and creativity to produce this work, and we are very thankful that they chose SIRS-2015 as the place to present it. All the authors who submitted papers, both accepted and rejected, are responsible for keeping the SIRS program vital. The program committee received 175 submissions. The committee had a very challenging task of choosing high quality submissions. Each paper was peer reviewed by at least three or more independent referees and the papers were selected based on the referee recommendations. The technical program of SIRS'15 comprises of 59 papers (41 regular papers and 18 short papers). This volume is organized into different topical sections. The papers offer stimulating insights into biometrics, digital watermarking, recognition systems, image and video processing, signal and speech processing, pattern recognition, machine learning and knowledge-based systems. Two workshops were co-located with the symposium: *workshop on Advances in Image Processing, Computer Vision, and Pattern Recognition (IWICP-2015)* and *workshop on Signal Processing for Wireless and Multimedia Communications (SPWMC'15)*.

The success of such an event is mainly due to the hard work and dedication of a number of people and the collaboration of several institutions. We are grateful to the members of the program committee for reviewing and selecting papers in a very short period of time. Many thanks to all the Chairs and their involvement and support have added greatly to the quality of the symposium. We also wish to thank all the members of the Advisory Committee, whose work and commitment were invaluable. We would like to express our sincere gratitude to local organizing committees that has made this event a success. Our special thanks also to the

keynote speakers and tutorial presenters for their effort in preparing the lectures. The EDAS conference system proved very helpful during the submission, review, and editing phases.

We wish to express our sincere thanks to Thomas Ditzinger, Senior Editor, Engineering/AppliedSciences Springer-Verlag and Janusz Kacprzyk, Series Editor for their help and cooperation.

Finally, we hope that you will find this edited book to be a valuable resource in your professional, research, and educational activities whether you are a student, academic, researcher, or a practicing professional.

Sabu M. Thampi
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Pattern Recognition/Machine Learning/Knowledge-Based Systems

Part I
Biometrics/Digital Watermarking/Recognition Systems

Emotion Recognition from Facial Expressions for 4D Videos Using Geometric Approach

V.P. Kalyan Kumar, P. Suja and Shikha Tripathi

Abstract Emotions are important to understand human behavior. Several modalities of emotion recognition are text, speech, facial expression or gesture. Emotion recognition through facial expressions from video play a vital role in human computer interaction where the facial feature movements that convey the emotion expressed need to be recognized quickly. In this work, we propose a novel method for the recognition of six basic emotions in 4D video sequences of BU-4DFE database using geometric based approach. We have selected key facial points out of the 83 feature points provided in the BU-4DFE database. A video expressing emotion has frames containing neutral, onset, apex and offset of that emotion. We have identified the apex frame from a video sequence automatically. The Euclidean distance between the feature points in apex and neutral frame is determined and their difference in corresponding neutral and the apex frame is calculated to form the feature vector. The feature vectors thus formed for all the emotions and subjects are given to Random Forests and Support Vector Machine (SVM) for classification. We have compared the accuracy obtained by the two classifiers. Our proposed method is simple, uses only two frames and yields good accuracy for BU-4DFE database. We have determined optimum number of key facial points that could provide better recognition rate using the computed distance vectors. Our proposed method gives better results compared with literature and can be applied for real time implementation using SVM classifier and kinesics in future.

Keywords Facial emotions · Key feature points · Apex frame · Euclidean distance · Random forests · Support Vector Machine

1 Introduction

Since few decades scientists are keen to improve the communication between human and computers. Human computer interaction has become indispensable as

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computing has become common in our daily life. To make an effective human computer interface, the interaction between them should be simple and easy as in human to human interaction. Emotions are fundamental to human beings and it plays a vital role in everyday life. The six basic emotions are anger, disgust, fear, happy, sad and surprise. Diverse applications include computer graphics, psychology, automatic driver fatigue detection, surveillance, etc. Emotion recognition consists of preprocessing, feature extraction and classification. In this work, we have used videos from BU-4DFE database, extracted neutral and apex frames automatically, extracted facial feature information that are contributing for recognizing emotions to form feature vector. They are given to classifiers for classification. We have implemented automatic retrieval of apex frame and with optimum number of feature points obtained encouraging accuracy. We have also determined optimum number of feature points as their selection plays an important role in recognizing emotions. Samples images with basic six emotions of BU-4DFE database are given in Fig. 1.

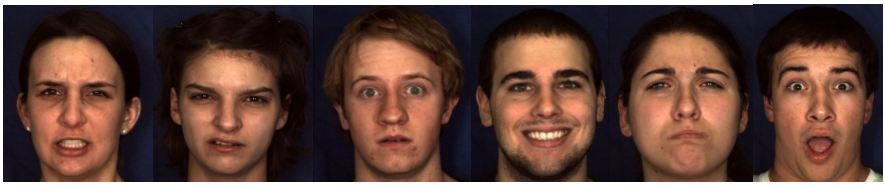

Fig. 1 Six basic emotions from BU-4DFE Database (anger, disgust, fear, happy, sad and surprise).

The reminder of this paper is organized as follows. In section 2, background work is discussed. In section 3, we present our proposed method. Result and analysis are given in section 4. Future work and conclusion are discussed in the last section.

2 Background Work

Various techniques have been proposed for emotion recognition during the last few decades. Not much work has been done in this area with respect to dynamic apex detection and emotion recognition using 4D videos. For emotion recognition using videos, the two approaches that are widely used for feature extraction are appearance based and geometry based. In geometric feature based methods, the facial components or facial feature points are extracted to form a feature vector that represents the face geometry. In appearance based methods, image filters, such as Gabor wavelets, are applied to either whole-face or specific regions in a face image to extract a feature vector [1].To recognize the emotions accurately we need to calculate deformations occurred on the face by calculating the change in distance from eyes, mouth and nose. In the recent years, several emotion recognition algorithms have been proposed. In 2012 Sandbach [2] proposed a method that includes Iterative Closest Point (ICP), Free Form Deformation (FFD), vector projections and HMM classifier for recognizing emotions using BU-4DFE and also

compared the results with a similar 2D system. In 2012 Songfan [3] developed an emotional avatar image concept based on Active Appearance Models (AAM), Local Binary Patterns (LBP) using FERA 2011 database. Chuan proposed a method using geometric based approach that uses Euclidean distance, PCA and SVM [4]. ASM model is used to localize the points automatically where the shape information has been extracted from the images and it is used to compute the distance parameters and finally classified emotions using SVM classification. Anwar developed a model using facial Points Localization Model PDM, where they have determined drop in recognition rate using general neutral model [5].

Ben in 2014 [6] proposed an approach using radial curves and Riemannian shape analysis. Chiranjeevi in 2015 [7] proposed a method to dynamically learn the neutral appearance at key emotion points using statistical texture model in a continuous video sequence. Peng in 2015 [8] proposed head motions in videos based on SIFT classification using SVM. Most of the existing methods discussed in literature deals with images (or image sequences) with large variation in appearance of facial expressions, identifying these expressions are a significant research challenge in various disciplines ranging from entertainment to medical applications and affective computing. Finding the optimum number of key points which gives maximum recognition rate using geometric based approach is indispensible. Literature suggests that it is difficult to recognize emotion when pose and head movements are seen in videos, occlusion of objects or person moving randomly in videos, ambiguity and uncertainty in face motion, etc.,.

The methods proposed in this area of research are complex involving high computation. Various challenges in recognizing emotions are all the subjects will not express the motion at same time, detecting the apex frame is a challenging task because as the emotion varies continuously in a video sequence and it is difficult to detect the apex of an emotion. The most important challenge is to determine optimum number of points that could provide maximum recognition rate. In this paper, we have proposed a simple approach using Euclidean distance through which the distance of feature points between two frames under consideration are calculated which then form the feature vector and classified in to six basic emotions. We have also determined optimum number of points that could provide better recognition using few frames. Our approach gives good accuracy for Support Vector Machine (SVM) and Random Forests.

3 Proposed Method

We have used BU-4DFE database [9] for implementation. It consists of 101 subjects expressing anger, disgust, happiness, fear, sadness, and surprise. Each expression sequence contains approximately 100 frames depending upon the duration of the video. 3D facial expressions are captured at a video rate (25 frames per second). 83 feature points are provided for every frame of the video sequence. The database comprises 606 3D facial expression sequences, with a total of approximately 60,600 frame models. Each 3D model of a 3D video sequence has the resolution of approximately 35,000 vertices. The texture video has a resolution of about

1040×1329 pixels per frame. The database consists of 58 female and 43 male subjects, with a variety of ethnic/racial ancestries, including Asian, Black, Hispanic/Latino, and White. We have used the videos of all six emotions expressed by 60subjects in our work. The steps involved in our proposed method are automatic peak detection, feature extraction, and classification which are explained in this section. The block diagram that describes the proposed method is shown in Fig. 2.

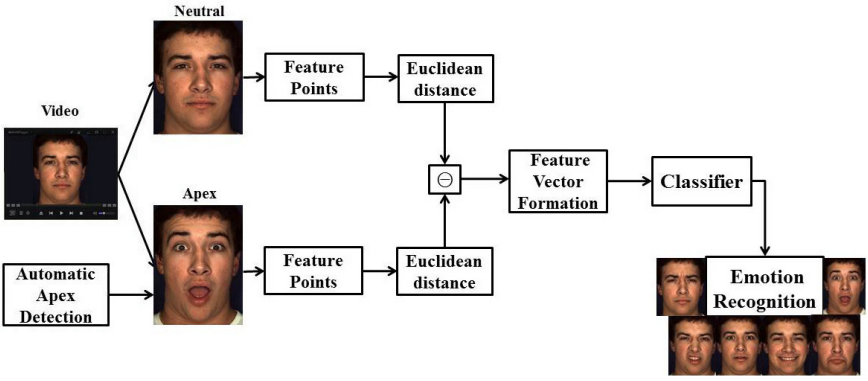

Fig. 2 Proposed emotion recognition system for 4D videos

3.1 Automatic Peak Detection

In automatic peak detection, we extract the neutral and apex frames from each subject for each emotion. In BU-4DFE database the emotions posed by the various subjects has sequence of frames which starts with neutral expression and followed by apex of an expression and ends with neutral expression. In few subjects the frames start with apex expression and ends with neutral expression. We have developed a method which automatically identifies the apex expression from the sequence of frames. From the entire sequence of frames in the database for an emotion enacted by a subject, only few frames are considered and a method has been developed to automatically detect the apex frame by summing the Euclidean distances between the identified frames. We assume an integer variable 'n' which represents an interval between frames in a video sequence. The starting frame in the video sequence is numbered as 1 and frames of the order 1, 1n, 2n, 3n, etc., are selected till the last frame of the video sequence. 83 feature points are given in the database for each frame. For the selected frames, Euclidean distance is calculated for the corresponding 83 feature points between the frames 1 & 1n, 1 & 2n, 1 & 3n, 1 & 4n, 1 & 5n and so on. The Euclidean distance calculated between two frames, neutral and peak frames is given by (1).

$$W = \sqrt{(x_i - x_j)^2 + (y_i - x_j)^2 + (x_i - x_j)^2}, (i, j) \in [\![1, 83]\!] \quad (1)$$

For example, if the number of frames in a video sequence is 65 and 'n' value is assumed as 5, then we select frames of the order 1,5,10,15,20,25,30……65. This