FACIAL EXPRESSION RECOGNITION BASED ON LUMINANCE STICKER

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FACIAL EXPRESSION RECOGNITION BASED ON LUMINANCE STICKER

by

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LIST OF ABBREVIATION

AFA	-	Automatic Face Analysis
AIC	-	Akaike Information Criterion
ANN	-	Artificial Neural Network
ANS	-	Autonomic Nervous System
AR Model	-	Auto Regressive Models
AUs	-	Action Units
BPN	-	Back Propagation Network
CCD	-	Charge Coupled Device
CMOS	-	Complementary Metal Oxide Semiconductor
CWT	-	Continuous Wavelet Transform
DBN	-	Dynamic Bayesian Network
DFT	-	Discrete Fourier Transform
DWT	-	Discrete Wavelet Transform
ECG	-	Electrocardiogram
EDA	-	Electro Dermal Activity
EEG	-	Electroencephalography
EGM	-	Elastic Graph Matching
EMG	-	Electromyography
EMG	-	Electromyography
EOG	-	Electrooculargraphic
FACS	-	Facial Action Coding System
FAU	-	Facial Action Units
FB	-	Forward Backward

FCM - Fuzzy C-Means

FFT - Fast Fourier Transform

FKM - Fuzzy k-Means

GA - Genetic Algorithm

GL - Geometric lattice

HCI - Human-Computer Interaction

HMI - Human Machine Interaction

HMM - Hidden Markov Models

HRI - Human Robot Interaction

ICU - Intensive Care Unit

IFT - Inverse Fourier Transform

IGA - Interactive Genetic Algorithm

IR - Infra-Red

JAFFE - Japanese Female Facial Expression

kNN - k-Nearest Neighborhood

LDA - Linear Discriminant Analysis

LFA - Local Feature Analysis

LR - Learning Rate

LS - Least Square

MHIs - Motion History Images

MMHIs - Multilevel Motion History Images

PAL-SVM - Probabilistic Actively Learned Support Vector Machine

PCA - Principle Component Analysis

PFFL - Particle Filtering with Factorized Likelihood

RVM - Relevance Vector Machines

SCR	- Skin Conductance response
SKT	- Skin Temperature
SNoW	- Sparse Network of Winnows
STFT	- Short Time Fourier Transform
SVM	- Support Vector Machine
TMD	- Temporomandibular disorders
YW	- Yule-Walker

MENGENAL PASTI EKSPRESI MUKA BERDASARKAN PELEKAT LUMINANS

ABSTRAK

Ekspresi muka adalah satu cara komunikasi yang sangat hebat dan semula jadi di kalangan manusia. Ekspresi muka mampu memberitahu emosi seseorang itu sebelum mereka dapat meluahkannya dengan kata-kata atau pun sebelum mereka menyedari perasaan mereka sendiri. Menyedari keberkesanan ekspresi muka ini dalam kehidupan seharian, ramai penyelidik telah cuba mengenal pasti ekspresi muka memandangkan potensinya untuk diaplikasikan dalam bidang sains tingkah laku, perubatan, keselamatan, biometrik dan interaksi di antara mesin dan manusia. Walaupun ramai penyelidik telah mencadangkan pelbagai kaedah untuk mengenal pasti ekspresi muka seseorang, namun bidang ini masih sangat mencabar terutamanya dalam aplikasi segera. Dalam kajian ini, kaedah mengenal pasti ekspresi muka berdasarkan pelekat luminans telah dicadangkan. Satu set pelekat luminans ditampalkan pada lokasi terpilih di muka subjek sebelum ekspresi muka dirakam dengan perakam video. Variasi daripada ciri-ciri ekspresi muka ini dikenal pasti melalui pergerakkan pelekat luminans yang mewakili aktiviti otot muka. Video yang dirakam diproses dengan menggunakan beberapa perisian komputer untuk mengekstrak nilai koordinat 2D bagi setiap pelekat dari setiap bingkai rakaman. Vektor koordinat 2D ini digunakan sebagai input data bagi kaedah pengekstakkan ciri untuk mengenal pasti ekspresi wajah berkenaan. Dalam kajian ini, ekspresi muka dikenal pasti dengan menggunakan tiga kaedah pengekstrakkan ciri seperti AR Model, FFT and DWT dengan turutan yang berbeza untuk mengkaji keberkesanan setiap kaedah. Enam pengukuran statistik seperti sishan piawai, varians, min, kuasa, tenaga dan entropi dikira sebagai pekali bagi ciri yang diekstrakkan melalui AR Model, FFT dan DWT untuk memilih pengukuran yang mana menyumbang kepada ketepatan klasifikasi yang lebih tinggi dalam mengenal pasti ekspresi wajah. Pengesahsahihan konvensional dan pengesahsahihan silang dilakukan keatas pengukuran-pengukuran statistik terpilih untuk mengesan kebolehpercayaan klasifikasi. Tiga kaedah klasifikasi berbeza digunakan dalam kajian ini seperti ANN, kNN dan LDA untuk menyelidik prestasi klasifikasi dalam mengklasifikasikan lapan jenis ekspresi muka. Dari analisa ini, didapati bahawa teknik mengenal pasti ekspresi muka menggunakan DWT memberikan ketepatan-ketepatan yang sangat positif (di antara 98.83 % dan 99.15%) dalam klasifikasi ekspresi muka untuk kNN dan LDA berbanding denagn teknik pengekstrakan ciri dan teknik klasifikasi yang lain. Oleh yang demikian, dapat disimpulkan bahawa kaedah yang dicadangkan boleh digunakan sebagai alat yang bermanfaat bagi aplikasi yang berdasarkan ekspresi muka seperti pengantara muka manusia dan mesin.

FACIAL EXPRESSION RECOGNITION BASED ON LUMINANCE STICKER

ABSTRACT

Facial expressions are the most powerful and natural means of communication among human beings. The face can express emotion sooner than people verbalize or even realize their feelings. By knowing the effectiveness of facial expressions in daily life, recently many researchers have attempted to recognize the facial expression due to its potential applications in behavioural science, medicine, security, biometrics and human machine interaction. Although many researchers have proposed various methods to detect and recognize facial expressions, this field still remains very challenging especially in real time applications. In this study, luminance stickers based facial expression recognition is proposed. A set of minute luminance stickers are fixed on selected locations in a subject's face and the expressions are captured by video recording. Face feature variations are identified through the movements of the luminance stickers which represent the facial muscular activities. The recorded videos are processed using some software to extract the 2D coordinate values of each sticker from each frame. This set of 2D coordinates vectors are used as an input data for feature extraction method to recognize facial expressions. In this research, facial expressions are recognized using three feature extraction methods such as AR Model, FFT and DWT with their different orders to study their effectiveness. Six statistical measures such as standard deviation, variance, mean, energy, power and entropy are computed for the extracted feature coefficients of AR Model, FFT and DWT to select the best statistical measure which contributes to higher accuracy of facial expression classification. Conventional validation and cross validation are performed on the selected statistical measures to study the reliability of the classifiers. Three different classifiers namely ANN, kNN and LDA are employed in this study to investigate their performance in correctly classifying a total of eight facial expressions. From this analysis, it is found that the facial expression recognition using DWT gives very promising accuracies (between 98.83% and 99.15%) of facial expression classification for kNN and LDA classifiers compared to other feature extraction methods and classifiers. It is, hence, concluded that the proposed method can be used as a valuable tool for facial expression based applications such as human machine interfaces.

CHAPTER 1

INTRODUCTION

1.1 Research Background

Facial expression based cursor control, controlling robot through facial expression and monitoring facial expression of Intensive Care Unit (ICU) patient are some of unique and beneficial applications in the field of facial expression recognition. This field can find many more applications especially for physically disabled person in their daily life. It is well known that the facial expressions are one of the most powerful, natural and immediate means for human being to communicate their emotions and intentions. They are visually observable, conversational and interactive signals that clarify our focus of attention and regulate our interactions with the environment and with other people in our vicinity (Russell, 1997). The face can express emotion sooner than people verbalize or even realize their feelings (Tian et al., 2001). In (Chibelushi and Bourel, 2002), the authors reported that facial expressions have a considerable effect on a listening interlocutor. The facial expression of a speaker accounts for 55 percent of the effect, 38 percent of which is conveyed by voice modulation and 7 percent by the spoken words. It can, hence, be concluded that the facial expressions play a significant role in our daily social and emotional life.

The concept of facial expression and its relations to the emotions and habits has been demonstrated by Darwin in 1872 (Darwin, 1872). However, in 1971, Ekman and Friesen (Ekman and Friesen, 1971) categorized the emotions into six basic emotions namely happiness, sadness, fear, disgust, surprise and anger. These basic emotions are seemed to be universal across human ethnicities and cultures. In addition, the Facial Action Coding System (FACS) developed by Ekman and Friesen (Ekman and Friesen, 1978) is the most comprehensive system for synthesizing facial expression based on what they are referred to as Action Units (AUs). The AUs represent the muscular activity that produces changes in facial appearance. Thus, with these contributions, the research area of facial expression recognition has attracted many researchers recently due to its potential applications in behavioral science, medicine, security system, biometrics system and human-machine interaction (HMI) (Pantic and Patras, 2005). Many researchers have proposed various methods to detect and recognize facial expression. However, this field still remains very challenging especially in real time applications due to the complex variations of facial dynamics.

Basically, facial expressions can be recognized through image based methods and video based methods. The image based methods assume that facial expressions are static and the recognition is conducted on single image while the video based methods recognize the facial expressions by integrating the temporal information of facial appearance (Yang et al., 2009). Furthermore, the multimodal bio-sensors like electromyography (EMG) have also been used to recognize the facial expression (Hazlett, 2006). The general process flow for facial expression recognition consists of data acquisition, feature extraction and classification. Cameras (image and video) and bio-sensors are widely used for data

acquisition. The feature extraction part normally includes one or more preprocessing techniques. The preprocessing is usually conducted to reduce the noise level in raw data and modify the raw data to be readable by the computer. The filtered data will be used for feature extraction. In the development of the feature extraction algorithm, the useful information will be identified and extracted from the data and the extracted features will be used for classification. Classification is a stage where the extracted features are studied for ascertaining the facial expressions. The recognized facial expressions can be used for any specific application such as facial expression controlled mobile robot.

In this research, the acquisition of data is carried out by using luminance stickers and video capturing. A set of minute luminance stickers are fixed on selected locations in a subject's face. Face feature variations are identified through the movements of the luminance stickers which represent the muscular activities. The recorded videos are processed using MaxTraq and MaxMate software. The MaxTraq software is mainly used for digitizing (labeling) and tracking the stickers for each frame while, MaxMate software extracts the 2D coordinate values with respect to the markers for each frame (*Qualisys*, 2009). The basic statistical features are extracted from the obtained data using time domain, frequency domain and time-frequency domain based algorithms. These extracted features are classified by using artificial intelligence methods such as Artificial Neural Network (ANN), k-Nearest Neighborhood (kNN) and Linear Discriminant Analysis (LDA) to recognize the facial expressions.

Facial expression recognition is different from human emotion recognition. Facial expression recognition deals with the classification of facial deformation into abstract classes that are purely based on visual information. But, the emotions can be recognized

through many additional factors such as body gestures, postures, vocal tones and other physiological means (Fasel and Luettin, 2003). Furthermore, emotion intelligence is described as a type of social intelligence that involves the ability to monitor one's own emotions and that of others, to discriminate among them and to use the information to guide one's thinking and actions (Mayer and Salovey, 1997). In this research, only the subtle changes in facial behavior which represent facial expressions are analyzed by recognizing facial muscle actions and not the facial emotions.

1.2 Research Objectives

The objectives of this research on facial expression recognition are as given below;

I. To acquire facial action unit data

Data acquisition is carried out using video recording of facial movements and computer processing. In order to represent the facial variations more clearly, facial action units (FAU) are used in this study. Facial action units are basically a set of minute luminance stickers. Facial expressions which are generated through the facial muscles movements can be studied by analyzing the variation of these luminance stickers. Sufficient number of stickers will be used to analyze facial expressions. These luminance stickers are harmless and do not impede the movements of facial muscles.

II. To propose feature extraction algorithms for facial expression recognition

Based on the literature studies, it is found that, most of the approaches to recognize facial expression have been done by analyzing the images, videos and biosensors. Many feature extraction methods have been suggested by many researchers such as Particle Filtering (Valstar et al., 2005), Principle Component Analysis (PCA) (Kapoor et al., 2003), Multilevel Motion History Images (MMHIs) (Valstar et al., 2004), Gabor Wavelets (Ying-li et al., 2000) and encoded dynamical Haar-like methods (Yang et al., 2009). Although many efforts have been taken to recognize facial expressions, yet it is still difficult to achieve higher classification accuracies. In this study, the performances of three feature extraction methods namely Auto Regressive (AR) Models, Fast Fourier Transform (FFT) and Discrete Wavelet Transform (DWT) will be investigated with the aim to achieve high classification accuracies.

III. To select the best statistical feature for the classification techniques.

The coefficients of extracted features provide a compact representation that shows the energy distribution of facial expression coordinates in time and frequency domains. In order to represent the energy distributions more clearly and to reduce the computational efforts, some statistical features namely variance, standard deviation, mean, power, energy and entropy will be derived from the extracted feature coefficients (Satiyan et al., 2010). A study will be made to ascertain the feature which gives the best performance in classification.

IV. To propose artificial intelligences based techniques for the classification of facial expressions

Developing a decision making system is a necessary task in almost all research fields. Designing a classifier for facial expression recognition is one of such tasks. Classifiers are used to map the statistical features into desired facial expressions. In the previous work, to recognize facial expressions, many researchers have proposed various classifiers such as Support Vector Machine (SVM) (Valstar et al., 2005; Kapoor et al., 2003), Relevance Vector Machines (RVM) (Michel et al., 2006), Artificial Neural Network (ANN) (Valstar and Pantic, 2006), Hidden Markov Models (HMM) (Lien et al., 2000) and k-Nearest Neighborhood (kNN) (Valstar et al., 2004 (b)). Each and every classifier has its own advantages and disadvantages. In this research, an effort is made to compare the classification performance by using linear and non linear classifiers. The linear classifier is Linear Discriminant Analysis (LDA) and the non-linear classifiers are kNN and ANN.

V. To compare and evaluate the performance of the suggested methods

In this study, the experiments consisting of the combination of three feature extraction methods, six statistical analysis, two validation techniques and three classifiers which provide results in terms of classification accuracies will be performed. A comparison of classification accuracies will be made to evaluate the efficiency of the suggested methods and to select the best combination of processes for facial expression recognition.

1.3 Thesis Layout

This thesis is composed of five chapters

Chapter 1 has discussed the introduction to the subject of interest, a brief discussion of the existing methods for facial expression recognition and the research objectives.

Chapter 2 describes the facial expressions and expounds the review of the previous documented research works in facial expression recognition. This chapter also presents a brief discussion about the methods undertaken in this study.

The alternative suggestions for identifying the facial expression are illustrates in **Chapter 3**. This chapter mainly covers the experimental methodology of facial expression recognition. In the first section of this chapter, the data acquisition procedures are explained. Then, a detailed study of feature extraction methods is made followed by the comprehensive descriptions of suggested classifiers.

Chapter 4 depicts the experimental results of suggested features extraction methods and classifiers. Comparative studies and performance evaluations are discussed in this chapter.

Chapter 5 deals with the conclusion of the research with a suggestion of a set of possible future research works.