CLASSIFYING DRIVER FACIAL EMOTIONS

NUR SURAYAHANI SURAINI
HERMILA M.A

PROCEEDINGS OF MUCEET 2009
MALAYSIAN TECHNICAL UNIVERSITIES CONFERENCE
ON ENFINEERING AND TECHNOLOGY
20 – 22 JUNE 2009
MS GARDEN, KUANTAN PAHANG

Proceedings of MUCEET2009
Malaysian Technical Universities Conference on Engineering and Technology
June 20-22, 2009, MS Garden,Kuantan, Pahang, Malaysia

MUCEET2009

Classifying Driver Facial Emotions

Nor Surayahani B.S, Hermila M.A

Abstract— This paper describes the emotion recognition to determine the driver's conditions. The emotion recognition could be envisioned to sense the driver emotions automatically through a camera. Therefore, facial images were analyzed to extract the features to characterize the variations between facial emotions images. The features extraction techniques apply was Principal Component Analysis (PCA), this algorithm finds the principle components of the covariance matrix of a set of face images. Then, the eigenvalues component will be used as an input to the K-Nearest Neighbor (KNN) classifier. The facial expression recognition used to investigate the emotion and thus carry out an awareness system for drivers to perform an appropriate intervention system.

***Keywords*: Emotions recognition, PCA**

I. INTRODUCTION

EMOTION can be detected through physiological signal such as facial expression, heart beat, temperature and galvanic skin response. In the psychological literature, emotion has been defined as an individual's response to goal-relevant stimuli that includes behavioral, physiological and experiential components. Emotion recognition influence many researchers to study human being social attitude and performance. Hence, the outcome can be used in many applications like automobile system, marketing and smart environment where many system and devices that had been created require user's face tracked by a video camera to capture images of a person's face on cell phones, webcams, even in automobiles with the goal of using facial information as a clue to understand more about the current state of mind of the user. The driver sensor is a camera based driver monitoring system which derives information about the driver's attention to the road and the driver's emotions level. The system can be integrated with other assistance systems such as braking system, steering vibration, lane departure warning and automatic cruise control. These systems accomplish intelligent automobile system in preventing unwanted incident on the road.

B. S. Nor Surayahani is with Computer Engineering Department, University Tun Hussein Onn Malaysia, (e-mail: nsuraya@uthm.edu.my).

M. A Hermila, was with University Tun Hussein Onn Malaysia. She is now a graduate student in BEng in Electric and Electronic.(e-mail: hermila@yahoo.com).

II. IMPORTANT REMARKS

- **Some of related works that similar with this paper are in Section III**
- **Techniques for feature extraction (PCA) discussed in Section IV and V**
- **Classification method (KNN) presented in Section VI.**
- **Section VII discuss and analyzed the result and conclude in Section VIII. The performance of this technique will benefit the efficiency of facial emotions applications.**

III. RELATED WORKS

For the synthesis of facial emotions for drivers, many related research have been studied. Driving is an important activity for people and research proves that drivers emote while they driving and their driving are affected by their emotions [1]. The ability of vehicles to sense their environment will increase the important of vehicle to intelligently dispatching warnings system to the driver effectively. The physiological measurements predict the rated emotion by gender where sadness was easily to predict in female face [3]. The inability to manage emotions while driving is often identified as one of the major causes for accidents. *Anger* is one of the emotions that negatively affect people driving. When drivers become angry, they start feeling self-righteous about events and anger impairs their normal thinking and judgment, their perception is altered, thus leading to the negative cause of events [6].

Once drivers are aware of their emotional states, it becomes easier for them to respond to the situation in a safe manner, but drivers can often lack in awareness. For example is sleepy, which is one of the most dangerous states to be in while driving. Yet when people find they are sleepy, they often force themselves to continue driving instead of stopping to rest [6]. Therefore, when the system recognizes driver's sleepiness, it might change the radio station for a different tune or roll down the window for fresh air [7]. Having a natural communication between the system and the driver will inject precautions actions depending on the driver's preferences [1]. The prevention system includes the emotions and voice car to improve the automotive safety [2]. Another appropriate awareness system among other driver's on the road will increase the automobile safety level where some indicator is needed to alert other driver's.

Meanwhile, research in face recognition was growth aggressively and many techniques were used to analyze the facial images through estimation of optical flow, holistic spatial analysis, such as principal component analysis, independent component analysis, local feature analysis, and linear discriminant analysis; and methods based on the outputs of local filters, such as Gabor wavelet representations and local principal components. This paper used the most popular technique for facial recognition which is Principal Component Analysis (PCA).

IV. PRINCIPAL COMPONENTS ANALYSIS

PCA is mathematically defined as an orthogonal linear transformation that transforms the data to a new coordinate system such that the greatest variance by any projection of the data comes to lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on.

The main idea of using PCA was a 2-D facial image can be represented as 1-D vector by concatenating each row (or column) into a long thin vector. Let's suppose we have M vectors of size N (= rows of image x columns of image) representing a set of sampled images. pj's represent the pixel values.

$$x_i = [p_1 .... p_N]^T, i = 1 ... M \qquad (1)$$

The images are mean centered by subtracting the mean image from each image vector. Let m represent the mean image.

$$m = \frac{1}{M}\sum_{i=1}^{M} x_i \qquad (2)$$

And let wi be defined as mean centered image

$$w_i = x_i - m \qquad (3)$$

Our goal is to find a set of ei's which have the largest possible projection onto each of the wi's. We wish to find a set of M orthonormal vectors e_i for which the quantity

$$\lambda_i = \frac{1}{M}\sum_{n=1}^{M}(e_i^T w_n)^2 \qquad (4)$$

is maximized with the orthonormality constraint

$$e_l^T e_k = \delta_{lk} \qquad (5)$$

It has been shown that the e_i's and λ_i's are given by the eigenvectors and eigenvalues of the covariance matrix

$$C = WW^T \qquad (6)$$

where W is a matrix composed of the column vectors w_i placed side by side. The size of C is N x N which could be enormous. A common theorem in linear algebra states that the vectors e_i and scalars λ_i can be obtained by solving for the eigenvectors and eigenvalues of the M xM matrix W^TW. Let d_i and μ_i be the eigenvectors and eigenvalues of W^TW, respectively.

$$W^T W d_i = \mu_i d_i \qquad (7)$$

By multiplying left to both sides by W

$$WW^T(Wd_i) = \mu_i(Wd_i) \qquad (8)$$

which means that the first M - 1 eigenvectors e_i and eigenvalues ¸i of WW^T are given by Wd_i and μ_i, respectively. Wd_i needs to be normalized in order to be equal to e_i. A facial image can be projected onto $M'(\leq M)$ dimensions by computing

$$\Omega = [v_1 v_2 ... v_{M'}]^T \qquad (9)$$

where $v_i = e_i^T w_i$. v_i is the i^{th} coordinate of the facial image in the new space, which came to be the principal component. the face class k that minimizes the Euclidean distance

$$\varepsilon_k = \|\Omega - \Omega_k\| \qquad (10)$$

where Ω_k is a vector describing the k^{th} face class. If ε_k is less than some predefined threshold θ_ε, a face is classified as belonging to the class k.

V. FACIAL EMOTIONS SYNTHESIS

. Preprocessing is a very important step for facial emotion recognition. By using original image from *Yaleface* database, the preprocessing in figure 1 involved locating centers both eyes, cropping image according to facial model by determined the height and width of the image, sampling image to standardized size (96x128) and performed histogram equalization to obtain better contrast.

Figure 1: (a) Centers both eyes, (b) Cropped image face detection

The description of synthesizable process may be further specified to the following tasks as in figure 2. Feature analysis could be obtained using PCA by computing the basis of a space which is represented by its training vectors to recognize the person emotions.

The input to the KNN classifier is the mean-square error which is the sum of the eigenfaces values of four principal components. Once the mean-square error of the eigenfaces have been computed, several types of decision can be made depending on the application, before categorized the face and assigned to a certain class.

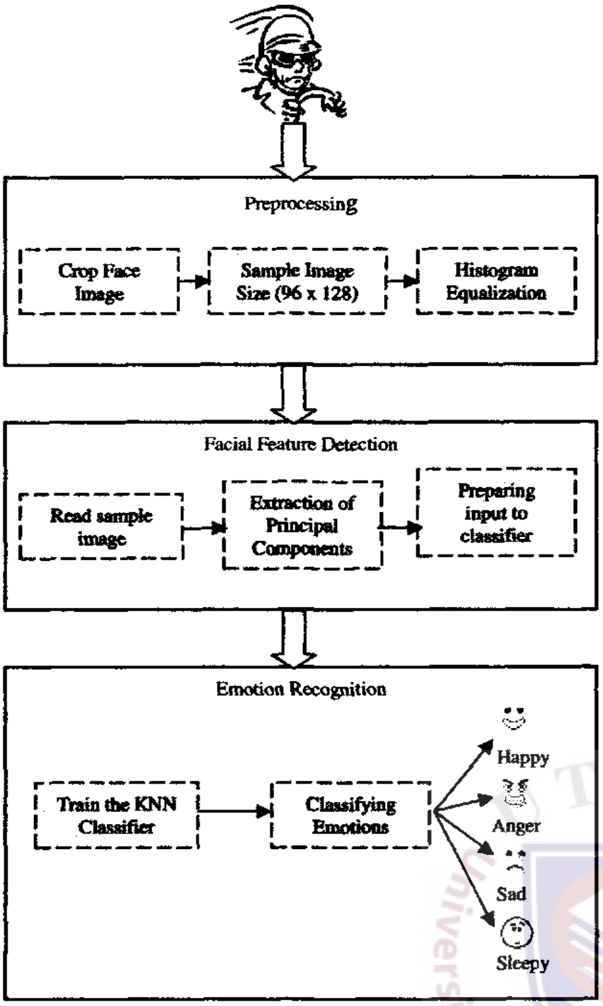

Figure 2: System Development Process

VI. CLASSIFICATIONS

In the second stage, a face image can be approximately reconstructed using a mean of the eigenfaces obtained. The mean values form a feature vector for face representation and recognition. Then, a number of face images will be used to train the neural network software in order to enable it to classify driver's emotions images into four categories of drivers as discuss earlier. Classification of an object is provided by K-Nearest Neighbor (KNN) classifier. When a new test image is given, the weights are computed by projecting the image onto the eigenface vectors. The classification is then carried out by comparing the distances between the weight vectors of the test image and the images from the database.

The input parameters are training set, class of each element of training set and a value of K. While the output parameters will determined class of testing example and number of classes, which have maximum in the nearest neighbor subset, i.e. figure 3 shows the 4 classes are (happy, sad, anger, sleepy) and K=8 then smile class have 4 elements , sad class have 2 elements and other two classes have 1 element each. The classifier will return smile class because maximum in the nearest neighbor subset is 4 and smile class occurs with this maximum frequency.

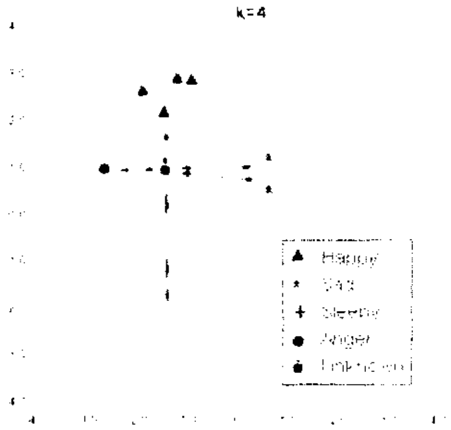

Figure 3: K-Nearest Neighbor Classifier

VII. TESTING AND ANALYSIS

Testing is carried out on the whole *Yaleface* database and captured driver's images. This testing method is based on the following two schemes: First: 2 images of each emotion for each person was taken and put in the training set (10 people * 4 emotions * 2 images per emotion = 80 training images). The remaining images are part of the testing set (120-80 = 40 testing images). Second: 2 images of each emotion for 5 drivers image captured while driving (5 drivers * 4 emotions * 2 images per emotion = 40 testing images). Then, testing image was compare with the training image to obtain the expected results. As for PCA testing, K-NN classifier parameter was set to all value between 1 and 15 and number of eigenfaces of covariance matrix.

Table 1: Performance of KNN Classifier

Emotions	Success Rate	KNN
Happy	88.64%	1,2
Sad	85.20%	2
Sleepy	90.35%	1,2
Anger	92.15%	3

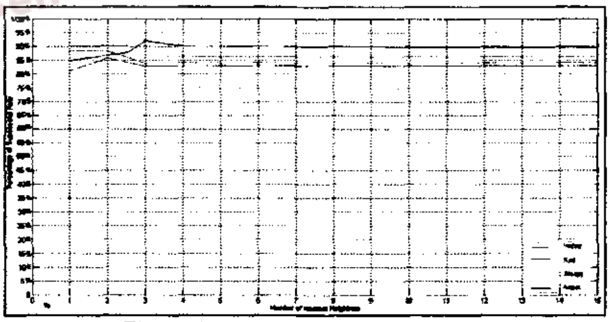

Figure 4: Percentage of Success Rate

Table 1 below represents the result of classifying facial emotions image using KNN classifier. The most recognizable features image in anger class, this maybe because of the obvious emotions faces. Meanwhile, sleepy faces also performed good effects by using PCA. Then, percentage of success rate with the relation between the numbers of nearest neighbor could be plotted as a graph in figure 4. Obviously, the graph showed that the KNN classifier takes only 1 to 3 nearest neighbor to classify the facial emotions in this paper.

VIII. CONCLUSIONS AND FUTURE WORK

As a conclusion, PCA give good effect in recognizing emotions images. Other technique like local point feature detector could be used to enhance the performance for this classifier. However, this paper has successfully produced results for the first stage in investigating driver's behavioral and their driving conditions by detecting the facials emotions thus design the human-computer interaction of automobiles awareness systems for future cars.

ACKNOWLEDGMENT

We are thankful for the helpful comments from our colleagues on the proposed grant project. We believed their suggestion will enhanced the quality of this project.

REFERENCES

[1] Cristine L.Lisetti, Fatma Nasoz, "Affective Intelligent Car Interfaces with Emotion Recognition" in Proceedings of 11th International Conference on Human Computer Interaction, Las Vegas,USA, July 2005.

[2] Clifford Nass, Ing-Marrie Jonsson,Helen Harris,Ben Reaves,Jack Endo,Scott Brave,Leila Takayama, "Improving Automotive Safety by Pairing Driver Emotion and Car Voice Emotion", CHI 2005, Oregon, USA.

[3] Jeremy N.Bailenson, Emmanuel D., Iris B, James J, Maria E, Cendri A.C, Clifford N and Oliver John, " Real-time classification of evoked emotions using facial feature tracking and physiological responses", Elsevier Human Computer Studies 2008.

[4] Gurvfinder Singh, Abdolhossein S, Olaf Diegel and Aruna S., "Computerized Sales Assistants:The Application of Computer Technology To Measure Consumer Interest-A Conceptual Framework", Journal of Electronic Commerce Research, Vol 9, No 2, 2008.

[5] Gianluca D, Marian S.B, Joseph C, Paul H, Terrance J., "Classifying Facial Actions" , IEEE Transactions on Pattern Analysis and Machine Intelligent, Vol 21, No 10, October 1999.

[6] J.A. Colquitt, J.A. LePine, and R.A. Noe. "Toward an integrative theory of training motivation: A meta-analytic path analysis of 20 years of research". Journal of Applied Psychology, 85:678-707, 2000.

[7] J. Larson and C. Rodriguez. "Road Rage to Road-Wise". Tom Doherty Associates, Inc., New york, NY, 1999.

[8] Ashish Kapoor Yuan Qi Rosalind W. Picard, "Fully Automatic Upper Facial Action Recognition" IEEE InternationalWorkshop on Analysis and Modeling of Faces and Gestures , Oct 2003.

[9] K Karibasappa p, David Oziem, Lisa Gralewski, Neill Campbell, Colin Dalton, David Gibson, Barry Thomas, "Face Recognition by ANN using Wavelet Transform Coefficients", Synthesising Facial Emotions,stol, Proceedings of the Theory and Practice of Computer Graphics 2004 (TPCG'04) 2004.

[10] Christine L. Lisetti Diane J. Schiano, "Automatic Facial Expression Interpretation: Where Human-Computer Interaction, Artificial Intelligence and Cognitive Science Intersect", Pragmatics and Cognition (Special Issue on Facial Information Processing: A Multidisciplinary, 2000.

[11] Rafael C.Gonzalez, Richard E.Woods, Steven L.Eddins "Digital Image Processing using MATLAB", Prentice Hall Pearson Education, 2004.

[12] S. T. Gandhe, K. T. Talele, and A.G.Keskar," Face Recognition Using Contour Matching" International Journal of Computer Science,2008

[13] Kyungnam Kim, "Face Recognition using Principle Component Analysis", unpublished.