A Survey on Facial Expression Recognition using DIP Techniques

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Abstract: Facial expression is that the handiest variety of non-verbal communication and it provides a clue concerning emotion, attitude and intention. Automatic recognition of facial expressions will be a crucial element of natural human-machine interfaces; it's going to even be utilized in activity science and in clinical observe, police work and security etc. though humans acknowledge facial expressions just about with no effort or delay, reliable expression recognition by machine remains a challenge. This paper presents a survey of facial features recognition, its hurdles in face recognition, and comparative analysis numerous facial features recognition approaches.

Keywords: PCA, LDA, DCT, SVM, HMM, Adaboost.

Introduction

Facial expression recognition in videos is a full of life topic within the field of image process, pc vision and bioscience over a few years. Analysis by A.Mehrabian[18] shows that 7% of human communication done by language, 38% by voice and 55% through expression of face.

Videos contain more abundant information than a single image so video contain spatio-temporal information. To improve the accuracy of facial expression recognition in video, information from multiple frames can be fused along with temporal information and multi poses of faces in videos make it possible to explore shape information of face and can be combined into the framework of facial expression recognition. The video-based facial expression recognition has many advantages over the image-based recognition. First, the temporal information of faces can be utilized to facilitate the recognition task. Secondly, more effective representations, such as a 3D face model or super-resolution images, can be obtained from the video sequence and used to improve recognition results. Finally, video-based recognition allows learning or updating the subject model over time to improve expression recognition results for future frames. So video based facial expression recognition is also a very challenging problem, which suffers from following nuisance factors such as low quality facial images, scale variations, illumination changes, pose variations, Motion blur, and occlusions and so on.

Literature Survey

A summary of some facial expression recognition systems from 2007 to till date is discussed below:Ming Liu, Rui Songa Yafang Wang, Zhigang Xu . et al. [1], proposes an algorithm based on the combination of gray pixel value and Local Binary Patterns (LBP) features. to classify the facial expressions. The gray values and the LBP features are all extracted from the actives patches i.e face regions that undergo major changes during different expressions and applied Softmax regression classifier and gained an average recognition rate of 96.3%. NeeruRathee, Ashutosh Vaish and Sagar Gupta. et al. [2] ,proposed system named as Adaptive System For Recognizing State Of Mind (ASFRSOM) for real time emotion detection , using LBP for feature extraction and extracted features are applied to Support Vector machine for emotion recognition. This approach resulted in 79% accuracy when evaluated on extended Cohn Kanade database. Wang, Xun; Liu, Xingang; Lu, Lingyun; Shen, Zhixin et al. [4], have proposed a new FER system, which uses the active shape mode (ASM) algorithm to align the faces, then extracts local binary patterns (LBP) features and uses support vector machine (SVM) classifier to predict the facial emotion. Kumar, V.; Basha, A.S.A.et al. [5] have presented a new approach to facial expression recognition, which uses Wavelet for reducing the high dimensional data of facial expression images into a relatively low dimension data andthen uses K nearest neighbour(KNN) as the classifier for the expression classification afterwards. Urvashi Bakshi, Rohit Singhal [6], have introduced a new technique to recognize human face artificially using DCT, PCA and SOM neural network. Principal component analysis (PCA) is a classical and successful method of dimension reduction. Discrete Cosine Transform (DCT) is a well known compression technique and Self Organize Map (SOM) act as a classifier and has been used for face space representation. Myunghoon Suk; Prabhakaran, B. et al. [7] have developed system uses a set of Support Vector Machines(SVMs) for classifying 6 basic emotions and neutral expression along with checking mouth status. The facial expression features for emotion recognition were extracted by Active Shape Model (ASM) fitting landmarks on a face and then dynamic featureswere generated by the displacement between neutral and expression features. Ameen, R.; Oztoprak, H.; Yurtkan, K. et al. [8] have developed a method for the facial expression recognition based on Local Binary Patterns (LBP) extracted from the texture information. The LBP operator and its extensions were applied to different color models which are gray-scale, RGB, oRGB, YCbCr and HSV. Frontal face images among six basic facial expressions which are anger, disgust, fear, happiness, sadness and surprise were considered. Support Vector Machine (SVM) was employed as the classifier.

Abdulrahman, M.; Gwadabe, T.R.; Abdu, F.J.; Eleyan, A. et al. [9] proposed a facial expression recognition approach based on Gabor wavelet transform. Gabor wavelet filter is first used as pre-processing stage for extraction of the feature vector representation. Dimensionality of the feature vector is reduced using Principal Component Analysis (PCA) and Local binary pattern (LBP) algorithms. K-Nearest Neighbour with Euclidean distance (L2) used as the classifier.

Mu-Chun Su, Chun-Kai Yang, Shih-Chieh Lin, De-Yuan Huang, Yi-Zeng Hsieh, and Pa-Chun Wang et al. [10], have presented an automatic facial expression recognition system based on self-organizing feature maps. First of all, Viola and Jones was used to detect a face from an image. After a human face is detected, a composite method was proposed to locate pupils so that the located face image can be rotated, trimmed, and facial features, and propose the use of SOMs. Finally, a multi-layer perceptron (MLP) was adopted for the classification of the seven expressions including six basic facial expressions. Reza Azmi, Samira Yegane .et al. [11] proposed LGBP features for facial expression recognition in occluded images. LGBP were initially used for face recognition. Using LGBP features the average accuracy 96.25% on non-occluded images, 88.77% on eyes occluded images, 92.78% on mouth occluded images, 89.18% on lower face occluded images and 90.17% on upper face occluded images was obtained. RuicongZhi& Markus Flierl 2011 [12] uses nearest neighbor classifier. It uses parts-based representations of facial images and accuracy lies between 88.8% to 93.3%. SaeidFazli 2009 [13] uses Gabor Filter Bank (PCA & LDA used for Feature reduction) for feature extraction and Probabilistic Neural Network (PNN) for classification. the common performance is concerning eighty nine. PNN classifier has the shortest coaching time compared to alternative neural networks. Kotsia et al., 2008 [14] uses 3 approaches: Gabor features, DNMF algorithm and Geometric displacement vectors extracted using Candide tracker for feature extraction, and uses multiclass SVM and MLP for classification. It Recognizes expressions in presence of occlusions. Discusses the effect of occlusion on the 6 prototypic facial expressions. Kotsia and Pitas [15], use Geometric displacement of Candide nodes for feature extraction and Multiclass SVM for expression recognition, It uses six category SVM, one for every expression. it's terribly high recognition rates nearly 97% .

Challenges In Facial Expression Recognition

Low video quality

Fig 1. shows depicts that video acquisition outdoors results in low image quality as the face picture area is tiny and this solely makes the recognition task tougher, however conjointly have an effect on the accuracy of face segmentation, as well as the accurate detection of the fiducial points/landmarks that are often needed in recognition methods.

Fig.1 Facial Expression Recognition in low resolution image

Pose variation

The images of a face in Fig.2 vary due to the relative camera-face pose (frontal, 45 degree, profile, upside down), and some facial features such as an eye or the nose may become partially or wholly occluded.

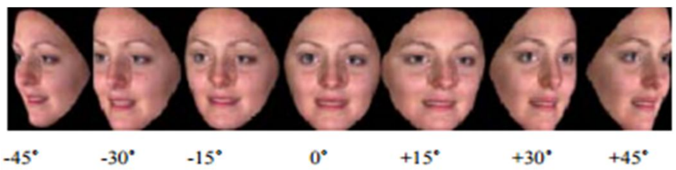

Fig.2 Facial Expression Recognition in various pose

Occlusion

Faces may be partially occluded by different objects as shown in Fig.3. In an picture with a bunch of individuals, some faces could partly cover other faces. Some components of face may additionally be missing due to glasses, scarf or mustaches.

Fig. 3 Facial Expression Recognition in occluded face.

Illumination

Same face appears differently due to change in lighting as in Fig.4. Illumination can change the appearance of an object drastically. Facial expression recognition must overcome irregular lighting.

Fig.4 Facial Expression Recognition in varying illumination

Facial Expression Recognition Methodology

Face expression recognition techniques have continually been a really difficult task. A typical video-based face recognition system mechanically detects face regions, extracts Features from the video frames, and classifies facial expression as shown in Fig. 5.

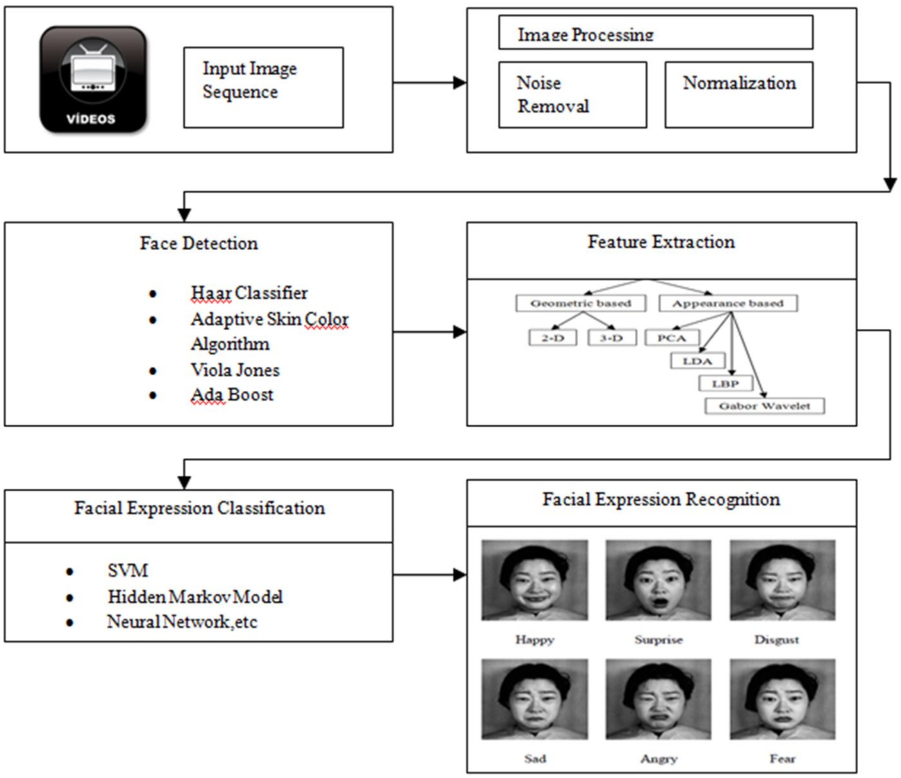

Fig. 5. Facial Expression Recognition Methodology

The preliminary step in facial expression recognition is face detection. Various methods for face detection in image are Knowledge based, Feature invariant, Template matching and Appearance based. Once the face is detected, features can be extracted using various techniques like Discrete Cosine transform, Gabor filter, Principle Component analysis, Independent Component analysis and Linear Discriminant analysis. Then various classification methods can be used to classify the expression such as Hidden Markov model, Neural Network, Support vector machine, Ada Boost and Sparse representation.

Face Detection

Face detection stage involves segmenting image into one that contains face and other that contain non face region. It can be achieved by Haar classifiers, Adaboost and contour points and adaptive skin color algorithms.Harr classifiers are accurate for face detection as Haar features can be scaled by increasing or decreasing the size of pixel group being examined, enabling detection of objects of varying sizes. Hence Haar classifiers are highly accurate, fast and less complex. Adaboost is cascade of classifiers whereby each classifier works on the output generated by previous classifier leading to detection accuracy. It does not require any computational cost for detecting face as new face is compared with the model built by the classifier. Adaptive skin-color models detects face based on skin color model. This method is highly accurate as it uses skin color to distinguish between face and non-face regions. This algorithm is highly complex and does not work well in the presence of illumination, thus not suitable for real time application.

Feature Extraction

Facial Expression are often classified into Geometric features and Appearance features. Geometry based approaches track the facial geometry information based on a set of facial landmark points (such as eyes, eyebrows, mouth, nose etc) over time and classify expressions based on their deformation. On the other hand, appearance-based approaches use information from the facial texture described by various types of texture descriptors, such as LBP, Gabor wavelets, and LPQ.

- **Gabor Filter for feature extraction**

  Gabor filters have been successfully applied to FER. Gabor filters are group of wavelets with each wavelet extracting features from the facial image aligned at certain angle and frequency. The most important parameters of a Gabor filter are its orientation and frequency. Certain features that share similar orientation or frequency can be selected and used to differentiate between different facial expressions depicted in images. A Gabor filter is a function obtained by modulating the amplitude of a sinusoid with a Gaussian function [11]. To extract Gabor features, the images are convolved with the two dimensional Gabor filters as follows:

$$G_{\omega,\theta}(x,y) = I(x,y) * \psi_{w,\theta}(x,y) \quad (1)$$

$$\psi_{\omega\theta}(x,y) = \frac{1}{2\pi\sigma_x\sigma_y} exp\left[-\frac{1}{2}\left(\frac{x'^2}{\sigma_x{}^2} + \frac{y'^2}{\sigma_y{}^2}\right)\right] exp\,[j\omega x'] \quad (2)$$

$$x' = x\,cos\theta + y\,sin\theta \quad (3)$$

$$y' = -x\,sin\theta + y\,cos\theta \quad (4)$$

  where (x, y) is the pixel position in the spatial domain, ω the radial centre frequency, θ the orientation of Gabor filters, and σ the standard deviation of the Gaussian function along the x- and y- axes. In most cases a Gabor filter bank with five frequencies and eight orientations is used to extract the Gabor features for face representation. These Gabor kernels form a bank of 40 different filters. Gabor feature algorithm has high accuracy due to high discriminative power but is not suitable in real-time due to high computational complexity and memory requirement.

- **Local binary pattern for feature extraction**

  Local binary pattern is a nonparametric descriptor, which efficiently summarizes the local structures of images. The original LBP operator was introduced by Ojala [16] for texture description. The operator labels the pixels of an image with decimal numbers. First the values of each pixel around the centre pixel are thresholded with the centre pixel value. A binary number is extracted and a decimal value is calculated. An example of the basic LBP operator is shown in Fig.6.

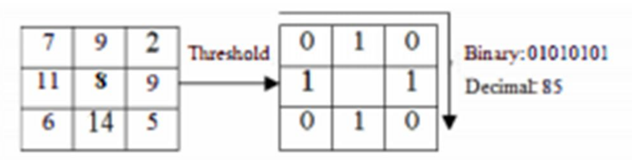

Fig 6 : Illustration of LBP operator

Given a pixel at (Xc, Yc), the resulting LBP [11] can be expressed in decimal form as follows:

$$LBP(x_c, y_c) = \sum_{p=0}^{p-1} s(i_p - i_c)2^P \quad (5)$$

Where ic and ip are, respectively, gray-level values of the central pixel and P surrounding pixels in the neighborhood, and function s(x) is defined as:

$$s(x) = \begin{cases} 1, & if\ x \geq 0 \\ 0, & if\ x < 0 \end{cases} \quad (6)$$

In LBP algorithm, histogram of different block sizes of a face image is used as feature vectors. A histogram of the labelled image f/(x, y) can be defined as:

$$H_i = \sum_{x,y} I(f_i(x,y) = i), \quad i = 0, \ldots, n-1 \quad (7)$$

in which n is the number of different labels produced by the LBP operator and

$$I(A) = \begin{cases} 1, & A\ is\ true \\ 0, & A\ is\ false \end{cases} \quad (8)$$

These features are calculated at multiple levels. Considering shape information of faces, face images are divided into small regions R1,R2, ... ,Rm-1 and a spatially enhanced feature histogram defined as:

$$H_{i,j} = \sum_{x,y} I(f_l(x,y) = i)\, I\left((x,y) \in R_j\right) \quad (9)$$

where i = 0, ... , n - 1 , j = 0, ... , m - 1. Figure. 7 illustrates this process

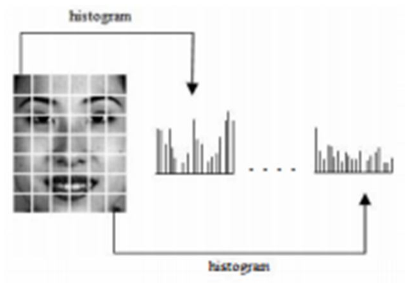

Fig7: A facial image is divided into 42 small regions from which LBP histograms are extracted and concatenated into a single histogram

Finally, the histograms are concatenated to form global features. Its recognition accuracy is very high and computationally simple, but it is difficult to implement in real-time due to time complexity.

DCT is found to be the powerful transformation for feature extraction due to its data compaction property. Discrete Cosine Transform (DCT) is a frequency domain transform that describes the image as coefficients of different frequencies of cosines. Discrete cosine transform is defined as

$$F(i,j) = \alpha(i)\alpha(j) \sum_{x=0}^{A-1} \sum_{y=0}^{B-1} f(x,y) \cos\left[\frac{\pi(2x+1)i}{2A}\right] \cos\left[\frac{\pi(2y+1)j}{2B}\right], \quad (10)$$

Where i=0,1,2... A=1 and j = 0,1,2,...B=1Here,

$\alpha(i) = \sqrt{(1/A)}$ for u,v = 0 and

$\alpha(j) = \sqrt{(2/B)}$ for u,v ≠ 0

The DCT of an image comprises of three frequency components; low, middle, and high. Each component represents some information and detail about the image. Low frequency component usually describes the average intensity of an image, which is highly desired in facial expression recognition systems [5]. Moreover in frequency domain, lower frequencies present high magnitudes and higher frequencies relatively indicate smaller magnitudes. Thus, the higher frequency components could be ignored without damaging the original image. DCT performs energy compaction. The low frequency generally contains the average intensity of an image which is the most intended in FR systems.

For appearance based methods features are extracted then data redundancy is reduced by applying some dimensionality reduction methods like PCA, LDA. The principal component analysis (PCA) is applied to the extracted feature vectors. occluded image patches. The feature vectors from the non-occluded patches are denoted as X^c. The data set S can be then written as: S = { X^c_1, X^c_2,.....X^c_M} , where M is the size of the training dataset. The mean vector X of feature vectors in S is computed as:

$$\bar{X} = \frac{1}{M}\sum_{m=1}^{M} X_m \quad (11)$$

The covariance matrix C can be written as:

$$C = \frac{1}{M}\sum_{n=1}^{M} \Phi_n \Phi_n^T = AA^T \qquad (12)$$

where. $\Phi_i = X_i - \bar{X}$, $A = [\Phi_1, \Phi_2, \dots, \Phi_M]$

- **Local Gabor Binary Pattern Feature extraction**
  LGBP is a combination of both Gabor filter and LBP. First step in LGBP feature extraction [11] is to convolve images with using Gabor filters, which generates Gabor map pictures (GMP). Then each GMP is converted into LGBP maps which is a collection of non- overlapping rectangular region for which individual histograms are computed for each region. Lastly histograms of all LGBP maps are concatenated to form final feature vector as shown in Fig.8.

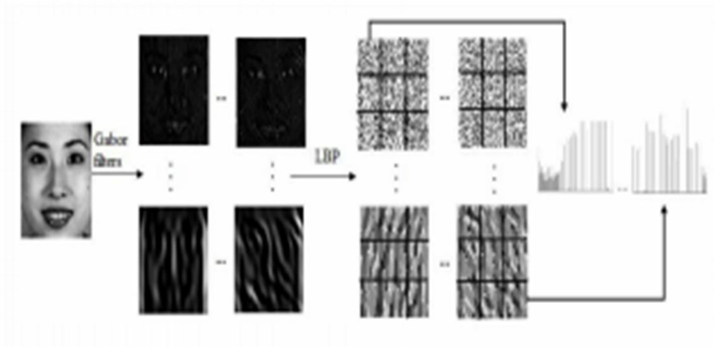

Fig.8: Feature extraction using LGBP

Appearance-based algorithms have high discriminative power but are less suitable for real-time applications, as the computational complexity and memory requirement of the algorithms are high. Geometric-based algorithms are more suitable in real-time environment as features can be tracked easily. Overall accuracy of FER using LBP, GABOR, LGBP features for various expressions is given in Table 1 below:

Table 1. Comparison of feature extraction techniques

Expression	**LBP**	**GABOR Filters**	**LGBP**
Anger	92%	98.33%	99.67%
Sadness	89.42%	80.08%	95.83%
Disgust	92.17%	95.17%	94.83%
Happy	95.92%	79.92%	95.58%
Surprise	89%	99%	96.33%
Fear	97.67%	91%	93%
Neutral	98.33%	98.67%	99%

Feature Classification

Hidden markov model (HMM) , Hidden semi-markov model(HSMM), Support vector machine(SVM), two nearest neighbor , random forest, decision tree are several classification algorithms used for expression classification.

- **Hidden Markov Model**
  HMM classify the higher level emotions like interested, unsure, disagreeing, encouraging and discouraging. Hidden markov expert rule (HMER) is used for segmentation and recognition of emotions in a set of video frames. A classification framework is used for every incoming frame wherein expression recognizer identifies head and actions to construct dynamic display. Then HMER topology is constructed for every emotional state.With HMM classifier, recognition accuracy is good and expressions such as ‘neutral’ and ‘disgust’ cannot be distinguished well.

- **K-Nearest Neighbor**

  KNN classifier is best suited due to its lesser execution time and better accuracy than other commonly used methods. KNN uses Euclidean distance metric to determine the closeness between the data points. The Euclidean distance is given by $d(x, y) = \sqrt{(x_1 - y_1)^2 \ldots\ldots\ldots.(x_n - y_n}$ (13)

  In The k-nearest neighbor algorithm, an object is classified by a majority vote of its neighbors, with the object being assigned to the class most common amongst its k nearest neighbors. K-NN Algorithm is the most simplest machine learning algorithm: Each data pixel value within the data set has a class label in the set, Class = {c1,...,cn}. The data points', k-closest neighbors (k being the number of neighbors) are then found by analyzing the distance matrix. The k-closest data points are then analyzed to determine which class label is the most common among the set. The most common class label is then assigned to the data point being analyzed.

- **Support Vector Machine**

  Support vector machines are also used as classifiers where each video frame is first scanned to detect frontal face view, then the faces are scaled into equal size image patches with bank of Gabor energy filters. Recognition classifier takes filtered images as input and codes expression into different dimensions. The facial feature is selected from Gabor filters using AdaBoost and is again trained with SVM. Then fully automated action coding is applied to obtain an accuracy rate of 93%.Support vector machines are highly suitable for real-time expression classification as they are highly accurate whereas HSMM delivers good results in partially occluded faces.

  In Ad boost classification, the frontal face in image sequence is classified into various emotion states, which considers displacement of land mark features in face, hence accuracy rate is 90%.

Issues with Existing FER Systems

Several existing expression recognition systems have their own pro and cons. The reliable countenance recognition system should rigorously choose a feature extraction methodology because it has major impact on expression classification as facial expressions are extremely unsure. Generally a face could offer mixed expression, in such situations the system should be ready to notice and classify mixed expressions.

Facial expression analysis system should additionally work well on live, spontaneous pictures from video stream to acknowledge and classify expression in variable angle, head create and occlusion because it isn't expected to urge front face image in real time applications. Thus, real time systems should not be restricted to frontal read. Reliable FER system should take less time interval to provide desired output just in case of real time issues. FER system should even be knowledge freelance, i.e. Expression classifier should work well even once pictures taken for testing are totally different from pictures used for coaching, and that successively could be a difficult task.

Current real-time FER systems are designed to recognize six basic expressions such as anger, disgust, fear, happy, sad and surprise, which can be extended to recognize other human facial gestures such as drowsiness, nodding, yawning etc.

Current datasets developed for training the FER systems are static; meaning they capture the emotions as a set of image sequences (video), which are pre-processed. They assume that the base frame is the first frame of the video. Moreover, they have afixed set of frames, having same video sizes. This leads to an expression being well-distributed over the length of the video, having the peak (maximum intensity) expression somewhere in the middle of the video. In actual real-time environment, the identification of the base from itself is a task. Moreover, having distinct spread of an expression over the distinct number of frames is also possible in real-time. To address these issues not only the available datasets are insufficient but also new techniques have to be evolved to address these problems of baseline frame detection and varied length of expressions.

Demand for Automatic Facial Expression Recognition

Facial expression recognition is meant to be employed in varied applications within the future that function as motivation for us to try and do analysis in those totally different areas such as image understanding, psychological studies, nervous facials grading in medication, face animations, artificial intelligence and video games. Facial expression recognition can be much useful and important in designing new interactive devices that may lead to develop new dimensions to interact with computer systems.

Conclusion

Facial expression recognition system is difficult because of varied imaging conditions. This paper has concisely overviewed face expression recognition methodology and process techniques The limitation of current systems is that it detects expressions from faces wanting upright at camera or frontal face read. More exploration are often undertaken within the following aspect :to acknowledge expression in low resolution pictures ,recognition of delicate and small expression, work the impact of occlusion as a parameter for world application, the notion of head movement can even be thought-about. Increasing demand for face expression recognition system in applications has to enhance the accuracy rate of predicting expressions.

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