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Identification and Recognition of Facial Expressions Using Image Processing Techniques: A Survey

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ABSTRACT

Facial expressions give important information about emotions of a person. Understanding facial expressions accurately is one of the challenging tasks for interpersonal relationships. Automatic emotion detection using facial expressions recognition is now a main area of interest within various fields such as computer science, medicine, and psychology. HCI research communities also use automated facial expression recognition system for better results. Various feature extraction techniques have been developed for recognition of expressions from static images as well as real time videos. The expression recognition model is oriented on the Facial Action Coding System (FACS). The hard constraints on the scene processing and recording conditions set a limited robustness to the analysis. A probabilistic oriented framework is used in order to manage the uncertainties and lack of information. The support for the specific processing involved was given through a Multimodal data fusion platform. The Bayesian network is used to encode the dependencies among the variables. The temporal dependencies are to be extracted to make the system be able to properly select the right expression of emotion. In this way, the system is able to overcome the performance of the previous approaches that dealt only with prototypic facial expression.

Keywords: Facial Expression, FACS, HCI, Feature Extraction

1. INTRODUCTION

Recognition of facial expressions results in classifying the basic human feelings like anger, fear, disgust, sadness, happiness and surprise. These expressions can vary in every individual. Mehrabian [1] indicated that 7% of message is conveyed by spoken words, 38% by voice modulation while 55% of message is conveyed by facial expressions. Facial expressions are formed by movement of facial features. The facial expression recognition system consists of four steps. First is face detection phase that detects the face from a still image or video. Second is normalization phase that removes the noise and normalize the face against brightness and pixel position. In third phase features are extracted and irrelevant features are eliminated. In the final step basic expressions are classified into six basic emotions like anger, fear, disgust, sadness, happiness and surprise. The Figure.1 shows architecture of facial expression recognition system.

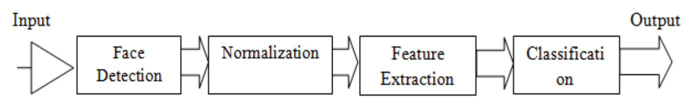

Figure 1: Facial expression recognition system

A. Facial expressions show the intention, affective state, cognitive activity, psychopathology and personality of a person [2]. In face-to-face interactions facial expressions convey many important communication cues. These cues help the listener to understand the intended meaning of the spoken words. Facial expression recognition also helps in human computer interaction (HCI) systems [3]. In some robotic applications facial expressions are also used to detect human emotions [4].

B. Automatic facial expressions analysis also have applications in behavioral science or medicine [2] [5]. The facial expression recognition also has major application in areas like behavioral science, medicine, social interaction and social intelligence. For automatic facial expression recognition system, representation and categorization of characteristics of facial features deformations is a problem area. The detailed information about the problem space for features extraction is given in [6].

2. FACIAL EXPRESSIONS AND EMOTIONS RECOGNITION

In 1884, William James gives the important physiological theory of emotion that is in a person emotions are rooted in the bodily experience. First we perceive the object then response occurs and then emotions appear. For example, when we see a lion or other danger we begin to run and then we fear. Each emotion has its own characteristics and appearance figures. Six basic emotions i.e. fear, surprise, sadness, happiness, anger and disgust are universally accepted. Basic emotions can be distinguished as negative and positive emotions. Happiness is a positive emotion and everyone wants to experience it. Happiness is an emotion or mood to attain a goal.

Figure 2: Facial expression with respect to person emotions

It generally used as a synonym of pleasure and excitement. Fear, anger, disgust and sadness are negative emotions and most people do not enjoy them. Sadness can be described simply as the emotion of losing a goal or social role [7]. It can be described as distraught, disappointed, dejected, blue, depressed, despairing, grieved, helpless, miserable, and sorrowful. Fear is a negative emotion of foreseen danger, psychological or physical harm [7] [8] [9]. Anger is the most dangerous emotion for everyone. During this emotion, they hurt other people purposefully. Although anger is commonly described as a negative emotion, some people often report feeling good about their anger but it can have harmful social or physiological consequences, especially when it is not managed [11].Surprise is neither positive nor negative [9]. It is the briefest emotion triggered by unexpected events when you haven't a time to think about that event [10]. Disgust is a feeling of disliking and is the emotion of avoidance of anything that makes one sick [9]. The Figure.2 shows facial expression with respect to person emotions.

Disgust usually involves getting rid of and getting-away from responses. Recently a real time emotion recognition system deployed on a Microsoft's Windows desktop is purposed that work on still images of face as well as in real time environment for feature extraction and emotion recognition [12].For an accurate and high speed emotion detection system edges of the image are detected and by using Euclidean distance Formulae edge distance between various features is calculated. This edge distance is different for every image and on the basis of these distances emotions are classified [13].

2.1 Basic Structure of facial expression analysis

The facial expression analysis system estimates the measurement of actions and also classifies the actions according to the manual of FACS [25]. The steps involved in facial expression analysis are 1. Face Acquisition 2. Facial Expression Extraction 3. Expression Recognition. Face acquisition is the first step in which faces are detected from the input images or image sequences. The Face acquisition may detect faces in input images or detect face in the first frame and track the face in the remaining frames in case of image sequences. Based on the type of input the faces can be classified into 2D or 3D faces. After the face is located then the facial features are extracted to identify the facial expression. Facial expression can be classified into two types namely Geometric or Intransient features and Appearance Features or Transient Features.

Geometric or intransient Features: The features that are always present in the face but may be deformed due to any kind of facial expression e.g. (Eyes, Eyebrows, Mouth, Tissue Textures, and Nose. The facial components or facial feature points are extracted to form a feature vector that represents the face geometry. Appearance or Transient Features: The features that appear temporarily in the face during any kind of facial expression like different kinds of wrinkles, bulges, forefront, regions surrounding the mouth and eyes. With appearance based methods, image filters, such as Gabor wavelets, are applied to either the whole-face or specific regions in a face image to extract a feature vector.

Facial expression recognition is the last step in facial expression analysis where the extracted features are recognized based on the action units. The recognizer identifies not only the basic emotions like anger, happy, surprise, sad but also identifies the expression caused due to pain[27],temporal dynamics[28], Intensity of Expression, Spontaneous expression[26]. The Figure.3 shows facial expression analysis structure.

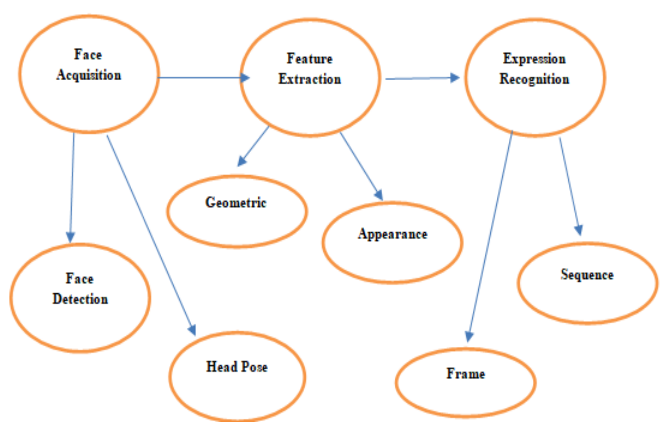

Figure 3: Basic Structure of Facial Expression analysis

2.1.1 Face Acquisition

The two basic face acquisition methods are to detect faces both in frontal view images and near frontal view images. To detect the faces, two methods are used namely face detection and head pose estimation.

2.1.2 Face Detection

Many detection methods have been employed to detect faces [29] [30] [31] [32] [33] some of the previous face detection methods since 2003 are summarized here. Mohammed Yeasin had used Robust and automated face detection[34] to segment the face region which was based on the work of Rowley [30].Marian Stewart Bartlett had designed boosting techniques for face detection in a generative framework[26] based on their own work[29].Y.Tong had drawn geometry of face by encoding the edges of the face in the graph[35] based on the work of L.Wiskott[36], Irene Kotsia had employed convolution neural network for detecting the face and the classification is performed using a rule based algorithm[30].

2.1.3 Head pose Estimation

To handle the out of plane head motion head pose estimation can be employed. The methods for estimating head pose can be classified as 3D model based methods [37, 38] and 2D image based methods [39]. In 3D Model based method Bartlett used a canonical wire mesh face model to estimate face geometry and 3D pose from hand labeled feature points. In 2D image based method to handle the full range of head motion for expression analysis, detected the head instead of the face [39]. The head is identified using the smoothed silhouette of the foreground object as a segment using background subtraction and computing the negative Curvature minima (NCM) points of the silhouette.

3. LITERATURE SURVEY

The recognition of facial expressions implies finding solutions to three distinct types of problems. The first one relates to detection of faces in the image. Once the face location is known, the second problem is the detection of the salient features within the facial areas. The final analysis consists in using any classification model and the extracted facial features for identifying the correct facial expression. For each of the processing steps described, there have been developed lots of methods to tackle the issues and specific requirements. Depending on the method used, the facial feature detection stage involves global or local analysis.

The internal representation of the human face can be either 2D or 3D. In the case of global analysis, the connection with certain facial expressions is made through features determined by processing the entire face. The efficiency of methods as Artificial Neural Networks or Principal Component Analysis is greatly affected by head rotation and special procedures are needed to compensate the effects of that. On the other hand, local analysis performs encoding of some specific feature points and uses them for recognition.

The method is actually used in the current paper. However, other approaches have been also performed at this layer. One method for the analysis is the internal representation of facial expressions based on collections of Action Units (AU) as defined in Facial Action Coding System (FACS) [25] [29]. It is one of the most efficient and commonly used methodologies to handle facial expressions. Principal Component Analysis (PCA) is a technique that reduces the dimensionality of image and provides the effective face indexing and retrieval. It is also known as the Eigen face approach [14]. Linear projection is used in PCA, which maximize the projected sample scattering [15]. Imaging conditions like lighting and viewpoint should not be varied for better performance. Fisher's Linear Discriminant is another approach that reduces the projected sample scattering and has better performance than PCA [15]. Independent Component Analysis (ICA) produces statistically independent basis vector while both PCA and LDA produces spatially global feature vectors [16]. ICA gives better performance than PCA but it is computationally expensive than PCA. All the above methods are 1-dimensional in nature so 2- dimensional Principal Component Analysis (2DPCA) is introduced [17]. In 2DPCA 2D matrix is used rather than 1D vector. It needs more coefficients for image representation therefore the storage space requirement for 2DPCA is much more than PCA. Since all above techniques can be used only for gray scale images therefore there is a requirement for the approaches that can work with color images.

Global Eigen Approach [18] and Sub pattern Extended 2-dimensional Principal Component Analysis (SpE2DPCA) [19] are so introduced for color space. Global Eigen Approach uses the color information present in the images rather than the luminance information as used in PCA and LDA. YUV colors space provides high recognition rate with respect of RGB color space. SpE2DPCA is also introduced to work with colored images. The recognition rate of SpE2DPCA is higher than PCA, 2DPCA, E2DPCA. Multilinear Image Analysis uses tensor concept and is introduced to work with different lighting conditions and other distractions. It uses multilinear algebra [20]. Recognition rate of MIA is greater than PCA but color information is not included in it. Color Subspace Linear Discriminant Analysis also uses tensor concept but can work with color space. A 3-D color tensor is used to produce color LDA subspace which improves the efficiency of recognition [21]. Gabor Filer Bank is another technique that gives greater performance in terms of recognition rate than other methods [22]. But this method has a major limitation that the maximum bandwidth is limited. A summary of some of the posed and spontaneous expression recognition systems (since 2000) is given in the Table.1.

Table.1: A summary of some of the posed and spontaneous expression recognition systems (since 2000)

References	Approach	Feature Extraction	Classifier	Database	Performance	Important Points
Dai et al 2000	Appearance Based	Calculate Difference image from YIQ image	Optical flow projection histogram for each expression is used to classify features	-	Performance is calculated on the basis of classification of facial features	1.compute optical flow histogram from adjacent frames 2.difference image from YIQ image
Zhang et al 2001	Appearance Based	Using AAM	-	-	Performance is calculated on the basis of classification of facial features	1.Used subspace method 2. Not successfully recognised identity of a person
Gokturk et al 2002	Appearance Based	Stereo tracking Algorithm	Support vector machines(SVM) provides a robust classification	-	Recognition rates up to 91% by classifying into 5 distinct facial motion & 98% for 3 distinct facial motion	1.independent to view & posed variation
Bourel et al 2002	Appearance Based	State based feature extractor	Rank-weighted K-nearest neighbour classifier	Cohn-Kanade facial expression database	Recognition rate 99%	1.Handle occlusion & noisy data 2. State based feature modelling
Ramachandran et al 2005	Appearance Based	Control points of the candidate model actually determined the transient features	Implement PCA + LDA classifier	Use FERET database for neutral & smiling face	The expression with expression normalized achieves 73.8% results	1.Model based approach 2.Provides synthetic image using affine warping of the texture
Fu et al 2006	Appearance Based	-	-	MPI Caucasian face data base	Refer(23)	1.Efficient for realistic face model 2.Reduced computations via M Face
Bronstein et al 2007	Feature Based	-	-	Expression Database	Minimum Error 7.09%	1.Embedding of geometric model with low dimensional space leads to less metric distortions 2.Representation of expression

						rather than generating Expressions
Bindu et al 2007	Appearance Based	1.Discrete Hopfield network for feature extraction 2.Hough transform & histogram approach	Reduced the size using PCA based classifier	Cohn-Kanade action unit coded facial expression database	Recognition accuracy of 85.5%	1.Model flexibility generates the number of Emotions 2.Cognitive emotions are sensed 3.Emotions are characterized with positive and negative reinforces
Martin et al 2008	Appearance Based	Using AAM based model	AAM classifier set instead of MLP & SVM based classifier	FEEDTUM mimic Database	Anger emotion with average accuracy of 94.9% but other emotions are low between 10to 30%	1.Real time facial expression recognition 2.AAM based model 3.Robust to lighting condition 4. False positive rate high for emotions except anger.
Amberg et al 2008	Appearance Model		-	Gava DB database & UND database	99.7% for Gava DB with improved speed	1.Handle noise 2. Recognition Rate high.
Vectos et al 2009	Appearance based	Model vertices are determined using PCA	SVM based classifier	Cohn –Kanade facial expression DB	Classification accuracy achieved up to 90%	1.Good Framework model based approach 2. Robust against 3D transformation operation on the face 3. Not sensitive to SVM configuration.
Sun et al 2010	Appearance Based	Locate ROI Region of interest Apply PCA to ROI to locate nose tip	PCA & LDA classifiers	4D face database called BU-4DFE	Expression dependant archives Up to 97.4% result	1.Highlights the lack of control points 2.Focus on 4D data 3.Forehead area not specified
Hsieh et al 2009	Feature based	Calculate intrapersonal	PCA & LDA classifiers	Binghamton	Average Recognition rate	1.Time taken by OF-Syn and

		OF from interpersonal + overall OF		University 3D Face expression (BU-3DFE) Database	of 94.44%	OF is 2.01 & 143s respectively 2.Costly
Choi et al 1994	Appearance based	Encoding & decoding with muscle based Aus of defacto standards	Deforming Rules for 34 AU for both upper & lower faces	-	Texture Update **Method 1** Less bit rate Low quality image **Method 2** Improves quality image Large memory space **No texture Update** Estimated bit rate 1.4,3.5 & 10.5 K bits/s	1.Facial expression video transmission 2.Image synthesize(decoding) 3.Texture update improves the quality of image 4.Handle head motion
Eisert et al 1997	Feature based	Encoding & decoding with FAPs of ISO/IEC standard developed by MPEG	-	-	Estimated bit rate of less than 1 Kbits/s with error rate of 0.06% in each frame for both synthetic & video sequence	1.Estimate 3D motion with facial expression 2.ZB-splines are suitable for modelling facial skins
Kobayashi et al 1997	Feature based	Data acquired using CCD camera	Back propagation neural networks ensemble classifier	-	Achieve recognition rate of 85%	Human machine interaction between robots & human beings
Essa et al 1997	Feature based	Optical flow based approach	FAC + instead of FAC	Database of S2 sequence	Recognition accuracy 98%	Efficient in term of time & space
Zhang et al 2001	Appearance based	FACs	FACs based anatomical spring model	Facial modelling using open GL/C++	-	1. Based on physical anatomical information 2. real time based synthetic image 3. Analyse relationship between deformed facial skin & inside state.
Kuilenburg et al 2005	Appearance based	Delauny triangulation	PCA based classifies that converts the shape into low	-	Emotional expression classifier accuracy up to 89% while AU	1.Use holistic based approach 2.Back propagation

			dimensional space FAC		detect with average accuracy of 86%	trained neural network 3.Use trained classification network
Ohta et al 2000	Feature based	Muscle based control points	-	-	Facial parameters like eyebrows. Mouth corners & upper lip shows effective results	1.Muscle based feature modelling 2.Provide deformable models
Tang et al 2003	Appearance model	Reference & current NURBS control points	-	VC++/Ope n GL	The more the NURBS flexible the more it gave the desired results	1.Control facial expression via NURBS 2.FACs based implementatio n
Chin et al 2009	Appearance based	Rubber Band method	-	Not Based on 3D database	Surprise achieve 8.3 Fear 5.5 Disgust 7.2 Anger 8.7 Happiness 8.0 Sadness 8.9	1.Transform facial expression in a target face 2.3D face model
Hong –Bo Deng , Lian-wen Jin , Li-xin Zhen,Jian Cheng Huang [2005]	Frame based	PCA Plus LDA	-	JAFFE		
Amir et al [2011]	Sequence based	Geometric Measurement	Fuzzy logic classification rate 90.33%			
P.Geetha Dr.Vasumathi Narayanan [2010]		2D Principal component analysis	Dynamic 2D cellular automata video frames classification rate 94.13%			
Sander Koelstra , student member IEEE, Maja Pantic senior member [2010]		Quad tree decomposition	Hidden markov model Classification rate 94.3%			
Peng Yang Qingshan lin Dimitris [2009]	Sequence based	Haar like feature	Adaboost classification rate 96.6%			
Le Hoang thai,et al [2011]	Frame based	PCA & ANN	Neural network classification rate 85.7%	JAFFE		
Guoying Zhao et al 2009		Adaboost	Boosted multi resolution spatio			

			temporal descriptions classification rate-93.85%			
Pooja Sharma 2011		Pattern tracking	Optical flow based analysis Classification rate 83.33%			
Peter s Aleksic Member, IEEE et al 2006	Frame based	Multistream hidden markov models		Cohn Kanade		
Anastasios.c Koutlas et al [2006]	Frame Based	Neural networks		JAFFE		
Marian stewart Bart Lett,Gwen.c et all [2006]	Frame based	SVM & Adaboost		RU-FACS		
Gwen littlewort merian stewart et al [2006]	Sequence based	SVM		Cohn-Kana de		
Irene Kotsia and Ioannis Pital et al [2007]	Sequence Based	Candid grid Tracking SVM, FAU		Cohn-Kana de		
Caifeng Shan, Shaoseng et al	Sequence Based	A Bayesian temporal Model of manifold	Classification rate 91.8%	Cohn-Kana de		

4. CHALLENGES

As we know that we can recognize human emotions using facial expressions without any effort or delay but reliable facial expression recognition by computer interface is still a challenge. An ideal emotion detection system should recognize expressions regardless of gender, age, and any ethnicity. Such a system should also be invariant to different distraction like glasses, different hair styles, mustache, facial hairs and different lightening conditions. It should also be able to construct a whole face if there are some missing parts of the face due to these distractions. It should also perform good facial expression analysis regardless of large changes in viewing condition and rigid movement [23].

Achieving optimal feature extraction and classification is a key challenge in this field because we have a huge variability in the input data [24]. For better recognition rates most current facial expressions recognition methods require some work to control imaging conditions like position and orientation of the face with respect to the camera as it can result in wide variability of image views. More research work is needed for transformation-invariant expression recognition.

5. CONCLUSIONS

The automatic facial expression recognition systems and various research challenges are overviewed. Basically these systems involve face recognition, feature extraction and categorization. Various techniques can be used for better recognition rate. Techniques with higher recognition rate have greater performance .These approaches provide a practical solution to the problem of facial expression recognition and can work well in constrained environment. Emotion detection using facial expression is a universal issue and causes difficulties due to uncertain physical and psychological characteristics of emotions that are linked to the traits of each person individually. Therefore, research in this field will remain under continuous study because many problems have to be solved in order to create an ideal user interface and improved recognition of complex emotional states is required.

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