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Facial Expression Recognition as an Implicit Customers' Feedback

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1 Introduction

In social interaction, face is playing an important role. Social psychology researches had agreed that among the three mediums in communication, facial expression is the one that is always active. Mehrabian [1] indicated that the verbal part of a message contributes only for 7 percent to the effect of the message as a whole; the vocal part contributes for 38 percent, while facial expression of the speaker contributes for 55 percent to the effect of the spoken message.

Psychologists Paul Ekman and Friesen in 1978 had come with a method to classifying muscle movement to measure the facial expression. This method, which later became the mostly used in classifying facial movement in behavioral science, is called Facial Action Coding System (FACS). Most of the research work on Facial Expression Recognition refers to the Facial Action Coding System. Paul Ekman [2], believed that basic emotion is universal, though he challenge those who can claim otherwise. The universality of emotion expression proposed by (Ekman,1999) was supported by various researchers. The study of emotion universality [3] using American and Indian to recognize emotion expression of 45 selected pictures had convinced that there is existence of universality in emotion expression. People from different backgrounds display similar expression in respond to similar stimuli [4], but it is reasonable to expect local variations. Thus Ekman suggested that extreme positions regarding the universality of emotion are incomplete. Seven Basic emotions established are; happy, sadness, anger, surprise, fear, disgust, and contempt.

2 Related Work

The research, facial expression analysis received significant attention with the wide range of commercial application and more feasible technologies available. All the existing methods for automated facial expression recognition are mainly based on three steps: face acquisition, facial extraction and facial expression identification from the observed facial image or image sequence.

The works of facial expression analysis has evolved from recognizing expression in static image to video and in simple background to complex background with different pose and illumination changes. Facial feature extraction is another challenging step and most of the works in extracting facial feature employed either motion-based method or deformation of face. Motion-based[[5, 6] method focuses directly on the occurring changes in the face due to

the facial expression while deformation-based[[7-9] have to rely on neutral face images or face model in order to extract facial features that are relevant to facial action. The processing of the facial feature could be done either locally or holistically where the face is process by focusing on facial feature areas that are prone to changes or the whole face to the latter.

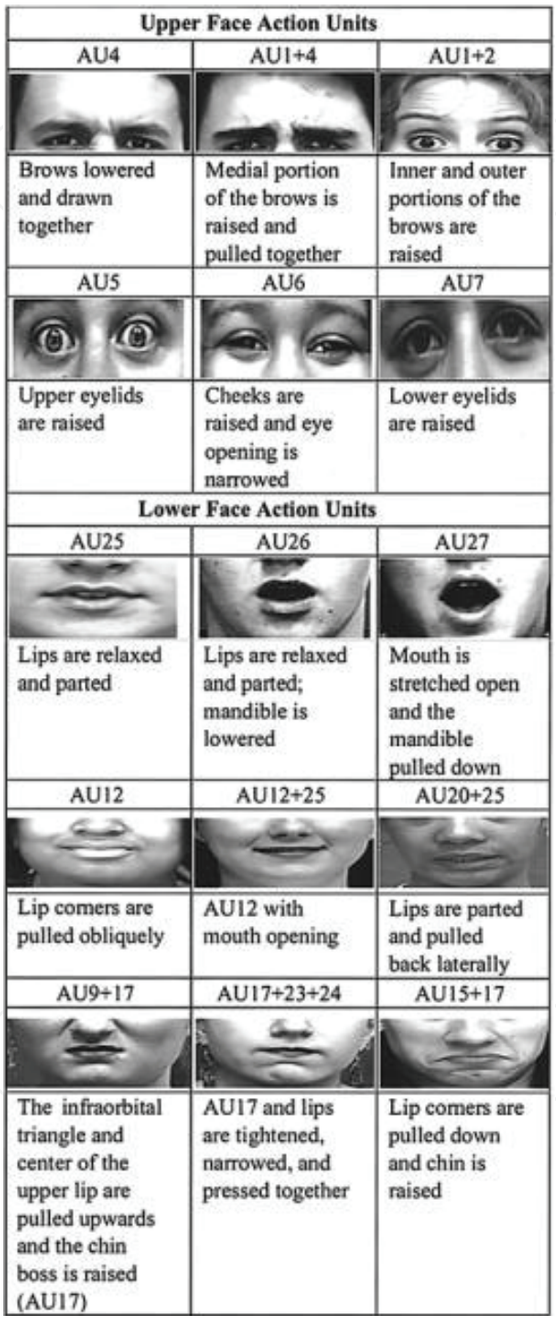


Figure 1. Sample Aus coded in FACS (Ekman and Friesen 78)

Research in machine learning techniques for spontaneous facial expression recognition that involves muscles movement have been widely conducted [10, 11]. In order to capture the facial expressions, Facial Action Coding System (FACS) has been developed[12, 13]. FACS

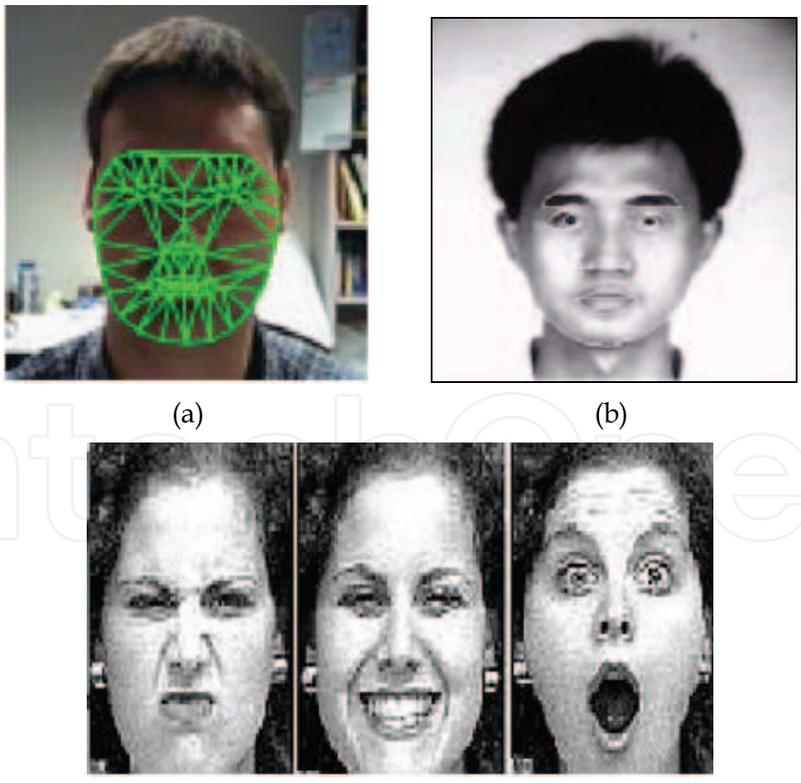
identifies all visually distinguishable facial activity that relates to individual facial muscles in expressing different expressions, such as, happy, sad, angry, surprise, fear and disgust on the basis of 44 action units (AU). Each AU has a numeric code that relates to the different expression. Figure 1 show some examples of the AUs coded in FACS and the muscle groups involved in each action.

2.1 Tracking

The first step in automatic facial expression recognition is to track the face in the video sequences. Tracking of object motions like the head or the face in a video sequence is important for good facial expression classification. Object motion can be the result of either camera motion with static object or object motion with static camera. Discussions on various tracking techniques can be found in [14-17]. This tracking can be achieved by detecting:

- Skin color using Gaussian models, histogram analysis and color probability distribution
- Geometric features like corners of the eyes, mouth, iris, brow or cheek
- 2D template model
- Deformable contours (also known as snakes) of objects like eyes and mouth

Figure 2(a) - 1(c) illustrate some samples on the face tracking techniques. Once the facial expression features have been extracted, they can be transferred to the facial expression recognition for facial expression classification.



(a) (b)

(c)

Figure 2. (a) Face tracking using 2D model, (b) Face tracking using active contour, c) Face tracking using contours of objects like corners of eyes and mouth (Wang and Singh 03)

2.2 Facial expression recognition techniques

There exist various techniques for facial expression recognition. Among the popular ones are artificial neural network (ANN)[18-20] and support vector machines (SVM)[21, 22]. ANNs were inspired from brain modeling studies that consists of layered network of artificial neurons (AN) [14]. An AN receives a vector of input signals, either from the environment or from other ANs. Each input signal is multiplied with a weight that is randomly selected to strengthen or deplete the input signal. Then, the output signal is produced by applying an activation function. Learning process is conducted by adjusting the values of the weight. An ANN may consist of multi-layers of AN but usually it consist of an input layer, hidden layers and output layer. Each AN in each layer is connected to other AN in the other layers. A typical architecture of the ANN is shown in Figure 3.

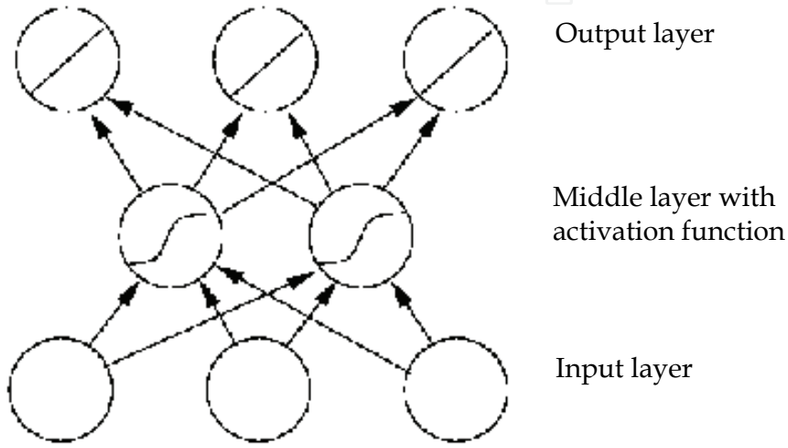


Figure 3. Typical architecture of an ANN

In facial expression recognition, the input nodes for the input layer may be represented as a vector of the color probability distribution of an image if the skin color is being used as the input features. If geometric features are being used, then the vectors may be the distance between the coordinates of the facial features like the top and bottom of the mouth or the eyes. Training process will be conducted to train the ANN by applying either a supervised or unsupervised learning algorithm. In supervised learning, a set of input and the target output is shown to the ANN while in unsupervised ANN, the ANN will cluster the input data into various patterns. Back propagation is one of the widely used supervised learning algorithms. Self-organizing map (SOM) is an example of an unsupervised ANN. Then, testing phase can be performed to measure the classification rate. Feedforward neural network (FFNN) and backpropagation neural network (BPNN) are two of the widely used supervised learning algorithms and enhancements have been made to the FFNN and BPNN to improve the classification performance. Constructive FFNN has been applied in [18] where a two-dimensional discrete cosine transform (DCT) for the entire face image has been used as the feature vector. The vertical distance, size and angle for the eyebrows, eyes and mouth have been used as the feature vector in [20] with enhanced FFNN classifier. Similar feature vectors have also being applied for the SVM in [21]. Self-organizing map (SOM) is an example of an unsupervised ANN. Then, testing phase can be performed to measure the classification rate. A 2D-template model is being used for the SVM in [22].

The SVM formulation uses the Structural Risk Minimization (SRM) principle while the ANN formulation uses the Empirical Risk Minimization (ERM). SRM minimizes an upper bound on the expected risk, while ERM minimizes the error on the training data[23].
The works of facial expression had been implement in many area such as security, biometric, robotic and Human Computer Interaction and [24] had suggest the ideal system that all of stages of facial expression analysis are to be performed automatically from face detection to facial expression information extraction and facial expression classification. The characteristics of automatic facial expression classifier are also mentioned as in Table 1 and Table 2.

	Characteristic
1	Automatic facial image acquisition
2	Subjects of any age, ethnicity and outlook
3	Deals with variation in lightning
4	Deals with partially occluded faces
5	No special markers/ make-up required
6	Deals with rigid head motions
7	Automatic Face detection
8	Automatic facial expression data extraction
9	Deal with inaccurate facial expression data
10	Automatic facial expression classification
11	Distinguishes all possible expression
12	Deals with unilateral facial changes
13	Obeys anatomical rules

Table 1. General Characteristic of automatic facial expression classifier

	CHARACTERISTIC
1.	Distinguishes all 44 facial actions
2.	Quantifies facial action codes
3	# interpretation categories unlimited
4.	Features adaptive learning facility
5.	Assigns quantified interpretation labels
6.	Assign multiple interpretation labels
7.	Features real time processing

Table 2. Characteristic of automatic facial expression classifier in Behavioral Science and HCI

Researcher [25] is an active researcher in facial expression area and she evaluates few face recognition and facial expression recognition techniques under various resolutions. The author found that the combination of technique gave a better result and the lowest resolution that the technique can still perform is 36x48.

3. Facial Expression And Satisfaction Level

Recent advances in image analysis and pattern recognition open up the possibility of automatic detection and classification of emotional and conversational facial signals. Possible area that could use the advance technology of Facial expression recognition system is the customer satisfaction measurement. The expression of customer being served at the counter is captured to evaluate the satisfaction of the customer. This multimedia approach of customer satisfaction measurement is an alternative of the conventional way of collecting customers' response.

Quality measurement and improvement have been an important agenda in many organizations to stay competitive. A good quality measurement needs a good instrument and most of the literature on quality service measurement is based on customer's perception, which is translated into numbers using likert scale. Perception is very subjective and complicated to be translated into numbers. Thus it is important to have a new way of collecting information that is more precise and scientific to make performance measurement more meaningful.

The objective of this work is to measure the satisfaction level of the new students during the registration process. Five parties were involves during the registration of new students at INTEC, UITM; Admission & Record, Bursary, Accommodation and Sponsor. The students were informed that their picture would be taken during the registration process for academic research purposes. The video was captured during the last transactions of the registration process, which is at the sponsors counter. To ease the registration process, the setup of the registration counters was arranged such that all involved parties for the registration were placed at the ad hoc registration venue.

4. Challenges Of Collecting User Satisfaction Based On Facial Expression

Facial expression recognition system may be able to classify intangible values like customer satisfaction. The system involve seven steps namely; identifying the best technique in facial expression, acquiring a library of images for system training, installing the appropriate camera and hardware/software at the identified location for the data collection, capturing the images in the real environment (as the customer is being served at the counter), storing the captured images in the database, processing the images, and store the processed result in the database. Figure 4 illustrates the process of image processing.

In facial expression analysis, mouth and eyes features are playing an important role and both features should be visible in order to extract the correct expression. [26, 27]works focus on upper and frontal view of facial features which are eye brows and eyes, while [28] works focus on recognizing facial expression in profile image sequence. Multistate face component models have been developed by [29] to handle different head pose. Different states head pose have to use different face component model to ensure the robustness of the systems. For example, a lip model of the front face does not work for a profile face.

Based on the different appearances of different components, different geometric models are used to model the component's location, shape, and appearance. Each component employs a multistate model corresponding to different component states. For example, a three state lip model is defined to describe the lip states whether it is opened, closed, and tightly closed. A two state eye model is used to model opened and closed eye. There is one state for brow and

cheek. Present and absent are use to model the states of the transient facial features. Seven head states (left, leftfront, front, rightfront, right, down, and up) are shown in Figure5.

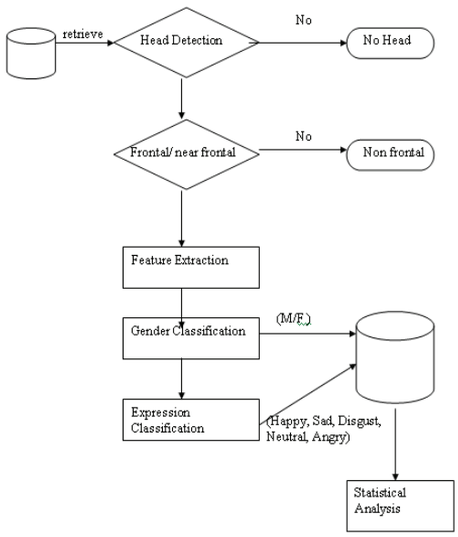


Figure 4. Sequence Image processing

Figure 5. Multistate Face Model

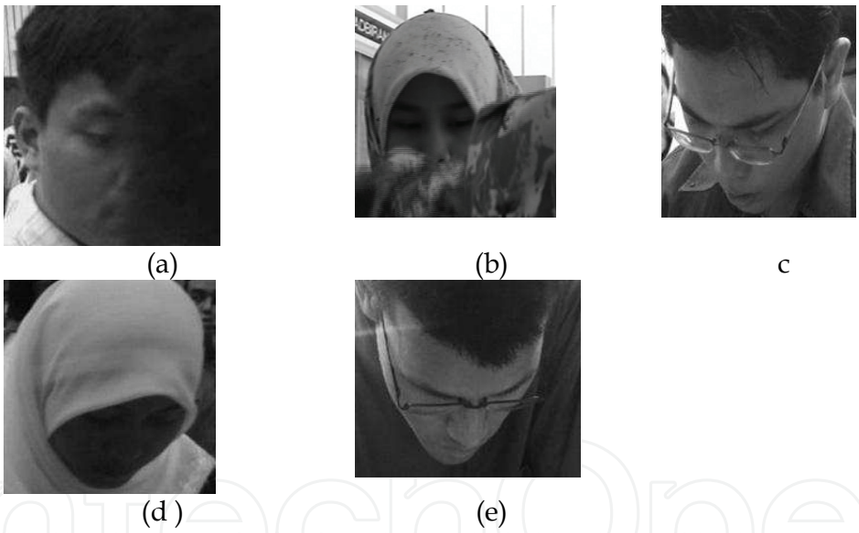
Most of data collections for the available databases are set up in the laboratory where the facial expressions were not spontaneous. Though few researchers have been conducting the research on the spontaneous behavior., their work ([30],[31]) collect the data by recording the subject while there were interviewed on a selected topic in controlled environment but the subjects were free to move their heads and out-of plan head was presents during the discourse.

Affective computing which apply the automatic facial recognition techniques is getting more attention ([32],[33],[9],[34]). The main idea of affective computing is that the computer could better adjust its behavior to user's current emotion. In this user-centered research, the data were collected by mounting the camera on the computer monitor and user's facial expression was captured during user interaction with the systems. The software will

intelligently change its behavior according to the expression of the users. If the user's facial expression show a sad expression, the software will interpret that user do not understand how to use the systems. The data is gathered and store in the database to be use later on how much the user happy with the systems. Affective computing have little challenges in collecting the data because user is always facing the monitor while using the systems and thus frontal or near frontal view is not so hard to obtain.

Facial expression application for spontaneous behavior such as at the counter service of student registration may have problem in data collection due to physical counter set up. On the normal counter service, staff on duty was seated behind a table while the customers (student) who was being served was either sitting down or standing up. When the customer is seated in front of the staff, the staff may obstruct the customer. Hence the frontal view is not possible. While when the customer is standing up forces the customer (student) to look down at the table and makes the image capturing very difficult. During the service, both student and staff were moving their head and obstructing the camera from capturing the student's face as shown in figure 6 (a).

The images in the database set up from laboratory making sure that the face is not occluded by the subject's hair as in figure 6 (b). Though the down-front face state have been mentioned by [29], in real environment , subjects tend look down that make it hard to track the mouth and eyes (figure 6 (c)-(e)).



(a) (b) c

(d) (e)

Figure 6. (a)-(b) subject was facing front but occluded by the staff (c)-(e) subject were facing down

5. Conclusion

The facial expression recognition has attracted intense attention from various group of computer vision research team and many techniques had been developed and many areas of application could benefit from it. The performance of an ANN may depend on the number of the training data or the parameters of the ANN like the learning rate or the threshold value. Similar experiments for the SVM can also be conducted. Thus, various experiments in tuning the values of the ANN and SVM parameters need to be made in order to maximize the classification performance. Comparative study between ANN and SVM for image

classification could also be performed since the same training and testing data could be applied. Future research could be made to compare the classification performance between ANN and SVM and there is always room for further enhancements for both techniques in improving the performance.

The effort of facial expression capturing in the real environment has been elaborated. The challenges and difficulties encountered when performing the experimentation were also highlighted. This work should be able to substantiate the holistic customer satisfaction study from the facial expression perspective rather than from the conventional customer satisfaction survey. The finding may benefit all enterprises that are concerned with their customer satisfaction in order to ascertain good management of supply chain and hence sustain strategic advantages and competitiveness.

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In these 34 chapters, we survey the broad disciplines that loosely inhabit the study and practice of human-computer interaction. Our authors are passionate advocates of innovative applications, novel approaches, and modern advances in this exciting and developing field. It is our wish that the reader consider not only what our authors have written and the experimentation they have described, but also the examples they have set.

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