DIAGNOSING THE LEARNING DIFFICULTY WITH FACIAL EXPRESSION RECOGNITION

Chien-Pen Chuang, Chi-Ming Li

Department of Industrial Education, National Taiwan Normal University, Taiwan, R.O.C

ABSTRACT

Face recognition is extensively applied in this monitoring system and the identity system. In this study, image pre-processing, face detection, and facial expression identification techniques are combined to diagnose learners' learning difficulty. Face image noise from a WebCam is dealt with integrative type of filter. Then, the feature at the edge is extracted through Sobel operator. After edge enhancement, the eye/mouth images are extracted by skin detection. Three criteria for diagnosing learning difficulty are selected as vectors of Approach-Withdrawal, Concentration, and Happiness to identify difficulty levels. Experimental results show that the correct rate of difficulty recognition reaches 92%. The proposed facial expression recognition system can be used to diagnose students' learning difficulty in an adaptive e-learning system.

Keywords: facial expression recognition, feature extraction, learning difficulty, concentration

1. INTRODUCTION

Face pattern recognition has been applied in secured entrance systems, ATM user, and criminal identification. It is also taken as means for facial expression controlled machines, home care service, or lie detectors. However, researchers have always regarded accuracy of recognition and speed as important study targets.

Nevertheless, there is no product available at the moment that applies face recognition in the teaching system. As the saying goes, "What one truly feels inside is manifested on the outside", from this we can deduce that learners' facial expressions can be used to reveal their "learning mood" and diagnose whether they are experiencing difficulties. In other words, the norm serves as the basis in determining whether they are "above the norm" or "below the norm." Then, appropriate teaching materials are in turn given. Since there are quite a few external influence factors which bear influence, the experimental environment has to be simplified, and various expressions of the test subjects, have to be recorded in the computer database before use. This facial-expression-based instruction system is more feasible than EEG-based system on instructional implementation.[2][6]

2. LITERATURE ANALYSIS

In terms of face image recognition, binary imaging is often used to rapidly outline the main body of the image. Some of the commonly used methods include: varimax method proposed by Chen, C. W. and Huang, C. L.[11], and histogram valley proposed by Otsu, N. [12] Meanwhile, Alattar, A. M. and Rajala, S. proposed transforming color space from RGB into YCrCb. [10] Since the human eye is more sensitive to brightness changes than color changes; YCrCb color series are setup to express brightness and color separately. As a result, Cr and Cb colors are used to distinguish skin color and non-skin color zones. After obtaining the face color range, facial features can then be extracted. Traditional methods include the use of deformable templates to search for more fixed features and contours such as the eyes, and mouth. Unfixed features such as eyebrows, and nostrils are extracted with active contour. [12] However, the calculation process of this type of facial feature extracting is complicated, and time-consuming; therefore, a more rapid face detection method is used in this study. [6].

In order to develop an emotional expression-based adaptive learning system, our proposed system not only contains image feature extracting algorithm, but also recognizes facial expression mood patterns. To take references from MIT Affective Computing Lab, Dr. Rosalind Picard and her PhD student Hyungil Ahn advocate that human affect and emotional experience play a significant, and useful, role in human learning and decision making. Most machine learning and decision-making models, however, are based on old purely cognitive models. They developed new models that integrate affect with cognition. And hope that an integrated affective-cognitive learning system should exhibit many improvements over the state of the art, ultimately enabling much smoother human-computer interaction and more intelligent human-machine systems. ［20］［21］。In European Center for Soft Computing, Dr. Gracián Triviño has the idea for personalized cognitive assistants. Its main goal is to create a symbiotic relationship between the user and the system, in such a way that human motivation and creativity is strengthened by computer's greater memory storage, higher computational performance and finer signal processing. Professor Wang Zhiliang presented his paper at IEEE International Conference on Systems, Man and Cybernetics (2001) with two dimensions of Approach-Withdrawal and Careness to define facial expression of emotion. [18] It then be used by Xie Yinggang to apply for an e-Learning system.[22] This paper proposed one more dimension to describe facial expression which is Happiness to improve the effectiveness of learning mood recognition.

3. FACE IMAGE PRE-PROCESSING

Face image pre-processing mentioned in this study can be divided into three parts: the first part is face noise filter; the second part is face edge detection; and the third part is edge enhancement. Since noise is produced by the dark current or false color of interpolation of CCD lens during the extracting process, some filters are used to reduce the interference of noises on the image. In this study, a boundary discrimination median filter [3][4][5][6] and a trilateral filter [7] are used to inhibit impulse noise and Gaussian Noise to retain the main body of information in the image. Moreover, by use of edge detection and generalized fuzzy enhancement, an edge enhancement algorithm [8], the image details are enhanced. Details of mage pre-processing are described as shown in Fig.1:

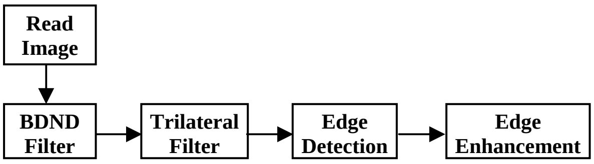


Fig.1 Image pre-processing

3.1. BDND Filter

BDND filter is an efficient filter that eliminates 10%~90% of impulse noises. The equation of the BDND filter is as shown in (1). By means of boundary discrimination noise detection, the location of noise can be computed and a noise map can be produced depending on the impulse noise location. After this process, a vector median filter is used, as shown in equation (2), and noise map locations are thus located to eliminate impulse noises.

$$Y_{i,j} = Median\{X_{i-s,j-t} \ |(s,t) \in W\} \quad (1)$$

$$S_i = \sum_{j=1}^{N} \left\| x_i - x_j \right\| \ , for \ i = 1, \cdots, N \quad (2)$$

3.2. A Trilateral Filter

A trilateral filter is a multi-functional filter capable of eliminating impulse noise and Gaussian noise. The algorithms in sequence are as shown in equation (3), (4)and (5). In view of the four characteristics of filter image namely domain weight, range weight, impulse weight and rank-ordered absolute differences, the above weight characteristics can be combined to eliminate impulse noise and Gaussian noise at the same time.

$$h(x_{i,j}) = \frac{1}{\Omega} \sum_{p=i-m}^{i+m} \sum_{q=j-n}^{j+n} f(x_{i,j}) w_r(x_{p,q}, x_{i,j}) \quad (3)$$

$$w_r(x\ , y\ ) = w_D(x, y) * w_R(x, y)^{1-J(x,y)} w_I(x, y)^{J(x,y)} \quad (4)$$

$$(\sigma_d\ , \sigma_r\ , \sigma_I\ , \sigma_J\ ) = (5,\ 20\ ,40\ ,50\ ) \quad (5)$$

3.3. Face Detection Algorithm

In this study, a more rapid face detection method is used.[9]This algorithm makes use of light compensation, and non-linear image YCrCb color space transformation. Subsequently, the skin color range is tallied and the face location is selected, and identified by selecting the eye/mouth map among the items that conform to face skin color. This will reduce the image identification data quantity. Details of the algorithm are as follows:

3.3.1 Eyes Map

This algorithm is applied based on the front of the face. The color space is converted from RGB into YCrCb. Then, the median color Cr and Cb in the question below are normalized. Finally, EyeMap_C and EyeMap_L are used in AND logic calculation and the scope of the eye is framed. The computations are as shown in equation (6) and equation (7):

$$EyeMap\ C = \frac{1}{3}\left\{ (C_b^2) + (\tilde{C}_r)^2 + \left(\frac{C_b}{C_r} \right) \right\} \quad (6)$$

$$EyeMap\ L = \frac{Y(x,y) \oplus g_\sigma(x,y)}{Y(x,y) \Theta g_\sigma(x,y) - 1} \quad (7)$$

3.3.2 Mouth Map

The mouth consists of stronger red and weaker blue parts; thus, the mouth color Cr is greater than Cb. In short, the mouth takes up a higher ratio than Cr/Cb. Similarly, the Cr and Cb are normalized in the following equation and are computed using equation (8), and equation (9). Finally, the location of the mouth is framed.

$$Mouth\ Map\ = C_r^2 \cdot \left(C_r^2 - \eta \cdot C_r / C_b \right)^2 \quad (8)$$

$$where:\ \eta = 0.95 \cdot \frac{\frac{1}{n} \sum_{(x,y)\in fg} C_r(x,y)^2}{\frac{1}{n} \sum_{(x,y)\in fg} C_r(x,y) / C_b(x,y)} \quad (9)$$

4. THE PROPOSED SYSTEM

Facial expression is one of the best tools to express emotions. The combination of different eyebrow and mouth curves and shapes will be derived as many facial expressions.[13] In this study, facial expressions of different difficulty levels are set to analyze the relationship between learners' learning conditions, facial expressions and emotions. Thus, only eyebrow-mouth expression space is defined in this paper. The change combinations are used to simulate the facial expressions of learners when they are confronted with questions of different difficulty levels. According to Hilgard's Psychology[14], the relationship between basic emotion space, and facial expression space can be inferred. The point of origin represents a facial expression without emotion. Therefore, the corresponding relationship between the two spaces is to rotate the basic emotion space 45 degrees clockwise. It is also defined that the range between the two spaces should be within the unit circle centered on the point of origin in order to avoid mismatching between the facial expression space, and the emotion space, which results in "out of mind."

4.1Approach-Withdrawal, Concentration, and Happiness

After detecting the scope of the face, the facial contour locations are then detected to calculate the corresponding location and size of the eye, and the mouth. The facial features are in turn used to identify facial expressions. The so-called facial expression identification is conducted by extracting facial features from information available. Then, they are quantified on the computer. From the information of facial features, human emotions can be analyzed and understood.

This system automatically extracts facial images through the digital camera and solidly defines Approach-Withdrawal Meanwhile, concentration and Happiness are also defined [18][19], and instantly matched with the database at the rear end. It is used to describe learners' mental state and confirm their facial expressions so that test subjects' learning scenario can be adjusted. It shall serve as reference in diagnosing learning difficulty level as well. Details on the algorithm are as follows:

(1) Approach-Withdrawal

Through face detection, the learner's Approach-Withdrawal toward learning contents during the learning process can be determined. Relative to a normal state, when the size of the face becomes smaller during the test, it means the test subject inclines backward and withdraws from learning during the learning process. The learner is not interested in the learning content, and the Approach-Withdrawal becomes smaller. The equation is as shown in equation (10):

$$e_x = \begin{cases} 0 & x \le x_{F\min} \\ \left[\dfrac{\sqrt{x} - \sqrt{x_{F\min}}}{\sqrt{x_{F\max}} - \sqrt{x_{F\min}}} \right]^{\frac{1}{2}} & x_{F\min} \le x \le x_{F\max} \\ 1 & x_{F\max} \le x \end{cases} \tag{10}$$

(2) Concentration based on eyes shape

Through measuring the eyeshade interval, it can be determined whether the learner stays focused during the learning process. Relative to the normal state, as the eyeshade interval increases, the learner is said to be very focused on the learning content. On the contrary, when Concentration increases and the eyeshades become smaller, the learner is said to be less focused on the learning content. The equation is as shown in equation (11):

$$e_y = \begin{cases} 0 & x \le x_{e\min} \\ \left[\dfrac{\dfrac{x}{p_I} - \sqrt{x_{e\min}}}{\sqrt{x_{e\max}} - \sqrt{x_{e\min}}} \right]^{\frac{1}{2}} & x_{e\min} \le x \le x_{e\max} \\ 1 & x_{e\max} \le x \end{cases} \tag{11}$$

(3) Happiness based on mouth shape

Through measuring the mouth interval, the Happiness of the learner during the learning process can be determined. Relative to the normal state, when the mouth interval increases, the learner is said to be very happy about the learning content. On the contrary, as the mouth interval decreases, the learner is said to be unhappy about the learning content, and Happiness decrease. The mouth happiness equation is as shown in equation(12):

$$e_z = \begin{cases} 0 & x \le x_{M\min} \\ \left[\dfrac{\dfrac{x}{p_I} - \sqrt{x_{M\min}}}{\sqrt{x_{M\max}} - \sqrt{x_{M\min}}} \right]^{\frac{1}{2}} & x_{M\min} \le x \le x_{M\max} \\ 1 & x_{M\max} \le x \end{cases} \tag{12}$$

4.2. Emotion Model Based on Eye/Mouth

The emotion measurement of the entire system comprises of Approach-Withdrawal, Concentration, and Happiness tests. Based on learning psychology, emotions are quantified as to intensity in the system. The emotion intensity, and emotion angle are obtained and defined as shown in equation (13),(14)and (15):

- Definition of emotion:

$$e = (e_x, e_y, e_z) \tag{13}$$

- Definition of emotion intensity:

$$r = \sqrt{e_x^2 + e_y^2 + e_z^2} \quad (-1 \le r \le 1) \tag{14}$$

- Definition of emotion angle:

$$\theta = \begin{cases} \arccos\frac{e_x}{r} & ,e_z > e_y > e_x \\ \arccos\frac{e_y}{r} & ,e_y < e_x < e_z \\ \arccos\frac{e_z}{r} & ,e_z < e_y < e_x \end{cases} \tag{15}$$

4.3. Emotion model discussion

During the emotional response stage, the system compares, determines, and diagnoses learners' learning difficulty level based on their emotional states. Learners' emotion algorithm is defined as follows:

(1) Determine if two emotions are the same

By determining if the coordinates of two emotions are the same or if the emotion intensity and emotion angle between two emotions are the same, we may determine whether two emotions are the same. This is shown in equation (16):

$$e_a = [e_{xa}, e_{ya}, e_{za}], e_b = [e_{xa}, e_{yb}, e_{zb}] , \begin{cases} e_{xa} = e_{xb} \\ e_{ya} = e_{yb} \\ e_{za} = e_{zb} \end{cases} \quad or \begin{cases} r_a = r_b \\ \theta_a = \theta_b \end{cases} \tag{16}$$

(2) Determine if two emotions fall under the same emotion type

Calculate if two emotions fall under the same scope in the emotion curve, or determine if two emotions fall under the same emotion type by calculating the emotion angle as shown in equation (17):

$$\frac{e_{xa}}{e_{ya}} \subset (k_1, k_2), \frac{e_{xa}}{e_{za}} \subset (k_1, k_3), \begin{cases} \theta_b \subset (\theta_{k1}, \theta_{k2}, \theta_{k3}) \\ \theta_a \subset (\theta_{k1}, \theta_{k2}, \theta_{k3}) \end{cases} \tag{17}$$

(3) Compare the intensity of two emotions

For emotions that fall under the same type, their emotional intensities are computed to compare the happiness level of these two emotions.

If $e_a = [e_{xa}, e_{ya}, e_{za}]$ and $e_b = [e_{xa}, e_{yb}, e_{zb}]$, then, they are both happy emotions; if $r_a > r_b$, it means emotional state e_a is more intensified in happiness as compared to emotional state e_b.

(4) Emotion enhancement

Under certain conditions, when outside stimuli are added, the present emotion will be affected. For instance, when one is in a calm state and he hears someone praising him, he becomes happy. Assuming the present emotional state is e_a, outside stimuli will trigger e_b emotional change; then, the present emotional state en can be computed. The emotion enhancement functions is as shown in equation (17):

$$\varphi(e_a + e_b) = e_{a+b} = [e_{xa} + e_{ya}，e_{xb} + e_{yb}，e_{za} + e_{zb}] \tag{18}$$

4.4. System design

The focus of this paper lies in studies related to the facial expression of man and the learning difficulty level. Therefore, the requirements of the basic system structure are as follows: (1) It is applicable in designing learning difficulty level expression under cognitive load. The system should also be interactive. In other words, during the learning process, when a difficulty level is expressed as a result of the cognitive load, the system ought to provide prompts to solve the problem. (2)The system is capable of analyzing emotions. (3) The system is capable of identifying facial expressions.

Based on system requirements, ABC structure [16] and Tok structure [17], the system structure is setup. It is explained as follows:

(1)In reference to Tok structure, three system components in this study include emotion module (C), cognitive load module (S), and behavior module (B). Since this paper focuses mainly on facial expressions and learning difficulty level; thus, the behavior module is changed to facial expression module (F), which is responsible for facial expressing. In the Tok structure, the language module is not included as a part of discussion.

(2) In addition, the system is to establish the relationship between facial expression and learning difficulty level, a time module is added into this system that is responsible for timing the test from the start to the end. If a test item is input for a student, his facial response will be compared to the difficulty level of that test item. If these two parts are equivalent, a "Match" signal will be displayed on the screen. If the result is not equal, a repeat signal will be given to check it again. The flow chart of this process is as Fig.2. Several modules are designed for this purposed system..

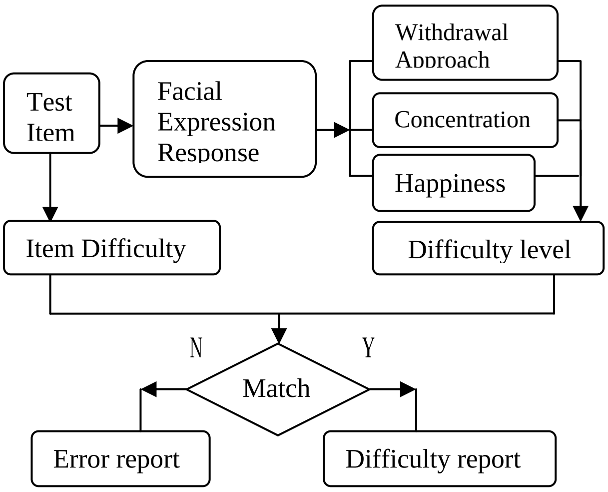


Fig. 2. System design concept

(3) System component

A. External Environment

The external environment refers to the world outside the system. It is made up of objects, users, and events, and it does not automatically transmit information to the system. Instead, the system acquires events or stimuli from the external environment through the sensor module. When a student is doing a test with this system, all other stimuli must be isolated.

B. Sensor module

The sensor module is an input unit that acquires information from the external environments. Stimuli such as test items or user's facial expression are transmitted to the emotion module. Note that the sensor module merely accepts events or stimuli from the users, it is not capable of affecting the world.

C. Emotion module

The emotion module includes intensified emotions and faded emotions. After conducting the math assessment learning unit designed by the researcher, corresponding emotions are produced.

D. Expression module

The expression module receives produced and intensified emotions from the emotion module. The emotions will be displayed on facial expressions. After comparing the facial expression characteristics with the preset facial expression database, a response will be given to the user.

E. Time module

The time module is responsible for recording the start and the end (time up) of math learning assessment unit.

F. Hint module

Hint module is available for student to solve hard items during the test is processing. A hint information will be given to the student if he encounters a "difficult" item, and his facial expression checked by the system to be a hard time for him, the prompt button will pop up from the system to provide him strategies to solve problems in time. After the problem is solved, the system will proceed to the next difficulty level. On the contrary, if the test subject fails to answer the question correctly, the system will return to the previous difficulty level.

5. EXPERIMENT AND DISCUSSION

5.1. Experimental design

Facial expressions are used in this study to diagnose learning difficulty level. Experimental equipments used in this proposed system include software such as Borland C++ Builder 6.0 and Visual C++ 6.0 . Asus 1.3M Webcam is used as map image lens. It is attached to a notebook microcomputer as shown in the Fig.3. All software language and hardware are listed in Table 1.The Experimental environment is setup as Fig. 3.

TABLE 1 Experimental equipment specification

Item	Equipment
Digital color camera	ASUS WebCam, CCD 1.3M
Image processed card	NVIDIA GeForce Go 7400
CPU	Genuine Intel(R) CPU T2300 1.66GHz
RAM	1GB
Program language	Borland C++ Builder 6.0 Visual C++ 6.0

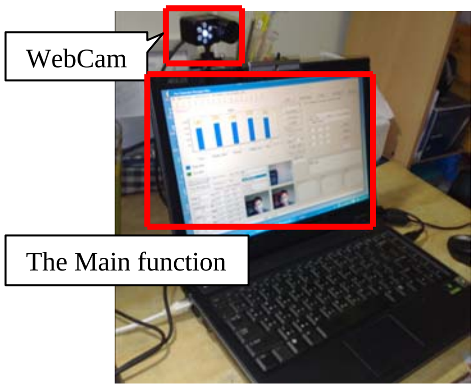


Fig. 3. Experimental environment

The adaptive learning system proposed in this study is shown in Fig. 4. The first step of this system is to preprocess the input image with BDND filter and trilateral filter to deal with impulse and Gaussian noise, secondly do the face contour extraction and mouth and eyes feature extraction.

In order to establish a face expression model, a prior test was made to record the face images with items of difficulty levels. The purpose of this prior test is to prepare a database for the future application. There are five difficulty levels of items to collect under-testers' facial expression images for pattern recognition during their learning period. The components of the response facial expression of each difficulty level is defined with three dimensions as Approach-Withdrawal, Concentration and Happiness as mentioned above.

The test items stored in the test bank are classified into five difficulty levels. It will be called by the system to compare with correspondent facial expression to decide next learning item. It works as IRT-model CAT system.

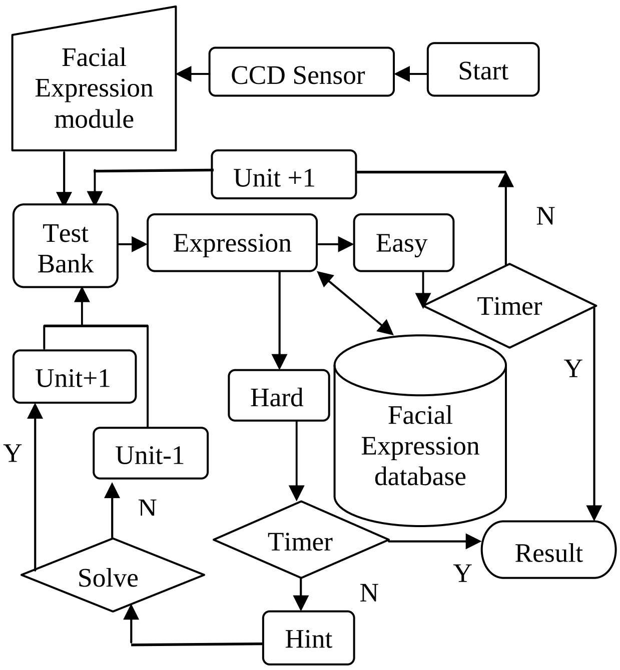
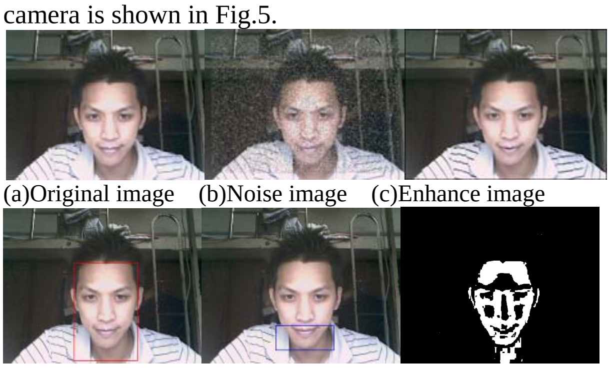


Fig.4. Proposed adaptive learning system

5.2. Pre-processing for face image

The pre-processing of input image through digital camera is shown in Fig.5.



(a)Original image (b)Noise image (c)Enhance image

(d) Facial detection (e) mouth detection (f) Facial mask

Fig. 5. Face image pre-processing

If any student wants to learn with this adaptive learning system, he must be asked to take a test with items of five different difficulties to establish a database of facial expression images as in the Fig.6. The five levels of difficulties are hard, middle hard, common, middle easy and easy. with three dimensions of withdrawal, concentration and happiness.

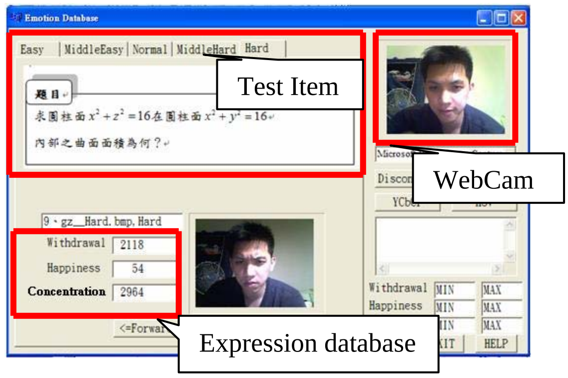
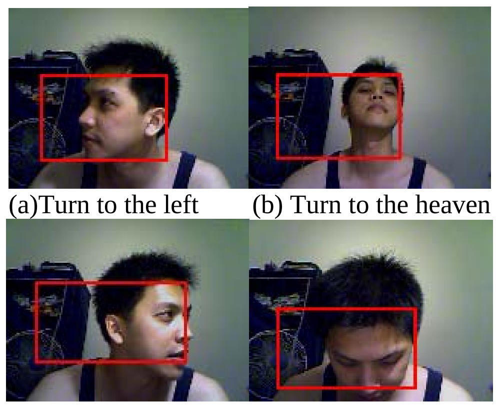


Fig.6 Database establishment

There are four kinds of error face direction which will be rejected by the purposed system as in the Fig.7. It is dealt with pattern recognition technique on the pre-test period to make this purposed adaptive learning system have better effectiveness.



(a)Turn to the left (b) Turn to the heaven

(a)Turn to the right (b)Turn to the earth

Fig.7. Error expression may make error result

5.3. Experimental results

In Fig.8, the purposed system give learner a response of "Match" diagram if his facial expression is correspondent to the difficulty of test item. The system then will output a result of difficulty level as shown in Fig.9.

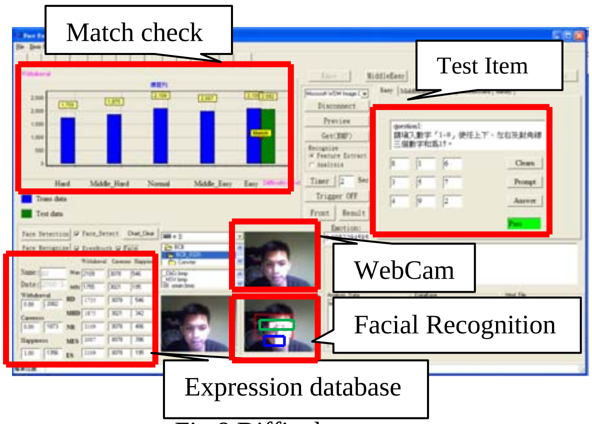


Fig.8 Difficulty test

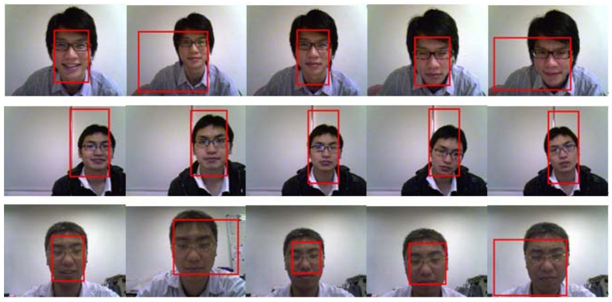
Fig.9 System output

The experiment results of three dimensions of criteria of facial expression for forty students can be seen on the TABLE 2. It is clear to see that the student's response to the Hard, Easy and Normal level are more discriminable than Middle Hard and Middle Easy. Some chaotic situations cause error results.

TABLE 2 Experiment results of three dimensions of criteria of facial expression

Expression / Item / Difficulty Level	Approach-Withdrawal MIN	Approach-Withdrawal MAX	Concentration MIN	Concentration MAX	Happness MIN	Happness MAX
Hard	0±0.01	0.32±0.01	0±0.01	0.14±0.01	0±0.01	0.28±0.01
Middle hard	0.34±0.01	0.36±0.01	0.15±0.01	0.39±0.01	0.29±0.01	0.34±0.01
Normal	0.38±0.01	0.63±0.01	0.4±0.01	0.61±0.01	0.35±0.01	0.65±0.01
Middle Easy	0.64±0.01	0.7±0.01	0.62±0.01	0.68±0.01	0.66±0.01	0.71±0.01
Easy	0.71±0.01	0.91±0.01	0.69±0.01	0.92±0.01	0.72±0.01	0.95±0.01

Fig. 10 shows that the five kind of facial expressions are established in the experiment based on difficulty level. The five facial expressions namely: hard, rather hard, average, rather easy, and easy are used to analyze the difficulty level of the learning assessment. 40 students trained the math learning unit test. Three students are selected as representatives to identify images. A difficulty level facial expression database is in turn established. When the system detects "hard", and "rather hard" facial expressions, Hint will be displayed to help test subjects solve the problems. On the contrary, when the system detects "easy", and "rather easy", Hint will not be displayed



(a) Easy (b)Middle Easy (c)Common (d)Middle Hard (e)Hard

Fig.10. Face image of facial expression database

In TABLE 3, 40 students are tested for the difficulty level of facial expressions. From the data, it shows that during the learning assessment, the identification of "hard" and "easy" was relatively easy and the error rate was low. The identification rate was about 94%. On the other hand, some errors occurred when identifying "rather hard", and "average" The identification rate was only 90%. In summary, the overall difficulty level identification rate reached 92%.

TABLE 3 Consistence of Facial expression and Difficulty of test item

Item difficulty / Face expression	Hard	Middle Hard	Common	Middle Easy	Easy
Hard	38	3	2	1	0
Middle Hard	2	37	2	0	0
Common	0	0	35	2	1
Middle Easy	0	0	0	37	1
Easy	0	0	1	0	38
Rate	0.95	0.925	0.875	0.925	0.95

6. CONCLUSIONS

After a period of experiment, the correct prediction rate results of this proposed system reached 92%, which is better than Japanese Female Facial Expression (JAFFE) Database (86%). And most students feel satisfactory in studying with this adaptive learning system. It is recommended that some stimuli are needed to make test objects express their responding expression if they are vacuous or in some still condition..

7. REFERENCES

[1] J. Y. Chang and J. L. Chen "Automated Facial expression recognition system using neural network", Journal of the Chinese Institure of Engineer , Vol. 24, No. 3,pp.345-356 , 2001.

[2] I. Kotsia and I. Pitas." Facial Expression Recognition in Image Sequences Using Geometric Deformation Features and Support Vector Machines", IEEE Transactions On Image Processing , Vol. 16, No. 1, pp.172-187,2007.

[3] P.E. Ng and K. K. Ma, "A Switching Median Filter With Boundary Discriminative Noise Detection for Extremely Corrupted Images," IEEE Transactions On Image Processing, vol. 15, no. 6, pp. 1506–1515, June. 2006.

[4] H.-L. Eng and K.-K. Ma, "Noise adaptive soft-switching median filter," IEEE Transactions On Image Processing, vol. 10, no. 2, pp. 242–251, Feb. 2001.

[5] W. Ping, L. Junli, L. Dongming, C. Gang, "A Fast and reliable switching median filter for highly corrupted images by impulse noise," IEEE , pp. 3427–3430, 2007.

[6] A. J. Bardos and J. Sangwine, "Selective Vector Median Filtering of Color Image ," IEEE,IPA97, pp. 708–711,July. 1997.

[7] W. C.Kao and H. S. Tai, "A Pipelined Architecture Design for Trilateral Noise Filtering," IEEE, 2006.

[8] Z. X. Guang,G. Ding and X. J. Jian, "Generalized Fuzzy Enhancement of Image for Radiographic Testing Weld," IEEE, ISPA05, pp. 94–104, 2005.

[9] R.L. Hsu, M. A. Mottaleb and A. K. Jain "Face Detection in color image ," IEEE Transactions On Image Processing,vol.24,No. 5, pp. 696–706,May, 2002.

[10]H. Zhao, Z. Wang and J. Men, "Facial Complex Expression Recognition Based on Fuzzy Kernel Clustering and Support Vector Machines",ICNC , 2007 .

[11] J. W. Hong, M. J. Han, K. T. Song and F. Y. Chang, "A Fast Learning Algorithm for Robotic Emotion Recogni- tion",IEEE ,pp. 25 - 30, 2007

[12]M. P. Loh, Y. P. Wong and C. O. Wong, "Facial Expression Recognition for E-learning Systems using Gabor Wavelet & Neural Network",IEEE , 2006

[13]Alattar, A. M. and Rajala, S. "A..Facial feature localiza- tion in front view head and shoulders images", Procee- dings of IEEE International Conference on Acoustics Speech and Signal Processing, Vol. 6, pp.3557-3560 , 1999.

[14]Chen, C. W. and Huang, C. L." Human face recognition from a single front view", International Journal of Pattern Recognition and Artificial Intelligence, Vol. 6, No. 4, pp.571-593 ,1992.

[15]Otsu, N.,"A threshold selection method from gray-level histogram", IEEE Trans. System, Man, and Cybernetics, Vol. 9, No. 1, pp.62-66 ,1979.

[16]Windy Dryden, translated by Wu Chih-Chen, "Rational Emotions-Introduction to Psychology, Shin Li Publishing Co., Ltd.,1997

[17]J. Bates, A. Bryan Loyall, W. Scott Reilly "Integra- ting Reactivity, Goals, and Emotion in a Broad Agent", 1992

[18]Wang Zhiliang, Zhao Yanling, "An Expert System of Commodity Choose Applied with Artificial Psychology", IEEE International Conference on Systems, Man and Cybernetics, pp. 2326-2330, 2001

[19] Conati, C, "Probabilistic assessment of user's emotions in education games", Journal of Applied Artificial Intelli- gence, pp. 555-575, 2002

[20]Hyungil Ahn, Rosalind W.Picard. Affective-Cognitive Learning and Decision Making: A Motivational Reward Framework for Affective Agents. First International Con- ference on Affective Computing and Intelligent Interaction. 2005: 866-873.

[21]Conati, C. Probabilistic assessment of user's emotions in education games. Journal of Applied Artificial Intelligence, 16(Special Issue on managing cognition an Affect in HCI), 555-575. 2002

[22]Xie Yinggang, Wang Zhiliang, The Research of Emotion Cognition Model and its Application. Proceedings of the 26th Chinese Control Conference, July 26-31, 2007, Zhangjiajie, Hunan, China.