Feature Extraction of Human Facial Expressions Using Haar Wavelet and Karhunen-Loève Transforms

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ABSTRACT
One of the challenging and active research topics in the recent years is Facial Expression. This paper presents the method to extract the features from the facial expressions from still images. Feature extraction is very important for classification and recognition process. This paper involve three stages which contain capture the images, pre-processing and feature extractions. This method is very efficient in feature extraction by applying haar wavelet and KL-T. Cohn-kanade used six expressions of anger, sadness fear, happiness, disgust and surprise. Features that have been extracted from the image of facial expressions were used as inputs to the neural network.

Keywords: Facial expressions, Haar wavelet, K-L transform, features extraction

1. Introduction
Facial expression known to be the best way to identify the person and his reaction in different situation. Facial expression is useful in knowing the conceded emotions which are used in verify wither if the information provided is true or not. Today it is used in combat passport fraud, supporting legal enforcement, in identifying missing children and reducing identity fraud. Also it's also used in the diagnosis of psychopathological stress level data and so on. Facial expressions are the facial changes in response to a person’s internal emotional states, intentions, or social communications. In 1971, Ekman and Frisen discovered six different facial expressions include happiness, sadness, fear, disgust, surprise and anger along with neutral face (Tanvi Sheikh, Shikh Agrawal, 2012). Facial expression analysis refers to computer systems that attempt to automatically analyze and recognize facial motions and facial feature changes from visual information. The analysis of facial expression is conceded as a challenging task as it is
similar to so many factors that's make similar expressions looks completely aging, ethnicity, gender makes have a major effect on classification results, but even when the person is the same (Chulhee Lee, David Landgrebe, 2009). The aim of this research is extract the feature from facial expressions images using Haar wavelet and KL-t hat can be embedded within classifiers.

This paper is organized as follows. The previous related works are discussed in presented in section 2. In section 3, the analysis of the facial expression has been presented. The process of features extraction is described in section 4. Section 5 explains the details process of the proposed approach. Lastly, the conclusion of the paper has been reported in section 6.

2. Literature Review

Many researchers have been studies the subject of extraction facial features and using different techniques to extract the features from facial images. This section reports the previous work related to facial feature extraction proposed in the literature. The work in (Sidra Batool Kazmi, Qurat-ul-Ain, M. Arfan Jaffar, 2009) introduces a method for automatic facial expression recognition. The process of feature extraction starts by performing three level 2-D discrete wavelet. The resultant reduced feature set database, containing feature set of each image, is then used for classification. The JAFFE database for testing and images belonging to five classes (neutral, happy, sad, angry and surprise) have been considered. The testing is performed 100 times and the result is promising.

The work in (Iman Makaremi and Majid Ahmadi, 2009) proposed a human face recognition technique that extracts the feature based on wavelet coefficient. Haar wavelet used for extract the features. The wavelet coefficients have been normalized between 0 and 1 for representation. Database includes 400 different pictures of 40 individuals. And the features represent input to the Hidden Markov Model (HMM).

Furthermore, the work presented in (Ongalo P. N. Fedha, et al., 2012) introduced a novel face expression recognition scheme based on Haar discrete wavelet transform and a neural network classifier. The proposed Experiments for evaluation were carried out on JAFEE database presenting the six facial expressions, 'angry', 'disgusting', 'fear', 'happy', 'sad', 'surprise' and the results that the proposed method can perform at 81% accuracy.

Joyeeta Singha, Karen Das, (2013) presents a method contain recognizing different hand gestures, the features of hand were extracted using K-L Transform technique and finally the input gesture was recognized using proper classifier. In this system, the tested for 10 different hand gestures and recognizing rate obtained was 96%.

The work in (S. Adebayo Daramola Tiwalade Odu, Olujimi Ajayi, 2014) proposes a method involves decomposition of captured face image into four sub-bands using Haar wavelet transform thereafter shape and texture features are extracted from approximation and detailed bands respectively. Test results prove that the method is robust enough to reduce the effect of varying face pose for effective face recognition.

Lastly, (Jyoti Chopra, Mandeep Singh, 2014) introduced combined approach of Haar Wavelet transform and 1D Correlation coefficient for face recognition. Viola-Jones algorithm was a
method for detect the face from background. ORL database was used in this paper, and used 390 images stored database for proceeding. System is more accurate to recognize the face at different poses and speedy.

3. Analysis of The Facial Expression

Expression refers to the changes of a person as seen on his or her face; expression usually refers to the change of a visual pattern over time (Suja , Shikha Tripathi and Keerthana, 2013). It is one of the most satisfactory biometrics, and it has also been the most widespread method of recognition that human uses in their visual interactions (Muhammad Hameed Siddiqi and Sungyoung Lee, 2013). Basic facial expressions which are typically recognized by psychologists are: happiness, sadness, fear, anger, disgust and depicted in Figure 1. In terms of the natural interfaces between humans and computers, facial expressions open up an opportunity to communicate basic information regarding various needs and demands to the machine. The Facial Action Coding System (FACS) the brainchild of Ekman and Friesen in 1978 is recognized as the most comprehensive standard for describing facial expressions ((Muhammad Hameed Siddiqi and Sungyoung Lee, 2013).

![Figure 1: Samples of simple facial expressions images](image1.png)

4. Feature Extraction

Feature extraction means getting the distinguishable features from each facial expression shape [10]. The feature extraction is used to reduce the dimension of the face space by transforming it into feature representation (Sangeeta Narsing Kakarwal, 2012). Wavelet domain is shown to provide a good match to the space-frequency characteristics of natural images. Its good localized time/frequency characteristics (Miryala Chandra Mohan, 2010).

The Haar wavelet applies a pair of low-pass and high-pass filters to image decomposition first in image columns and then in image rows independently are demonstrated in Figure 2. As a result, it produces four sub-bands as the output of the first level Haar wavelet (Sangeeta Narsing Kakarwal, 2012). The haar wavelet separates an image into a lower resolution approximation image (LL) as well as horizontal (HL), vertical (LH) and diagonal (HH) detail components.
The process can then be repeated to compute multiple scale wavelet decomposition, as in the three scales DWT (Miryala Chandra Mohan, 2010).

\[
\Psi(t) = \begin{cases} 
1 & 0 \leq t < 0.5 \\
-1 & 0.5 \leq t < 1 \\
0 & \text{else}
\end{cases} \quad (1)
\]

\[
\Psi m, nn(t) = 2^{-m} \Psi(2^{-m} t - n) \quad (2)
\]

\[
T = HFH \quad \text{.... (...}(3)
\]

Where \( F \) is an \( N\times N \) image matrix, \( H \) is an \( N\times N \) transformation matrix, and \( T \) is the resulting \( N\times N \) transform. Then the Haar basis functions are:

\[
h_0(z) = h_{00}(z) = \frac{1}{\sqrt{N}} \cdot Z \in [0,1] \quad \text{.... (4)}
\]

For the Haar transform, transformation matrix \( H \) contains the Haar basis functions, \( h_k(z) \). They are defined over the continuous, closed interval \( z \in [0, 1] \) for \( k=0,1,2,3,\ldots,N-1 \), where \( N=2n \). To generate \( H \), we define the integer \( k \) such that \( k=2p+q-1 \), where \( 0 \leq p \leq n-1 \), \( q=0 \) or \( 1 \) for \( p=0 \), and \( 1 \leq q \leq 2p \) for \( p \neq 0 \).

The Karhunen-Loève transform (KLT) is defined as the linear transformation (Dony, R.D., 2001), the Eigenvectors obtained using K-L Transform, KL-T is a powerful tool for analyzing data and by reducing the number of dimensions (Suja, Shikha Tripathi and Keerthana, 2013). KL-Transforms minimize the total mean squared error (Adebayo Daramola Tiwalade Odu & Olujimi Ajayi, 2014). The Karhunen–Loève theorem is random variables and the expansion basis depends on the process (Dony, R.D., 2001).

\[
x = [ x_1, x_2 \ldots x_n ]^T \quad \text{.... (5)}
\]

\[
[C]X = E[(X - M)(X - M)^T] \quad \text{.... (6)}
\]

\[
Y = [W]^T X \quad \text{.... (7)}
\]
Were \([C]\) represent covariance matrix, \(W=\) linear transformation matrix \(Xi\) which are the inputs of the matrix. Each column vector, \(wi\), of \([W]\) is a basis vector of the new space so the output \(Y\) can calculate as:
\[
Y = W_i^TX \quad \ldots \ldots (8)
\]

5. **The Proposed Approach**

There are many steps need to be performed in order to extract the features based on Haar wavelet transform which is orthogonal wavelet transform and KL-Transform. The details steps of the proposed approach are explain as follow:

5.1 **Steps of proposed approach**

1. Read the images from database.
2. Implement the sharp image using unsharpen mask with the radius 10 and the amount is 1.
3. Crop the region of interest from the images using cascade object detector and Resize the images to (300,300).
4. Implement median filter on the crop images.
5. Implement the discreet wavelet which separates the image to four part LL, LH, HL, and HH.
6. Implement the Karhunen-Loève transform (KLT) to fined highest eigenvector.
7. Chose the higher eigenvector in column (151).
8. Sort to the eigenvector ascending. Take the higher 50 value which represent the features that input to the neural network. The proposed approach is illustrated in Figure 3 which is containing the details process flow of facial feature extraction process.

9. Database captures stages: cohn-kanade database for facial expressions used in implement system, it consist of 420 images which contain 10 person and 7 expressions and for each expression 6 images.

10. Pre-processing stage: this stage contains the process that enhances the pictures, detect the face and implement the median filter; Usefulness of the median filter is to improve the image and noise removal. After the procedure is adjusted to the image size (300 ×300) this process illustrate as in Figure 4.
Figure 3: The details process flow diagram of the proposed approach

Feature extraction stage: Haar Wavelet transform has been used to extract features of the reasons for that special type of transform that convert the frequency domain to the spatial domain. The sub band LH represents the alterations in the image along horizontal directions. In Figure 5 demonstrates the image after the Per-processing into four parts and applied to work on (LH) (Prachi Agarwal & Naveen Prakash, 2013).
Through the use of haar wavelet transform to extract the features were extracted 50, used algorithm KL-T, which represents the principle components of the image, which represent each image Eigen Value has Eigen Vector, and then choose the column that value of 151 which is the highest value. This method was a method to improve the process of extract of features. KL-T is based on the grounds that it establishes a new coordinate system whose origin will be at the center of the object and the axis of the new coordinate system will be parallel to the directions of the Eigen vectors. The result of use KL-T illustrate in Figure 6.
One of the advantage of K-L transform is it can reduce the closely data. Table 1 presents features for facial expressions images for one person for six expressions. It can be illustrated by the top 50 highest values that represent the green color through Figure 7.

Table 1: Samples of features points of facial expressions for one person

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Figure 7: The top 50 highest values represent green color
6. Conclusion

In this paper a facial feature extraction method has been proposed. The proposed method used hybrid approach by implementing the haar wavelet transform to extract 50 point center in the facial expressions images, and The Karhunen–Loève (KL-T) where it was obtain the best features of a data set of images by selecting the 50 highest point and then determine eigenvector and arranged in ascending order and choose the best features. Cohn–Kanade database used in this research. This method improved the process of choosing features and thus improved the process of classifying expressions the face.

REFERENCES