การศึกษาวิธีการสกัดคุณลักษณะการรู้จำการแสดงออกอารมณ์ทางใบหน้า
The Study of the Feature Extraction Method in Facial Expression Recognition

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บทคัดย่อ

ในบทความนี้ได้เสนอการศึกษาวิธีการสกัดคุณลักษณะในการรู้จำการแสดงออกทางใบหน้า ซึ่งการรู้จำการแสดงออกทางใบหน้า (Facial Expression Recognition: FER) เป็นโปรแกรมประยุกต์ที่สำคัญในการประมวลผลภาพในการรู้จำใบหน้า (Face Recognition) ประสิทธิภาพการรู้จำของระบบจดจำใบหน้าในทางปฏิบัติจะเป็นประโยชน์ส่วนใหญ่โดยมีเงื่อนไขมากมาย เช่น แสงสว่างที่ต่างกัน การมองเห็นหรือท่าทาง การแสดงออกทางใบหน้า อายุ และการปลอมตัว อารมณ์หรือสภาพจิตใจของบุคคลคือการแสดงออกของใบหน้าซึ่งรวมถึงความสุข (Happy)ความเศร้า(Sad)ความกลัว(Fear)ความรังเกียจ (Disgust)ความประหลาดใจ (Surprise) และความโกรธ (Anger)ในทฤษฎีการจดจำการแสดงออกทางสีหน้าและวิธีการสกัดคุณลักษณะ ได้แก่ การตรวจจับใบหน้า การสกัดคุณลักษณะและการแยกแยะการแสดงออกทางสีหน้า การเสนอวิธีการใหม่ของการรู้จำการแสดงออกทางสีหน้าในการใช้วิธีการสกัดแบบไฮบริดที่ใช้ภาพแสดงออกทางสีหน้า บทความนี้เป็นงานวิจัยนำเสนอในวรรณกรรมที่ครอบคลุมอย่างกว้างขวางโดยแยกประเภท ขั้นตอน วิธีการกระบวนการคำนวณและอัตราการรู้จำได้อย่างเป็นระบบ
คำสำคัญ: วิธีการสกัดคุณลักษณะ / การรู้จำการแสดงออกทางสีหน้า / วิธีการสกัดคุณลักษณะแบบผสมผสาน

Abstract

In this paper, we propose to study the feature extraction method in facial expression recognition. Facial Expression Recognition (FER) is an important application programs of image processing in Face Recognition. Recognition performance of the practical FR system is largely influenced by the variations in illumination conditions, viewing directions or poses, facial expression, aging, and disguises. The mood/mental state of a person is the expression of face which include happy, sad, fear, disgust, surprise and anger. In theoretical facial expression recognition and feature extraction methods include Face Detection, Feature Extraction and Expression Classification.The proposed a novel taxonomy of FER of hybrid feature extraction approaches used in facial expression image. The paper is extensively and comprehensively investigate works proposed in the literature and systematically classify them based on methods of computational processing and recognition rate.
Keywords: Feature Extraction Method / Facial Expression Recognition / Hybrid Feature Extraction Approaches

1. Statement of the Problem

Facial Expression Recognition (FER) is an important application programs of image processing in Face Recognition. Generally, foreigner workers are Facial Expression images with various resolutions to evaluate human character, feelings, judgment, and viewpoint. Recognizing Human Facial Expression is not just an easy and straightforward task due to several circumstances like illumination, facial occlusions, face shape/color etc. For method/techniques which use face acquisition, facial feature extraction and facial expression classification. Variously, there are difficult feature expression analysis images, which can reduce some useless information to subsequent

feature extraction. Therefore, improving the accuracy of the facial expression recognition image can enhance the efficiency of the facial expression recognition using hybrid method.

2. Objective

To study of the feature extraction method in facial expression recognition.

3. Introduction

Face recognition (FR) has become a popular research topic in the computer vision, image processing, and pattern recognition areas. Recognition performance of the practical FR system is largely influenced by the variations in illumination conditions, viewing directions or poses, facial expression, aging, and disguises (Li et al., 2014). Recently, near infrared imagery (NIR) method has been used in many FR systems because of the high robustness of NIR cameras to illumination variations and the high quality of the acquired images (Luo et al., 2016).

Due to this learning ability machine can perform some tasks automatically like making accurate predictions, suggesting remedies for the disease, recognizing human face expressions, etc. The most important way among all is the facial expressions recognition (Pantic &. Rothkrantz, 2000). Recent research has proven that facial expressions and other emotions are an excellent source of conveying the non-verbal communication cues in face to face interactions.

Currently, Facial Expression Recognition (FER) is One of the non-verbal communication method by which one understands the mood/mental state of a person is the expression of face which include happy, sad, fear, disgust, surprise and anger (Khatri et al., 2014).Features extraction is an automatic recognition approach for facial expression from nearly front view face image automatic recognition approach for facial expression from nearly front view face image and summarized the three main component of facial expression recognition which includes: 1) face detection, 2) facial expression feature extraction and 3) facial feature classification (Zhang et al., 2012).

This paper focus Facial Expression Recognition Based on Hybrid Features. It was extensively and inclusively analyzed current works and systematically classify them based on methods of computational processing. The paper will help to enhance an understanding of various principles of FER. Future work, I can get still problems and improve better and more efficiency of Hybrid methods in FER.

4. Theoretical Facial Expression Recognition

Retrospectively, evidence on emotion signals includes universals, development, spontaneous versus deliberate actions, and masked emotions. The face also provides conversational signals and signs relevant to cognitive activity. The logic of comprehensively measuring facial movement illustrates how Facial Action Coding System (FACS) scores facial behavior, the mechanics of facial movement, and options for what to score (intensity, timing, symmetry) (Ekman et al., 1993). The various approaches for facial recognition are categorized into two namely holistic based facial recognition and feature based facial recognition. Holistic based treat the image data as one entity without isolating different region in the face where are feature based methods identify certain points on the face such as eyes, nose and mouth etc. The facial expression recognition is analyzed with various methods of facial detection, facial feature extraction and classification. (Hemalatha. &

Sumathi, 2014). The Steps of facial expression recognition has three main components: the first step in face detection De et al (2015) is preprocessing and one of the important fields of study for human-computer interaction. To detect a facial Expression one system need to come across various variability of human faces such as colour, posture, expression, orientation, etc. The second part, feature extraction Lai & Ko (2014) is used the threshold local binary pattern to transform a facial image into a feature image and extracted the most discriminate features from the feature image by using the block-based center-symmetric local binary pattern. The third part, expression classification tasks based on drawing separating lines to distinguish between objects of different class memberships are known as hyperplane classifiers. Support Vector Machines are particularly suited to handle such tasks (Chen et al., 2012). Steps involved in Facial Expression Recognition in Figure 1.

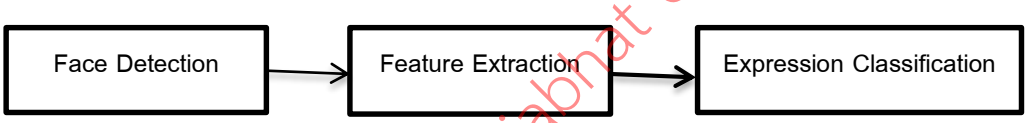

Figure1. Steps involved in Facial Expression Recognition

4.1. Facial Detection methods

In addition, In face detection is preprocessing to obtain facial images with normalized intensity, uniform size and shape. The steps involved in converting a images to a normalized pure facial image for feature extraction is detecting feature points, rotating to line up locating and cropping the face region using a rectangle, according to the face model. Detecting faces in a single image involves four methods.

1) Knowledge based :

According to the author (Lee et al., 1996) the knowledge is based on many recognition methods using partial knowledge have been proposed. They include approaches based on the human face profile or human front face and the hybrid method of these two approaches with recognition methods employing the human face profile, feature extraction is easy.

2) Feature invariant:

According to the author (Yow & Cipolla, 1997) feature invariant components such as Facial features, Texture ,Skin color and Multiple Feature.

2.1) Facial Features Bayoumi et al. (2004) is proposed face detection based on adopted skin color model. In the following, the modeling procedure is described.

The Adapted Skin-Color Modeling Procedure:

1. Calculate the overall mean p(r,g) for all skin-regions of the samples set in the chromatic color space:

$$r = \frac{1}{N}\sum_{i=1}^{N} r_i \text{ and } g = \frac{1}{N}\sum_{i=1}^{N} g_i , \quad (1)$$

2. Let j=n=1,

3. Calculate the mean (m_j) of the specified skin-region 'j'.

4. Substitute the calculated mean into the following equation:

$$Z = (\sum_{k=i}^{n} m_j^i \sum -1\, m_k)^{-1} m_j^i \sum \bar{\mu}^{-1} \quad (2)$$

Where m_k; k = 1 ... n, is the previous mean vectors, m_j is the estimated mean of the current skin-region and Z is an identity matrix.

5. Update the estimated mean value of the current region (adapted mean), using the following equation:

$$\widehat{m_j} = \sum_{k=1}^{n} \alpha_j m_k \quad (3)$$

6. Let j=j+l, go to step 3.

2.2) Texture based Punitha & Geetha (2013) is proposed the approach for emotion recognition is based on the texture features extracted from the gray-level co-occurrence matrix (GLCM). The adjacency can be defined to take place in each of four directions 0°, 45°, 90° and 135° degrees in a two-dimensional square pixel image (directions horizontal, vertical, left and right diagonals) as in Figure 2

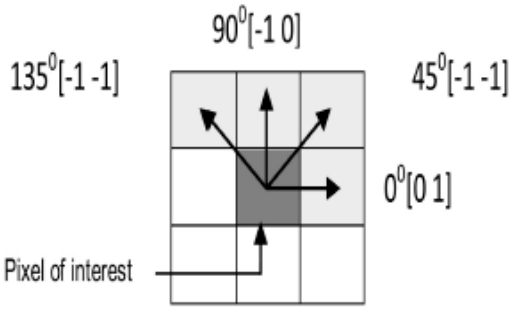

Figure 2. The four directions of adjacency that are defined for calculating the texture features

2.3) Skin Color Kang et al. (2016) is proposed were commonly used as a basic element for efficient characteristic-based face detection in existing face detection. The following in Figure 3.

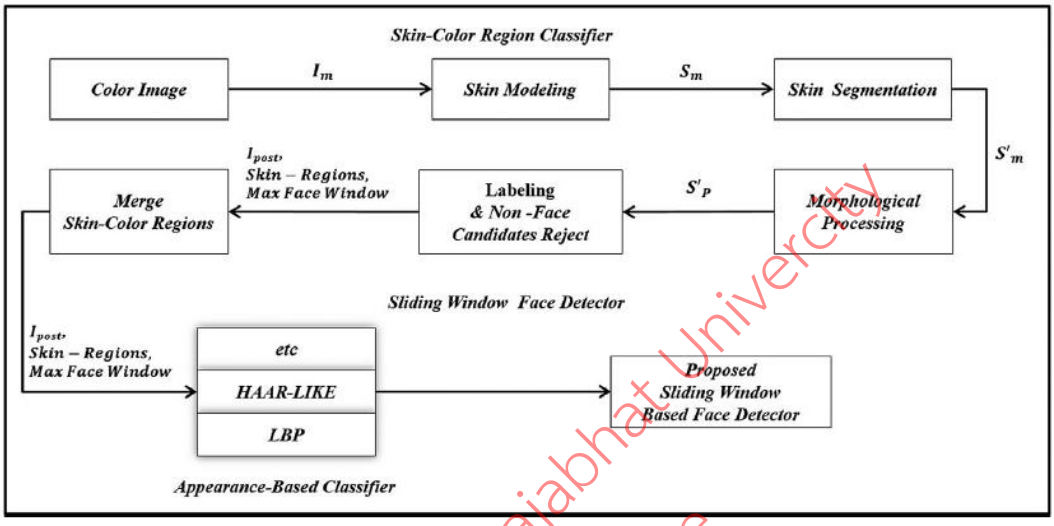

Figure 3. The proposed face detection flow.

2.4) Multiple Feature Yu et al. (2014) is a spectral embedding based multi-view dimension reduction method to fuse multiple features for facial expression recognition and multiple face region features are selected by an algorithm ,such as Adaboost (Hong et al., 2014).

3) Template Matching is represented based on statistical local features, local binary patterns (LBP) for person independent expression recognition. The expression matching method based on half of one face, which can solves the facial shade and slightly sloping problem in actual (Yu et al., 2015). and it is into 2 categories, namely Predefined face templates and Deformable templates, such as Active Shape model (ASM) Sarnarawickrame & Mindya (2013), which it is used to locate the facial feature deformations of a face detected by using Haar classifiers..

4) Appearance Based is applied to variety of images taken under different lighting and backgrounds (Abboud et al., 2004). in involved seven methods Eigenface, Distribution based, Neural Network, Support Machine (SVM), Naïve Bayes classifier, Hidden Markov Model(HMM), Information-Theoretical approach, but proposed the major two methods in following 4.1 and 4.2.

4.1) Eigenface Chakrabarti & Dutta (2013) is used dimensionality reduction techniques on a large standard dataset. The following in Figure 4.

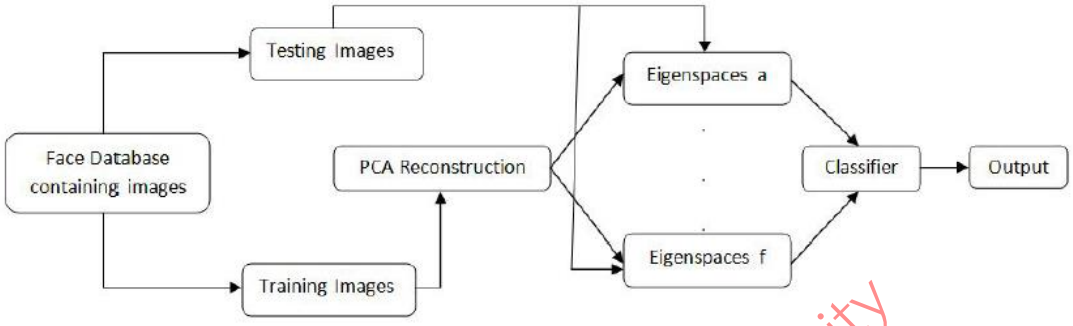

Figure 4. General process flow for our modified approach

4.2) Distribution based Kalita & Das (2013) were acquired and cropping of five significant portions from the image was performed to extract and store the Eigenvectors specific to the expressions. The following in Figure 5.

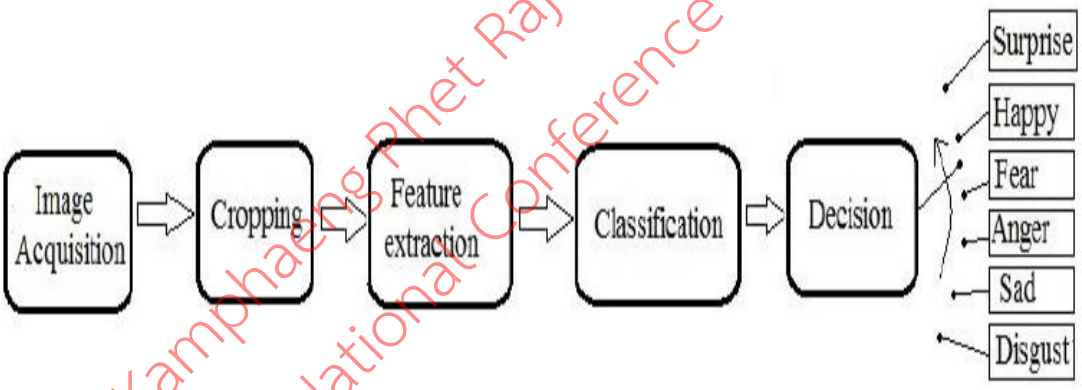

Figure 5. Block Diagram for the Expression Recognition System

4.2. Feature Extraction

Basically, the Feature Extraction is a method in facial recognition. It involves several steps like dimensionality reduction, feature extraction and feature selection. Dimensionality reduction is an important task in pattern recognition system (Zhang et al., 2016). After the face has been located in the image or video frame, it can be analyzed in terms of facial action occurrence. A facial feature extraction technique computes significant and distinctive features from the face with a purpose to shrink the amount of data to be processed. The choice(alternatives) of the feature extraction relates to the recognition quality and computational effort, several approaches to extract these facial points from digital images or video sequences of faces were proposed, which falls into two categories: geometry and appearance based techniques (Rathi & Shah, 2016).

4.2.1 Feature Extraction using Discrete Transform (DCT)

According to the author Gupta et.al (2011) is applied on input image. The DCT coefficient values are kept in the vector at the zigzag positions. Zigzag manner is implemented to convert 2D DCT image matrix to feature vector by keeping the dominant frequency components at the start of the vector. Experiment results show that proposed techniques have 93.4% recognition rate while facial expression recognition using DCT method on the JAFFE databases.

4.2.2 Feature Extraction using Gabor Filter:

According to the author Zhang et.al (2014) in this paper proposes a facial expression recognition approach robust to facial occlusion and investigates the effect of different types of occlusion on FER performance. The performance of the approach is not significantly affected by changes in parameters such as the number of orientations and scales of Gabor filters or the size of templates, for most types of occlusion. Evaluations with occlusion of the eyes and the mouth demonstrate that the proposed approach can achieve more than 75% and 90% accuracy on the JAFFE and CK databases, respectively.

4.2.3 Feature Extraction using Principal Component Analysis (PCA):

According to the author L. Yuan et.al (2013) Principal component analysis (PCA) is a method that can reduce the dimension of image data and simplify the data structure. It is a good way to solve the problem that LBP is susceptible to random noise and the change of non-monotone illumination when local texture features are extracted. Experimental result proves that the method has good robustness, and is more effective to extract facial expression features than the method of solely using PCA and it have 86.61% recognition rate.

4.2.4 Feature Extraction using Local Binary Pattern (LBP):

According to the author Ouyang et.al (2013) local binary pattern (LBP) seems a suitable feature to meet these two principles, well-known for its powerful performance on texture classification and robust to various illuminations. But the results in show that LBP + SRC can only perform an accuracy rate of 62.9% on the CK database.

4.2.5 Feature Extraction using Independent Component Analysis (ICA) :

According to the author Long et.al's (2012) Independent Component Analysis (ICA) The experimental results on the well-known Cohn-Kanade databases how that the learned features perform better than engineered features. The comparison experiments on recognition of low intensity expressions show that our method yields a better performance than spatiotemporal Gabor features and based on SVM classification is used for performance evaluation.

4.2.6 Feature Extraction using Linear Discriminant Analysis (LDA):

According to the author.Wang et.al.(2016) Linear Discriminant Analysis for dimension reduction and classification, which can accommodate LDA to the situation of a few of

labeled data available. The experimental results on eight datasets show that the performance of SLDA is superior to that of traditional LDA and some state-of-the-art semi-supervised algorithms.

4.2.6 Feature Extraction using Fuzzy Inference System (FIS):

According to the author Ilbeygi et.al. (2012) Fuzzy Inference System (FIS) is even able to recognize emotions from Partially Occluded Facial Images. Experimental results report an average precision rate of 93.96% for Emotion Recognition of six basic emotions, which is so promising.

4.3. Classifications

The Classification is a general process related to categorization, the process in which ideas and objects are recognized, differentiated, and understood, In the current works of classification studies.

4.3.1 Hidden Markov Model (HMM) as Classifier:

According to the author Pardàs & Bonafonte (2002)Hidden Markov Model (HMM) for an emotion (that is, to adjust its parameters), it will use as training sequences all those sequences that it select as representatives of the given emotion. It is used all those sequences from the Cohn–Kanade facial expression database manually classified as belonging to this emotion. Experiments have been repeated involving only three emotions, obtaining 98% recognition rate when joy, surprise and anger are involved, and 95% with joy, surprise and sadness.

4.3.2 Neural Networks as Classifier:

According to the author Lopes et al.(2017) in this paper Neural Networks (NN) apply some pre-processing techniques to extract only expression specific features from a face image and explore the presentation order of the samples during training. The experiments employed to evaluate our technique were carried out using three largely used public databases (CK+, JAFFE and BU-3DFE). A study of the impact of each image pre-processing operation in the accuracy rate is presented. The proposed method: achieves competitive results when compared with other facial expression recognition methods 96.76% of accuracy in the CK+ database.

4.3.3 Support Vector Machine as Classifier:

According to the author Luo et.al. (2013) in this paper Support Vector Machine (SVM) is a kind of machine learning method on the basis of statistical learning theory.
It is used for expression classification and recognition and a set of supervised learning methods used for classification, regression and outliers detection. The advantages of support vector machines are: Effective in high dimensional spaces. Still effective in cases where number of dimensions is greater than the number of samples. Experimental results show that the method adopted in this article is robust in different expressions.

4.3.4 AdaBoost as Classifier:

According to the author Owusu et.al. (2014) in this paper AdaBoost is a kind of machine learning method on the basis of statistical learning theory. AdaBoost-based feature reduction technique. The selected features which represented the facial deformation patterns were then fed into a 3-layer feed-forward neural network that is trained by a back-propagation algorithm. It is interesting to note that Bessel down-sampling techniques have never been adopted for facial expression recognitions. The system is trained and tested with datasets from JAFFE and Yale facial

expression databases. An average recognition rate of 96.83% and 92.22% are registered in JAFFE and Yale databases, respectively.

5. Literature Review

In the works of Facial expression recognition (FER) is currently a very active research topic in the fields of computer vision, pattern recognition, artificial intelligence, and has drawn extensive attentions owing to its potential applications to natural human–computer interaction (HCI), human emotion analysis, interactive video, image indexing and retrieval, etc. Automatic FER system is fully automatic and consists of the following modules: face detection, facial detection, feature extraction, selection of optimal features, and classification (Lajevardi & Hussain, 2012). The face detection is based on AdaBoost algorithm and is followed by the extraction of frame with the maximum intensity of emotion. This is as show in Figure 6.

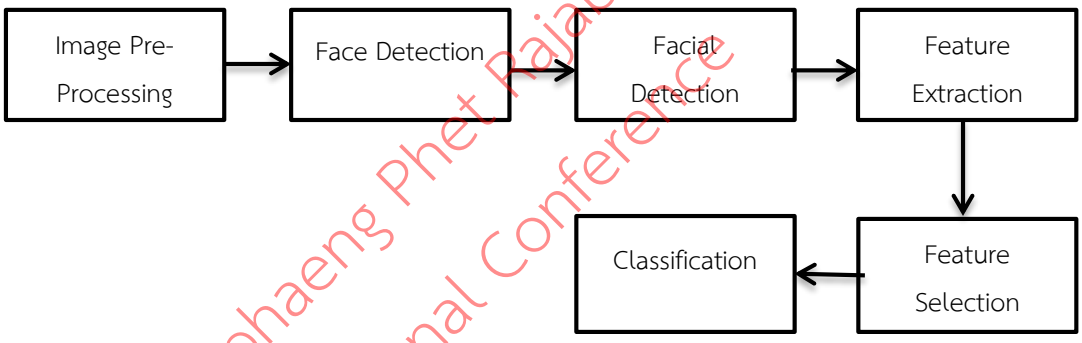

Figure 6. Block diagram of the facial expression recognition systems

The feature extraction process converts pixel data into a higher-level representation of shape, motion, color, texture, and spatial configuration of the face or its components. The extracted representation is used for subsequent classification. Feature extraction generally reduces the dimensionality of the input space. The reduction procedure should (ideally) retain essential information possessing high discrimination power and high stability Lajevardi & Hussain (2012).

However, the six basic emotions (Kumar, 2009) the human face is capable of displaying expressions for a variety of other emotions. This categorization is shown in Table 1.

Table 1. The emotion categories.

1. Disgust	2. Fear	3. Joy	4.Surprise	5.Sadness	6. Anger

The selected frames are then processed to generate characteristic features using different methods including:

5.1 Principal Component Analysis (PCA)

Facial expressions recognition is an important part of the study in man-machine interface. Principal component analysis (PCA) Yuan et al. (2013) is an extraction method based on statistical features which were extracted the global grayscale features of the whole image. But the grayscale global features are environmentally sensitive. and it is finding the best projection direction which represents the original data in the condition of least mean-square (Zhou et al., 2013). The equation is defined as Eq. (1).

$$\boldsymbol{X} = \left[\xi_{11} - \bar{\xi}, \xi_{12} - \bar{\xi}, \ldots, \xi_{ij} - \bar{\xi}\right] = \left[\zeta_1, \zeta_2, \ldots, \zeta_k, \ldots, \zeta_N\right]; \quad i=1,2,\ldots,C,\ j=1,2,\ldots,M,\ k=1,2,\ldots,N \tag{4}$$

Perform calculation on the covariance matrix $X^T X$ to generate its eigenvalues and eigenvectors, which is defined as Eq. (2).

$$Y_k = P^T \zeta_k \ ; \ k=1,2,\ldots,N. \tag{5}$$

Then the dimension of original image vector is reduced to r(r<N) and Y_k called the PCA feature of the original image.

5.2 Local Binary Pattern (LBP)

LBP Yuan et al. (2013) is used to extract the local texture information of grayscale image. Supposing g_c (x_c, y_c) is any pixel within a local area of a face image, c g as the center of a 3×3 window and the other eight points are g_0 ,..., g_7.

Define the local area texture as $T_{LBP} = t(g_c , g_0 ,..., g_7)$ and carry on binary processing for the other eight pixels within the window using the threshold, here set the gray value of center pixel in the window as the threshold. The equation is as Eq. (6).

$$T_{LBP} \approx t[s(g_0 - g_c),..., s(g_7 - g_c)] \tag{6}$$

Where s(x) = {1 x>0; 0 x<= 0;

Read out an 8-bit binary number in the clockwise direction as an eigenvalue of the central pixel. Convert the binary number into a decimal number by the following formula for each symbol function. Then, LBP code which is described the spatial structure of local image texture feature is got through Eq. (7).

$$T_{\mathrm{LBP}}(x_c, y_c) = \sum_{u=0}^{7} s(g_u - g_c)2^u \tag{7}$$

A LBP operator is shown on Figure 7.

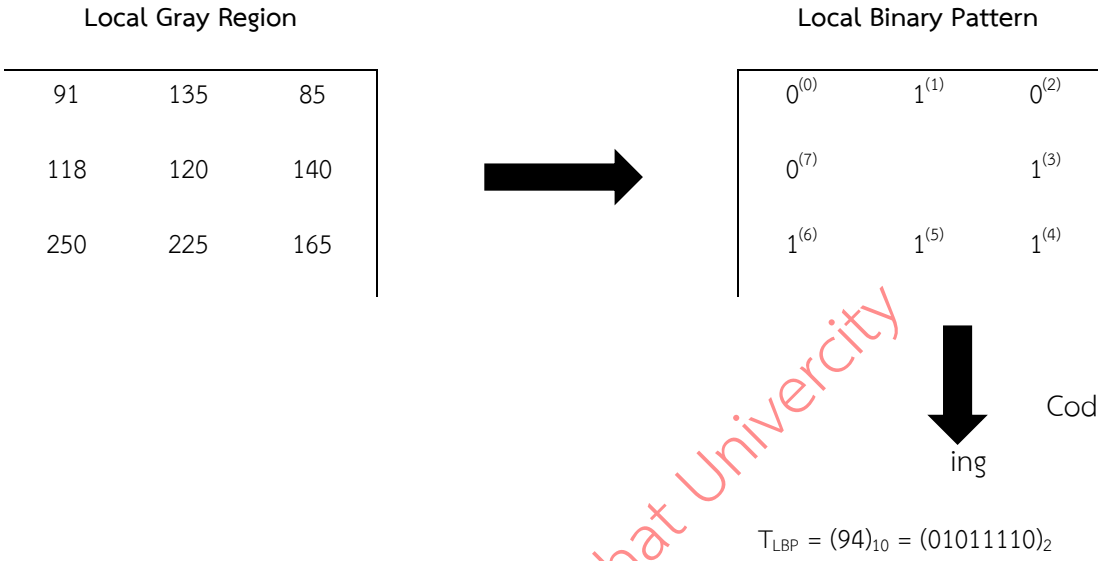

Figure 7. LBP operator

After scanning a facial expression image by LBP operator, the LBP coding image of original image is 01011110_2.

5.3 Linear Discriminant Analysis (LDA)

The traditional Linear Discriminant Analysis (LDA) Zhou et al. (2013). is proposed by R.A. Fisher. so it is also known as Fisher's Discriminant Analysis (Wang et. al., 2016). LDA searches for a linear transformation such that the feature clusters are most separable after the transformation which can be achieved through scatter matrix analysis.

Given the training set $V = (v_1, v_2, \cdots, v_m)$, $V \subset R^{nxm}$ each column of contains pixel values of one face image, and each image belongs to classes, the between-class scatter matrix S_w and within-class scatter matrix S_b are defined as

$$S_w = \sum_{i=1}^{c} \sum_{j=1}^{N_i} (V_j - \mu_i)(V_j - \mu_i)^T \quad (8)$$

This method aims at searching for a group of basis vectors, which makes different class samples, have the largest between-class scatter and the smallest within-class scatter.

5.4 SVM Classifier

SVM (Chen et al., 2012). is a kind of data learning method based on the theory of statistical learning. SVM can deal with spurious regression problem and pattern recognition successfully. The mechanism of SVM is looking for a hyper plane meet for the requirement of classification, which is a best support vector to distinguish two different classes, under the condition of limited information

based on small sample and maximizes the gap between classes and ensures the accuracy of classification at the same time. It can resolve the problems of insufficient sample of facial expression and big difference of quantity between different expressions.

5.5 Database

This paper, the Japanese Female Facial Expression (JAFFE) Database (Dailey et al., 2010). is used in experiments. The database contains 213 images of 7 facial expressions (6 basic facial expressions + 1 neutral) posed by 10 Japanese female models. Each image has been rated on 6 emotion adjectives by 60 Japanese subjects. The database was planned and assembled by Michael Lyons, Miyuki Kamachi, and Jiro Gyoba. We thank Reiko Kubota for her help as a research assistant. The photos were taken at the Psychology Department in Kyushu University. The following on Figure 8.

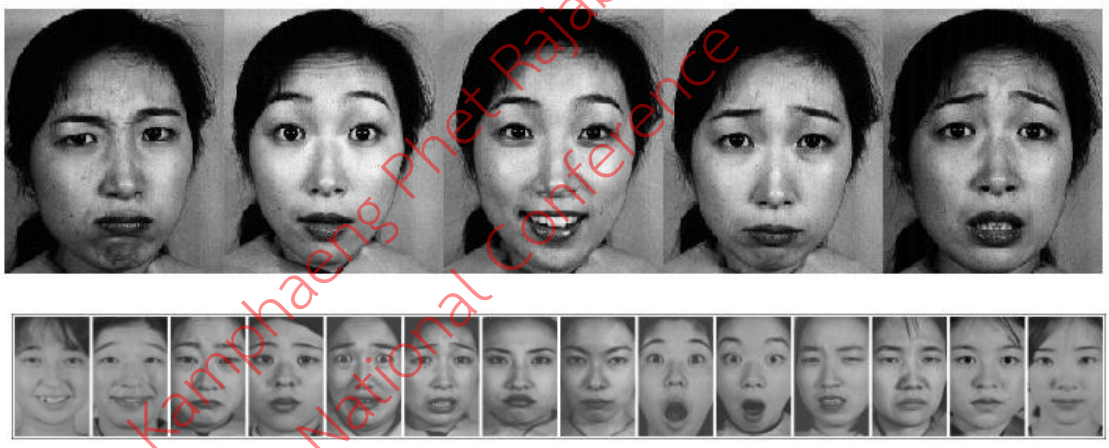

Figure 8. Images are from JAFFE

6. Materials and Methods

6.1. Input Data: Images from the JAFFE database (Dailey et al., 2010).

6.2. Image Facial Expression Recognition algorithm:

PCA+LBP+LDA+SVM algorithm (Zhang, et. al., 2012: Yuan et al., 2013: Luo et al., 2013: Zhou et al., 2013)..

6.3. Assessment of Facial Expression Recognition Accuracy rate the better than of other Methods [41] have 1.52% with an accuracy of 97.74 and 96.02%. The facial expression recognition system following on Figure 9.

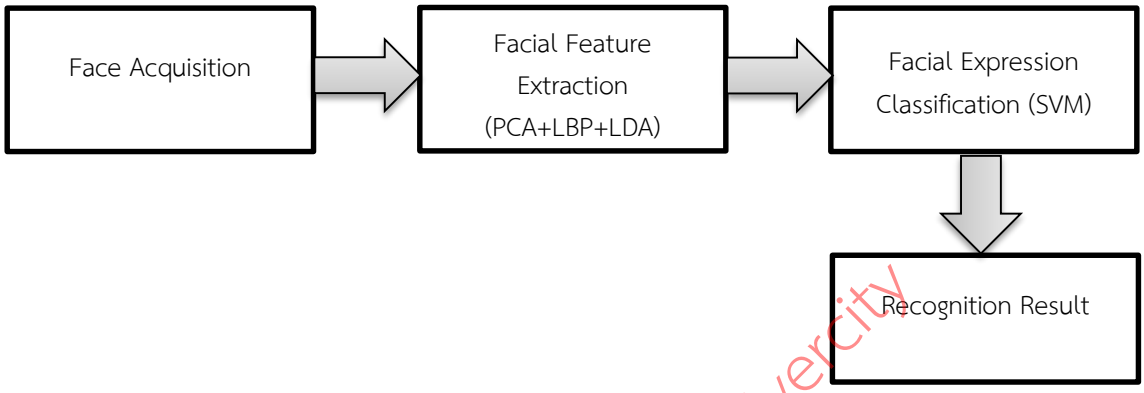

Figure.9 The facial expression recognition system

7. Contribution

In this paper, many different perspectives on FER of feature extraction methods that have been discussed and proposed during the last three Methods. As a result, it is very difficult to have a feature extraction view of the field and to select an appropriate method to solve a specific problem in expression image analysis. In order to solve this problem, this paper proposes a novel taxonomy of FER of hybrid feature extraction approaches used in facial expression image. The paper extensively and comprehensively investigate works proposed in the literature and systematically classify them based on methods of computational processing and recognition rate. This work will help to enhance an understanding of various principles of study the feature extraction method in facial expression recognition.

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