Thai Buddhist Sculpture Recognition System (TBuSRS)

Chomtip Pornpanomchai, *Member, IACSIT*, Vachiravit Arpapong,
Pornpetch Iamvisetchai, and Nattida Pramanus

***Abstract*—The objective of this research is to develop a computer system that can recognize some Thai Buddhist sculptures. The system is called "Thai Buddhist sculpture recognition system (TBuSRS)". The TBuSRS consists of five components, which are 1) image acquisition, 2) image preprocessing, 3) feature extraction, 4) image recognition, and 5) display result. In the image acquisition component, the Buddhist sculpture picture is taken by a digital camera. In the image preprocessing component, the Buddhist statue image is enhanced for easy extraction of the Buddhist features. In the feature extraction component, the TBuSRS extracts 14 features used for recognizing a Buddhist sculpture. In the image recognition component, the Euclidean distance technique is applied to recognize the Buddhist sculpture image. In the display result component, a graphic user interface (GUI) is created for displaying the recognition results. The TBuSRS trained the database with 50 kinds of Buddhist sculptures with a total of 500 images. The experiments were conducted on 50 kinds of Buddhist statue images, with a total of 500 images for testing a training data set, and 21 kinds of Buddhist statue image with a total of 105 images for testing an un-training data set, with the precision rates of training and un-training data set of 90.00 percent and 72.38 percent, respectively. The average access time of the system is around 2.72 second per image.**

***Index Terms*— Buddhist sculpture, Image processing, Euclidean distance, Buddhist sculpture recognition.**

I. Introduction

Thailand is the land of Buddhism. There are more than 40,000 temples in Thailand [1]. Suppose there is one principal Buddhist sculpture in a temple. It means that there are more than 40,000 Buddhist sculptures in Thailand. Therefore, it is very difficult for Thai people to identify Buddhist sculpture. There are not only a large number of principal Buddhist images but also many Buddhist sculpture styles that make people feel difficult to recognize a Buddhist sculpture. The Buddhist sculpture styles in Thailand depend on the period in which they were created, which have the following details [2].

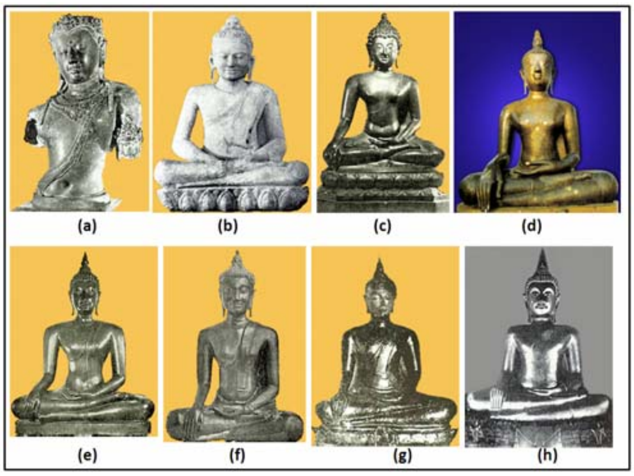


Fig. 1 The Buddhist sculpture styles in Thailand

- *Dvaravati period (7th through 11th centuries)*

This period consisted of three Buddhist image styles, which are: 1) Sri Vijaya images (as shown in Figure 1(a)), 2) Lopburi image (as shown in Figure 1(b)) and 3) Chiang Saen (as shown in Figure 1(c)) and Lanna images (as shown in Figure 1(d)).

- *Sukhothai period (14th century)*

This period had Sukhothai (as shown in Figure 1(e)) and U thong Buddhist image styles (as shown in Figure 1(f)).

- *Ayutthaya period (14th through 18th centuries)*

This period had Ayutthaya Buddhist image style (as shown in Figure 1(g)).

- *Modern Time (19th through now)*

This period has the modern Thai Buddhist image style (as shown in Figure 1(h)).

Based on a lot of Buddhist image styles and a huge number of Buddhist sculptures in Thailand, the objective of this research is to develop a computer system that can help people to recognize Thai Buddhist sculptures by using image processing techniques. The related works are presented in the next section and the system details are explained in the methodology section. Finally, the experimental results and conclusions are presented.

II. Related Works

All Buddhist sculptures are imitated for the Lord Buddha. Therefore, the Buddhist sculpture face looks like a human face. For this reason, this research applies human face recognition to identify Buddhist sculpture images. Many researchers have proposed so many methods to recognize human faces, which have the following details.

Manuscript received April 20, 2011, revised July28, 2011.
Dr. Chomtip Pornpanomchai is an Assistant Professor in the Faculty of Information and Communication Technology, Mahidol University, Bangkok 10400, Thailand, e-mail: itcpp@mahidol.ac.th, Tel:662-3544333.
Vachiravit Arpapong, Pornpetch Iamvisetchai, and Nattida Pramanus are graduated from the Faculty of Information and Communication Technology, Mahidol University, Bangkok 10400, Thailand, e-mail:{u5088020,u5088140,u5088211}@student.mahidol.ac.th, Tel:662-3544333.

A. Face recognition by support vector machine

Peichung S. and Chengjun L. (2005) proposed a technique for detection of faces and important identity on faces, called "Distribution-based Distance and Support Vector Machine (DBD-SVM)." The algorithm has 3 processes. First, the discriminating feature vector is defined by combining the input image, its 1-D Haar wavelet representation, and its amplitude projections. Then the DBD-SVM method statistically models the face class by applying the discriminating feature vectors and defines the distribution-based distance measure. Finally, based on DBD and SVM, three classification rules are applied to separate faces and non faces [3].

B. Face recognition by neural network

Yong R. et al. (2009) used Cellular Simultaneous Recurrent Network to recognize faces in an audio-video face data set. Jianming L. et al. (2007) showed that a fuzzy clustering and parallel neural network method is better than a back-propagation neural network, parallel neural network, hard c-means and pattern matching system for face recognition. Thaahirah S.M. et al. (2005) developed a singular valued decomposition as face features extraction and a back-propagation neural network for classification. Shang H.L. et al. (1997) proposed probabilistic decision-based neural networks for face detection, face features extraction, and face recognition. Chomtip P. and Chittrapol I. (2010) presented face recognition by Euclidean distance and neural network techniques [4, 5, 6, 7, 8].

C. Face recognition by Euclidean distance

Sina J. et al. (2008) used iso-depth and iso-geodesic to identify facial landmark and used Euclidean distance to compare each facial feature. Malkauthekar M.D. et al. (2009) used a Euclidean distance method to recognize the face database. Wei J.C. et al. (2008) proposed principal component analysis followed by linear discriminate analysis to measure various face angles. Then, they applied Euclidean distance to identify probed faces. Yu S. et al. (2009) applied feature vector, which consisted of Euclidean distance, curve distance, angle and volume to recognize a human face. Liwei W. et al. (2005) presented IMage Euclidean distance (IMED) to apply to all image recognition, which included face recognition [8, 9, 10, 11, 12, 13].

There are many techniques, which can recognize Buddhist sculpture faces like human faces. However, there is no consensus as to which method is the best one. Therefore, the TBuSRS uses the Euclidean distance method to recognize Buddhist sculpture face because it is a simple technique and easy to implement. The TBuSRS system design and implementation are presented in the next section.

III. Methodology

In this section, the TBuSRS details are presented. First, the conceptual diagram of the TBuSRS is presented. And then the structure chart of each component is illustrated. All the system diagrams have the following details.

A. System Conceptual Diagram

The TBuSRS starts with a user taking an unknown Buddhist sculpture picture from a temple. Then the user loads the unknown image to the TBuSRS for recognizing. Finally, the user gets the TBuSRS recognition result. The TBuSRS conceptual diagram is shown in Fig. 2.

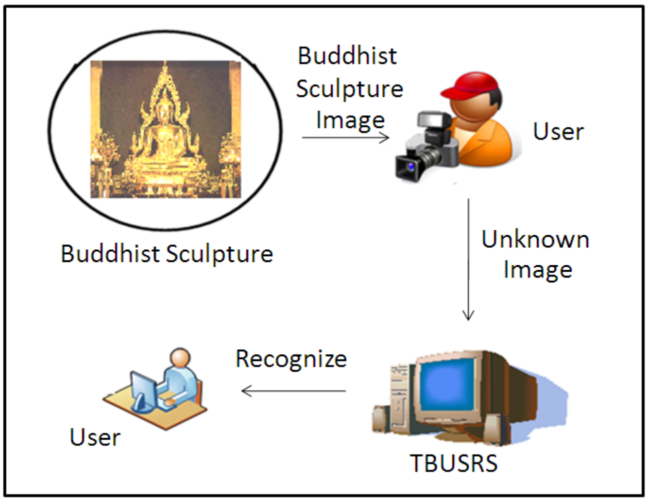


Fig. 2 TBuSRS conceptual diagram.

B. System Structure Chart

The conversion of the TBuSRS system's conceptual diagram in the previous section into a structure chart is shown in Fig 3. In the structure chart, it consists of five main components of: 1) image acquisition, 2) image preprocessing, 3) feature extraction, 4) recognition, and 5) display result. Each component has the following details.

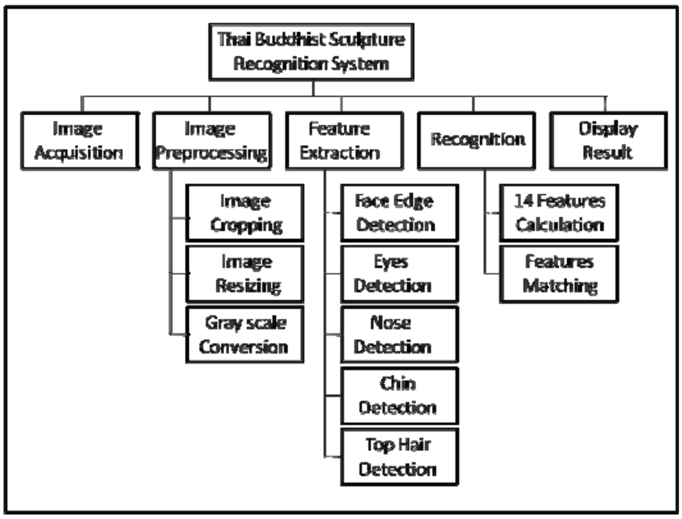


Fig. 3 TBuSRS structure chart.

1) Image acquisition

This component takes Buddhist sculpture images to train and to test in the system. Most images are taken from the principal Buddhist sculptures in a temple in Thailand.

2) Image preprocessing

This component prepares the Buddhist image in the proper characteristics for the image processing method. The image preprocessing component consists of three modules, namely:

1) image cropping, 2) image resizing and 3) gray-scale conversion. In the image cropping module, the TBuSRS crops only the Buddhist face. In the image resizing module, the system reduces every Buddhist image to the same size of 375 X 500 pixels. In the gray-scale conversion module, the system converts the original RGB color image (as shown in Fig. 4(a)) to a gray-scale image (as shown in Fig. 4(b)).

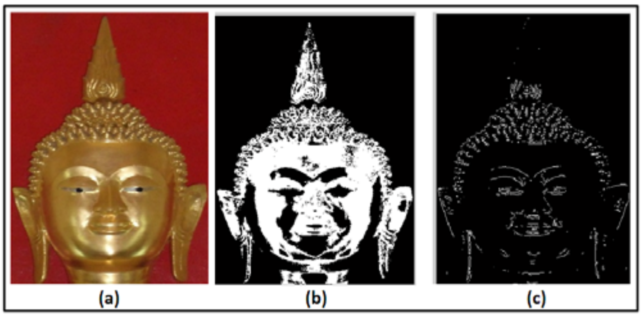


Fig. 4 Buddhist images (a) an original image, (b) a gray-scale image and (c) a Sobel edge detection image.

3) *Feature extraction*

This component detects five important Buddhist image features, which have the following details.

- Edge detection feature - this feature applies the Sobel edge detection technique to find Buddhist face edge image (as shown in Fig. 4(c)).
- Eyes detection feature - this feature uses the Buddhist edge picture in Fig. 4(c) to detect both left and right eye positions.
- Nose detection feature - this feature uses a Buddhist edge picture in Fig. 4(c) to detect a nose that is below both eyes.
- Bottom neck feature - this feature detects by using the point above the Buddhist sculpture shoulder.
- Top hair feature - this feature detects by using the first pixel from the Buddhist sculpture head.

4) *Recognition*

This component consists of two modules, which are 14-feature detection and feature matching for Buddhist image recognition. The 14 features have the following details.

- The distance between left eye and right eye (as shown in Fig. 5(a)).
- The distance between right edge and right eye (as shown in Fig. 5(b)).
- The distance between left edge and left eye (as shown in Fig. 5(c)).
- The ratio between width and height of the image (as shown in Fig. 5(d)).
- The distance between nose and right eye (as shown in Fig. 5(e)).
- The distance between nose and left of the eye (as shown in Fig. 5(f)).
- The distance between right eye and top hair (as shown in Fig. 5(g)).
- The distance between left eye and top hair (as shown in Fig. 5(h)).
- The distance between right edge and nose (as shown in Fig. 5(i)).
- The distance between left edge and nose (as shown in Fig. 5(j)).
- The distance between nose and top hair (as shown in Fig. 5(k)).
- The distance between nose and bottom neck (as shown in Fig. 5(l)).
- The distance between right eye and bottom neck (as shown in Fig. 5(m)).
- The distance between left eye and bottom neck (as shown in Fig. 5(n)).

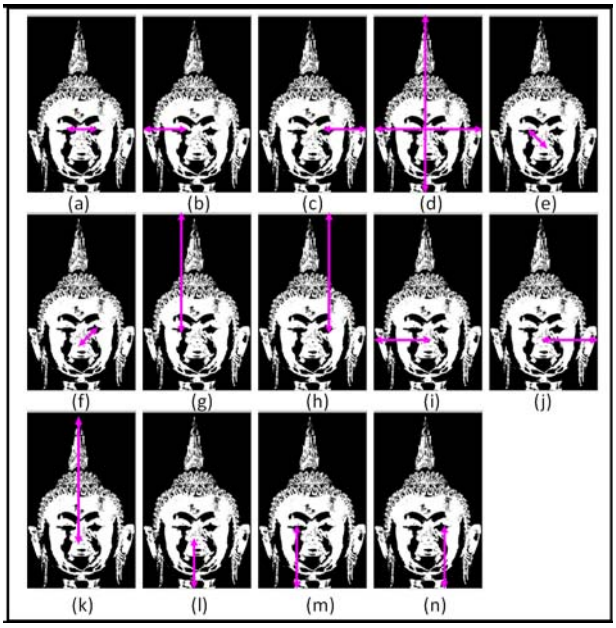


Fig. 5 The 14 features used for recognizing the Buddhist sculpture image.

The TBuSRS applies the Euclidean distance method (as shown in Equation 1 to compare an unknown image with the training images in the system database.

$$ED = \sqrt{\sum_{i=1}^{n} (X_i - Y_i)^2} \quad (1)$$

where ED is the Euclidean distance value, n is number of features, X_i is a value of feature i in the system database, Y_i is a value of feature i of an unknown image.

1) *Display Results*

The final stage is a display result module. Based on the TBuSRS graphic user interface in Fig. 5, the user screen consists of four image boxes and three command buttons. The four image boxes are: 1) the original Buddhist sculpture image (label number 1), 2) the recognition results image box (label number 2), 3) the recognition Buddhist sculpture details (label number 3), and 4) the 14-feature values (label number 4). Moreover, the three buttons have the following details: 1) the training button for training an unknown image to the system database (label number 5), 2) the input button for loading an unknown image for recognition (label number 6), and 3) the recognition button for recognizing an unknown Buddhist image (label number 7).

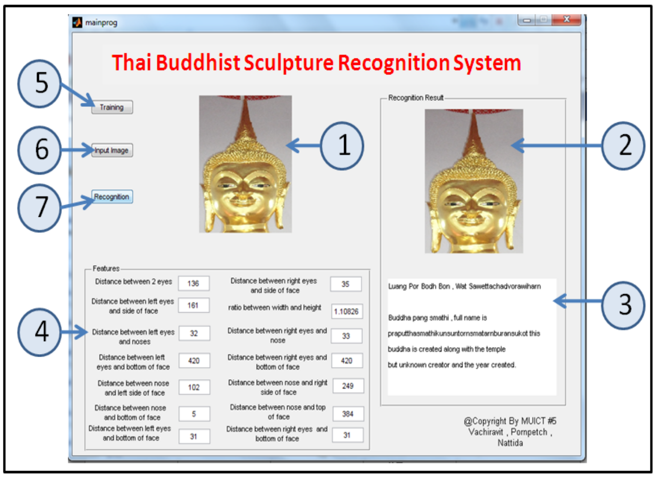


Fig. 5 TBuSRS graphic user interface.

TABLE 1 TBUSRS TRAINING DATASET PRECISION RATE.

No.	Buddhist Sculpture Name	Temple	N	M	S	U
1	Luang Por Chim	Wat Suttharam	10	9	0	1
2	Luang Por Bodh Bon	Wat Sawetchatvoraviharn	10	10	0	0
3	Luang Poo Kao	Wat Suntithummaram	10	10	0	0
4	Pra Putthrairatananayok	Wat Kalyanamitr	10	10	0	0
5	Phra Yim Rub Fah	Wat RakangKositaram	10	9	1	0
6	Luang Por Pa	Wat Bukkalo	10	9	1	0
7	Luang Por Pae	Wat Kantatararam	10	10	0	0
8	Phra Putthamahamongkol.	Wat Paknam	10	10	0	0
9	Luang Por Nakprok	Wat Nakprok	10	10	0	0
10	Phra Putthayannawa	Wat Yannawa	10	10	0	0
11	Phra Putthapatimapratharn	Wat Thepthidaram	10	10	0	0
12	Phra Putthammitsrajlokthaddilok	Wat Arunrajwararam	10	10	0	0
13	Luang Por Dang	Wat Rajsingkorn	10	10	0	0
14	Luang Por Kee Kai	Wat Raj Varint	10	10	0	0
15	Phra Putthajularak	Wat Rajsittaram	10	9	1	0
16	Phra Srisakaytamuni	Wat Sutatthepwararam	10	10	0	0
17	Phra Puttamahasuwanpatimakorn	Wat Traimitr	10	9	0	1
18	Phra Putthanarasapatotsapon	Wat Sampantwongsaram	10	8	2	0
19	Principal buddha	Wat Kanigapol	10	10	0	0
20	Phra putthamahachanok	Wat Patumkongka	10	10	0	0
21	Phra Attharos	Wat Jedeeluang	10	9	0	1
22	Luang Por to	Wat Pah Lelai	10	8	0	2
23	Luang Por Pan tao	Wat Pantao	10	10	0	0
24	Phra Putthakodom	Wat Worajanyawas	10	9	0	1
25	Luang Por Kao	Wat Intakilsaduemuang	10	8	0	2
26	Luang Por Wat Rai Khing	Wat Rai Khing	10	7	0	3
27	Luang Por Putthasila	Wat Rajburana	10	10	0	0
28	Principal Buddha	Wat Itisukato	10	9	0	1
29	Principal Buddha	Wat Na Kwang	10	9	1	0
30	Principal Buddha	Wat Khaoluntom	10	9	0	1
31	Luang Por putthasuwanpoom	Wat Kae	10	10	0	0
32	Principal Buddha	Wat Shesukksaem	10	10	0	0
33	Phra Loi	Wat Phra Loi	10	9	0	1
35	Luang Por Pra sri mahatad	Wat Phra sri ratana mahatad	10	10	0	0
35	Phra Putthatotsaponyanmuni	Wat Piharndang	10	10	0	0
36	Principal Buddha	Wat Nor Puttangkooon	10	10	0	0
37	Phra Puttanimit	Wat Kaotakiab	10	10	0	0
38	Phra Putthachaimongkol	Wat Yai Chaimongkol	10	8	0	2
39	Principal Buddha	Wat NaPramaenrachigaram	10	8	0	2
40	Principal Buddha	Wat Cherngtar	10	6	0	4
41	Luang Por Phrom	Wat Sripoh	10	9	0	1
42	Principal Buddha	Wat Panomyong	10	7	0	3
43	Principal Buddha	Wat Salapoon	10	9	0	1
44	Phra Mongkonbopitr	Wat Mongkonbopitr	10	10	0	0
45	Luang Por yim	Wat TahGarong	10	10	0	0
46	Principal Buddha	Wat Kasatyatiraj	10	9	0	1
47	Principal Buddha	Wat KlangWoraWiharn	10	6	0	4
48	Principal Buddha	Wat Asokaram	10	7	0	3
49	Luang Por Toh	Wat Panancherng	10	5	0	5
50	Luang Poo Kao	Wat Phobanaoi	10	6	0	4
		Total	500	450	6	44

Where: N=Number Tested, M=Match, S=Mismatch, U=Unknown

IV. EXPERIMENTAL RESULTS

The experiment was conducted on 50 principal Buddhist sculptures from 50 temples in Thailand for a training data set, and 21 principal Buddhist sculptures from Thailand, Japan and Hong Kong for an un-training data set. Each Thai Buddhist sculpture uses 10 pictures to train the system database. The TBuSRS database consists of 500 pictures. The study is based on 500 Buddhist sculpture images for the training data set and 105 images for the un-training data set. The precision rates of the TBuSRS of the training data set are around 90.00 percent, 1.2 percent and 8.8 percent for match, mismatch and unknown, respectively (as shown in Table 1). Moreover, the precision rates of the TBuSRS of the un-training data set is around 0.00 percent, 27.62 percent and 72.38 percent for match, mismatch and unknown, respectively (as shown in Table 2).

TABLE 2 TBUSRS UN-TRAINING DATASET PRECISION RATE

No.	Buddhist Sculpture Name	Temple	N	M	S	U
1	Phra putthapatimakorn	Wat Prachetupon	5	0	3	2
2	Luang Por Pra ruang	Wat Mahanparam	5	0	5	0
3	Phra ruang rojanarit	Wat Phra patomjedee	5	0	2	3
4	Phra puttaroobsongkruangyai	Wat Nangtong	5	0	5	0
5	Luang Por Choe Hae	Wat Phra tad choe hae	5	0	3	2
6	Luang Por sothorn	Wat Sothorn	5	0	0	5
7	Luang Por Yai	Wat Waramatkantastaram	5	0	0	5
8	Principal Buddha	Wat Chaiyasatan	5	0	0	5
9	Phraja Kao Tue	Wat Suan Dok	5	0	3	2
10	Principal Buddha	Wat Fah Ham	5	0	0	5
11	Principal Buddha	Wat Hua hin	5	0	0	5
12	Principal Buddha	Wat Upakoot	5	0	0	5
13	Phra Putthamuneesrimongkol	Wat Sarapee	5	0	0	5
14	Principal Buddha	Wat Kadegaram	5	0	2	3
15	Principal Buddha	Wat Pratad Chang Kumm	5	0	0	5
16	Phra Patarnporn	Wat Paichayont	5	0	0	5
17	Principal Buddha	Wat Chaprakiat	5	0	3	2
18	Phra Putthasanpet	Wat KrueWanWorawiharn	5	0	0	5
19	Principal Buddha	Hong Kong Temple	5	0	2	3
20	Principal Buddha	Japan Temple 1	5	0	1	4
21	Principal Buddha	Japan Temple 2	5	0	0	5
		Total	105	0	29	76

Where: N=Number tested, M=Match, S=Mismatch, U=Unknown

V. CONCLUSION

The TBuSRS fulfills the research objective, which is to develop a computer system that can recognize the Thai Buddhist sculpture picture by using the image processing technique. The system uses 14-feature tracking from a Buddhist sculpture face, combined with the Euclidean distance technique to recognize the Buddhist sculpture. The system is completed, with the precision of 90 percent for a trained data set, and 72.38 percent for an untrained data set. The average access time of the system is around 2.72 second per image.

This research is just in the beginning stage for recognizing the Buddhist sculpture in Thailand because there are a lot of Buddhist sculptures in different styles. In the previous day, people recognized Thai Buddhist sculptures from their experience. We hope that the TBuSRS can help people to recognize Thai Buddhist sculptures in the near future. We need more manpower and time to create the TBuSRS database and the intelligence of the system.

REFERENCES

[1] List of Buddhist temples in Thailand, Available: http://en.wikipedia.org/wiki/list_of_buddhist_temples_in_ Thailand, 2011.

[2] Buddha images in Thailand, Available:

http://en.wikipedia.org/buddha_image_in _Thailand, 2011.

[3] Peichung S. and Chengjun L., Face Detection Using Distribution-based Distance and Support Vector Machine, *The Inter. Conf. on Computation Intelligence and Multimedia Applications*, 2005, pp. 1-6.

[4] Yong R., Khan M.I. and William E.W., Recurrent Neural-Based Face Recognition Using Image Sequence, *The IEEE Symposium on Computational Intelligence for Multimedia Signal and Vision Processing*, 2009, pp. 41-46.

[5] Jianming L., Xue Y. and Tahashi Y., A Method of Face Recognition Based on Fuzzy c-Means Clustering and Associated Sub-NNs, *The IEEE Journal Transaction on Neural Networks*, 2007, pp.150-160.

[6] Thaahirah S.M.R., Othman O.K. and Yuslina K., Face Recognition Based on Singular Valued Decomposition and Back-Propagation Neural Network, *The Inter. Conf. on Computers, Communications & Signal Processing with Special Track on Biomedical Engineering,* 2005, pp. 304-309.

[7] Shang H.L, Sun Y.K. and Long J.L., Face Recognition/Detection by Probabilistic Decision-Based Neural Network, *The IEEE Journal Transaction on Neural Networks*, 1997, pp. 114-132.

[8] Chomtip P. and Chittrapol I., Human Face Recognition by Euclidean Distance and Neural Network, The Inter. Conf. on Digital Image Processing, 2010, Page 7-12.

[9] Sina J., Hyohoon C., Yang L. and Alan C.B., Three Dimensional Face Recognition Using Iso-Geodesic and Iso-Depth Curve, *The Inter. Conf. on Biometrics: Theory, Applications and Systems*, 2008, pp. 1-6.

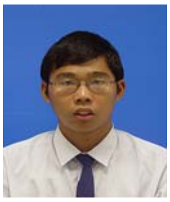
[10] Malkauthekar M.D., Sapkal S.D. and Kakarwal S.N., Experimental Analysis of Classification of Facial Images, *The Inter. Advance Computing Conf.,* 2009, pp. 1093-1098.

[11] Wei J.C., Kah P.S., Heng F.L., and Li M.A., New 3D Face Matching Technique for 3D Model-Based Face Recognition, *The Inter. Symposium on Intelligent Signal Processing and Communication systems*, 2008, pp.1-4.

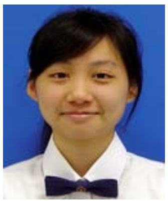
[12] Yu S., Wenhong W. and Yanyan C., Research on 3D Face Recognition Algorithm, *The Inter. Workshop on Education Technology and Computer Science*, 2009, pp. 47- 50.

[13] Liwei W., Yan Z. and Jufu F., On the Euclidean Distance of Image, *The IEEE Journal Transaction on Pattern Analysis and Machine Intelligence*, 2005, pp. 1334-1339.

Chomtip Pornpanomchai received his B.S. in general science from Kasetsart University, M.S. in computer science from Chulalongkorn University and Ph.D. in computer science from Asian Institute of Technology. He is currently an assistant professor in the faculty of Information and Communication Technology, Mahidol University, Bangkok, Thailand. His research interests include artificial intelligence, pattern recognition and object-oriented systems. Email: itcpp@mahidol.ac.th



Vachiravit Arpapong was born in Bangkok Thailand. He received his B.S. in Information and Communication Technology, Mahidol University, Bangkok, Thailand. Email: u5088020@student.mahidol.ac.th



Pornpetch Iamvisetchai was born in Bangkok Thailand. She received her B.S. in Information and Communication Technology, Mahidol University, Bangkok, Thailand. Email: u5088140@student.mahidol.ac.th

Nattida Pramanus was born in Bangkok Thailand. She received her B.S. in Information and Communication Technology, Mahidol University, Bangkok, Thailand. Email: u5088211@student.mahidol.ac.th