An Overview on Facial Expression Perception Mechanisms

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Abstract

A lot of information can be perceived through human expressions. We cannot learn the languages of entire world; rather we can interpret most of the expressions of a person in the universe. A facial expression provides information about the condition of user's conduct in different situations and places. Facial expression can be computerized through various human-computer interface and programming methodologies. The facial expression perception includes detection of face, extraction of features and finally determination of the type of the expression. In this work, we have taken an overview of the numerous facial expression perception mechanisms available in the literature.

Keywords - *Face perception system, face detection, expression classification.*

I. INTRODUCTION

The expression of face is a non-verbal communication technique which is used to perceive the mood and psychological state of a person at any instance of time. The state can be happiness, anguish, irritated, neutral, depressed, fearful and repulsive. In the era of computerization, facial expression can be perceived automatically and henceforth it has become a motivating and inspiring research area in computer vision. There are a lot of application areas of facial expressions like identification of mental situation [1], security[2], automatic psychotherapy, fusion of face expression, lie detection, computerized training systems [3], human fatigue revealing [4] and many more applications. Figure 1 shows complete process of feature extraction methodology. The popular techniques for face recognition are [5-6], Eigen based [7], fisher face based [8], Gabor filters[9], Linear Discriminant Analysis (LDA) [10], Local Directional Pattern [11], Local Gradient Code [12] and Local Binary Patterns [13] etc. Classification of expression is generally performed through Support Vector Machine (SVM) [14] and Nearest Neighbour [15] methods.

In a facial expression structure, face detection is performed for the detection of features such as eyes, eyebrows, nose and mouth. After detection feature extraction is performed through numerous approaches like geometric and appearance based methods. The geometric techniques work on the shape and dimension of the face and facial elements such as eyes, eyebrows, nose, lip appearance etc. The facial expressions are classified on the basis of comparative position of the facial components. In numerous real-world circumstances, it is challenging to attain positions of facial markers, and therefore very precise and trustworthy facial detection methods are needed. For different humans, the distance among facial markers is different and hence it causes the human autonomous expression detection system less trustworthy. To reduce the problem of appearance, related method can be employed which comprises a variety of filters like Wavelets, Gabor, and Local Binary Pattern (LBP) etc. These methods can be applied either on complete face or at some specified zone of the face and encrypt the texture of that part. Principal component analysis (PCA), independent component analysis (ICA), LDA etc. are some dimensionality diminution techniques which are used in looks. The classification of expressions is conducted in the learned subspace, i.e. divide the face into numerous modules and then extract the features. However, this process fails in the event of inappropriate face arrangement and obstructions. According to training data, features from specific face regions, regulate the facial areas which add better expression perception. The positions and sizes of the facial patches vary according to different methods and therefore it is hard to perceive a general configuration.

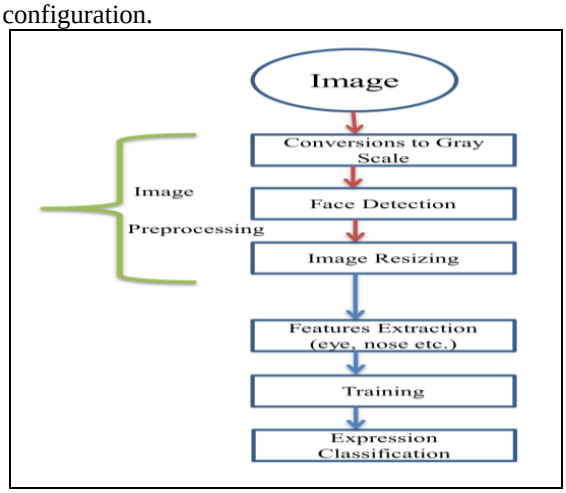

Fig 1: Feature extraction process

II. RELATED WORK

Authors in [16-17] have provided a survey on recognition of facial expressions. Authors in [18] have proposed a SVM, principal component analysis (PCA) and local binary pattern based procedure for facial expression perception. Authors in [19] have used SVM to mine information from silent patches. Authors in [20] have used SVM and artificial intelligence approaches to detect a facial expression.

Authors in [21] have used SVM classification for feature extraction in human relevant and non-relevant situations. Authors in [22] have tested the classification enactment on feature vectors constituted of facial marks convolved with Gabor and Log-Gabor filters, and through complete image pixel depiction of stationary facial images. PCA was employed over these facet vectors, and category precisions related by LDA. They have conducted numerous investigations on different databases and exhibit analogous operation among Gabor and Log-Gabor filters, by a classification precision of nearby 85%. They have conducted experiments on low-resolution pictures which don't require precise local facial points on all facial images.

Authors in [23] have provided a good concept for the perception of facial expression through a Convolution Neural Network (CNN). They have ensemble the frames of classifiers which are utilized to categorize the dissimilar emotions from the video sequence. They have used Gabor filters for the temporal features extraction such as eye and mouth. They have applied z-score normalization to produce the feature vector. Ultimately through the Gabor features, they have discovered the classification of universal emotions.

Authors in [24] have used Spatial Gabor energy filters (GE) to describe facial expressions in computer vision based applications such as facial identification and expression examination. The GE filters estimate the reaction of composite cells in prime visual cortex. Though, the neurons are modified by both the temporal as well as spatial characteristics of the pictorial symbol. Therefor it can be conclude that spatial-temporal Gabor filters can offer valuable depictions for mechanisms which include video series. The authors have investigated Gabor motion energy filters like a biologically stimulated illustration for lively facial expressions. Experimentations over the Cohn-Kanade expression data groups demonstrate that energy based global filter beats GE mainly in problematic small intensity expression perception.

III. FACE DETECTION METHODS

First of all a face or some facial components are being detected in a given scenario or image. The current part of the work discusses few popular face detection methods available in the literature.

A. Appearance based methods

Authors in [25], used Eigen-face linked process to numerous images which were captured across diverse lighting environments and settings.

B. Feature Based

These are known as local feature or geometric methods. Here facial expressions are categorized through facial features such as node, eye, eyebrow and lips etc. It has

(i) Model based method in which major facial features are detected like eye, mouth and nose. It improves the quality of face model.

(ii) Contour based method which covers not so significant expression from the face and built a base for facial expressions.

(iii) Optical flow based method which extracts information from moving pictures.

C. Knowledge Based

It works according to color and texture of the skin and perform mapping between window size and color signature to compute the distances [26].

D. Template Matching

Authors in [27] used statistical local features tools like LBP which are employed for general expression identification and here texture investigation is performed through SVM.

IV. FEATURE EXTRACTION METHODS

The features from a face are extracted by employing certain type of filters over the entire image taken as a single unit and. The Gabor filters indicates outstanding facial study enactment with superior computation rate in context of time and memory utilization.

A. Local binary pattern (LBP)

It was invented for texture analysis. It allocates a label to every pixel in the P-neighbourhood (in a given radius R, the P is an equally spaced pixel value) and taking a central vale g_c and converting these values into a decimal number by:

$$LBP_{P,R}(X_C,Y_C) = \sum_{p=0}^{p-1} S(g_p - g_c) \text{ where, } \quad s(x) = \begin{cases} 1, & x \geq 0 \\ 0, & otherwise \end{cases} \tag{1}$$

B. Local gradient code (LGC)

It is based on the association of the neighboring pixels rather than considering only central pixel value.

C. Local directional pattern (LDP)

It gives good performance in the presence of noise and illumination. It has two categories; Local Directional Pattern Variance (LDPV) which provides a mixture of contrast and texture, and LDN25 which encrypts the guiding info along with signal.

D. Histogram of gradient orientations (HOG)

It is an illumination invariant which is built by using magnitude/pixel alignment. The angular alignments are separated into fragments known as bins. Next, the picture is separated into cells. The magnitude is binned into equivalent bins provisional to angular part to which it fell. Next, the attained bin values are normalized to cope with contrast issue.

According to analysis available in the literature the LGC is best for feature extraction of emotions. The performance of LBP and HOG is same while the functioning of LDP is worst.

E. Principal Component Analysis (PCA)

It is based on the Eigen face technique [5]. It reduces the dimensions of an image through linear projection. Fig. 2 demonstrates a PCA based face detection method.

F. Independent Component Analysis (ICA)

It is more powerful than PCA.

G. Linear Discriminant Analysis (LDA)

It computes the discriminant vectors in two phases [21]. Initially the equal areas of a face image are clustered on the basis of identical geometric characteristics which are based on partitions. Within the partition area, the mean gray value is employed for pixel and therefore the face image is condensed as feature vectors. Next the discriminant prediction axes are focused on the LDA and determined through the feature vectors.

H. Gabor Filter

These are used to detect edge detection purpose. The facial images are pre-processed and then the estimated separately using dissimilar Gabor filters and different expressions are estimated through different Gabor filters.

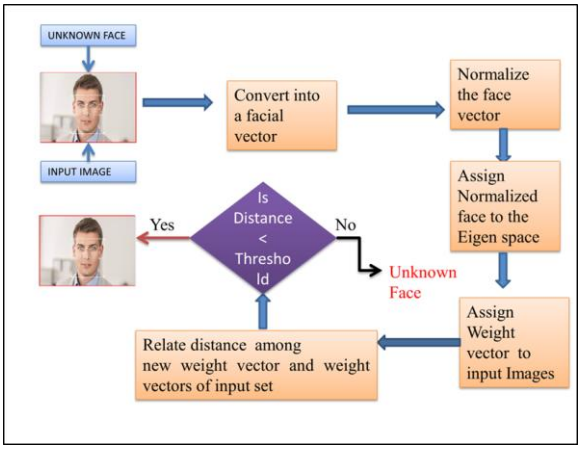

Fig 2: Principal Component Analysis Method

V. CLASSIFICATION OF FACIAL EXPRESSIONS

Face expressions are formed by making some changes in the features of the face like; anger is represented through lower eyebrow, tight lip and lid, (b) sadness is expressed as mixing of lower brow and depressed lip corners, (c) surprise is expressed as a combination of jaw drop and eye brow raiser, (d) fear is expressed as a combination of tight/stretch lips and eye brow raiser/lower, (e) disgust is expressed as a combination of lip depression and nose wrinkle. The classification can be performed through several methods such as

A. Support vector machine (SVM)

It is a highest boundary hyper plane classification procedure and it is based on statistical learning theory. It can perform well in case of inadequate training data. Figure 3 express the functioning of the SVM.

Table 1 provides an overview of the support vector machine based facial expression perception methods.

B. Gabor Filter

Gabor filters are band-pass filters that are employed in image handling for feature extraction, texture analysis, and stereo inequality estimation. The instinct reaction of this filter is produced through multiplication of a Gaussian envelope operator with a compound fluctuation. The basic functions lessen the space and time improbability product. It is imaginable to build filters that are careful about orientation through the extension of these functions to 2-D [7] . In case of specific settings, the stage of the reaction of Gabor filters is almost linear. This characteristic is used in stereo methods and it employs the phase-variance among left and right filter reactions to approximate the inequality in the stereo pictures. The processing of Gabor filter has been shown in Fig. 4. Table 2 represents an overview of the procedures which uses Gabor filter for facial expression extraction.

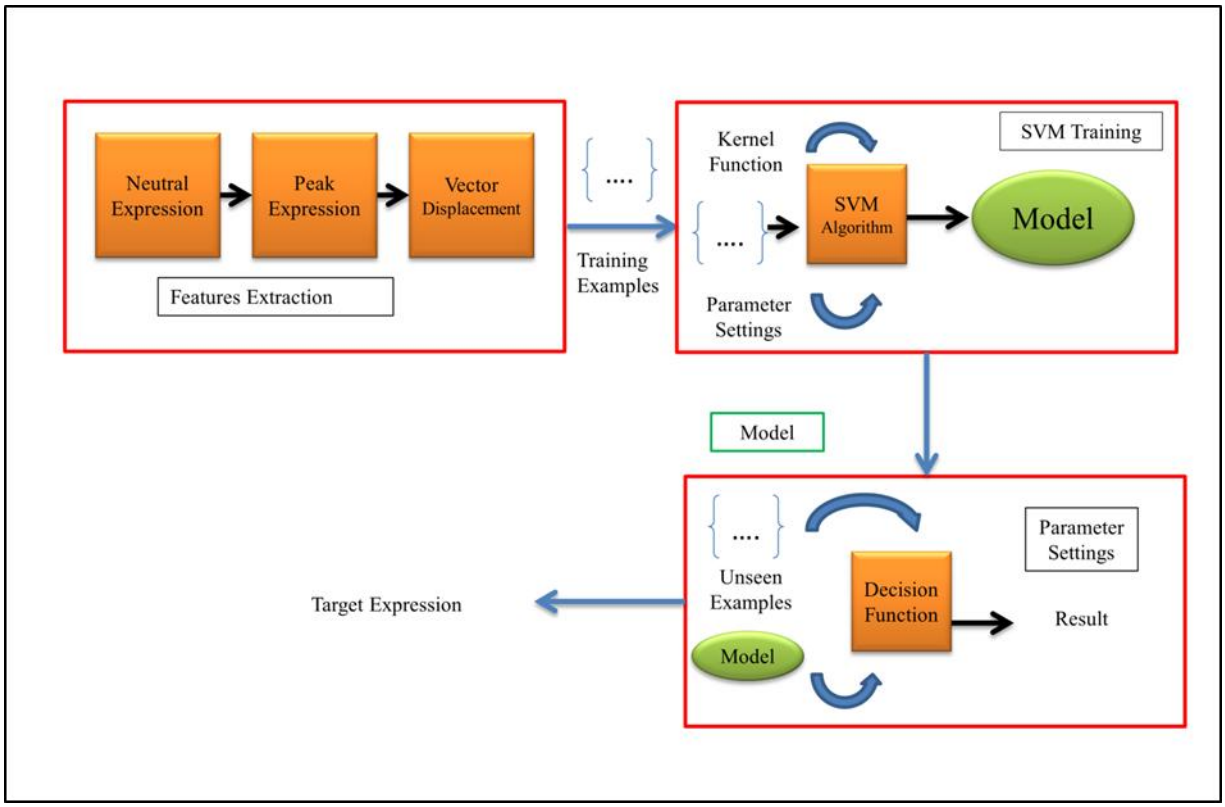

Fig 3: Processing of SVM classification

TABLE I
SVM Based Methods

Sr. No.	Method Name	Supporting Technique	Procedure	Comparison	Recognition rate
1.	Facial expression using SVM [18]	SVM, PCA and LBP	Build training sets and use LBP and PCA for feature extraction. Used SVM for classification.	k-nearest neighbour classifier	87%-100 %
2.	classification on mic-micro patterns [19]	SVM	Extract the features at micro and macro levels across a pixel-patch.	Boost LBP Gabor Filter SLGS ASM	97.61 %
3.	Real time Emotion Detection [20]	SVM + AI	Implement Java applet for expression detection	Self-created Database	80 %
4.	Expression recognition for E-learning [21]	SVM + Gabor wavelet coefficient	Used Linear and radial basis function(RBF) in PRFER (person relevant) and in PIFER (person- irrelevant)	PRFER+ Linear PRFER + RBF PIFER + Linear PIFER + RBF	70—80 % 70 -90 % 50 – 60 % 50-55 %

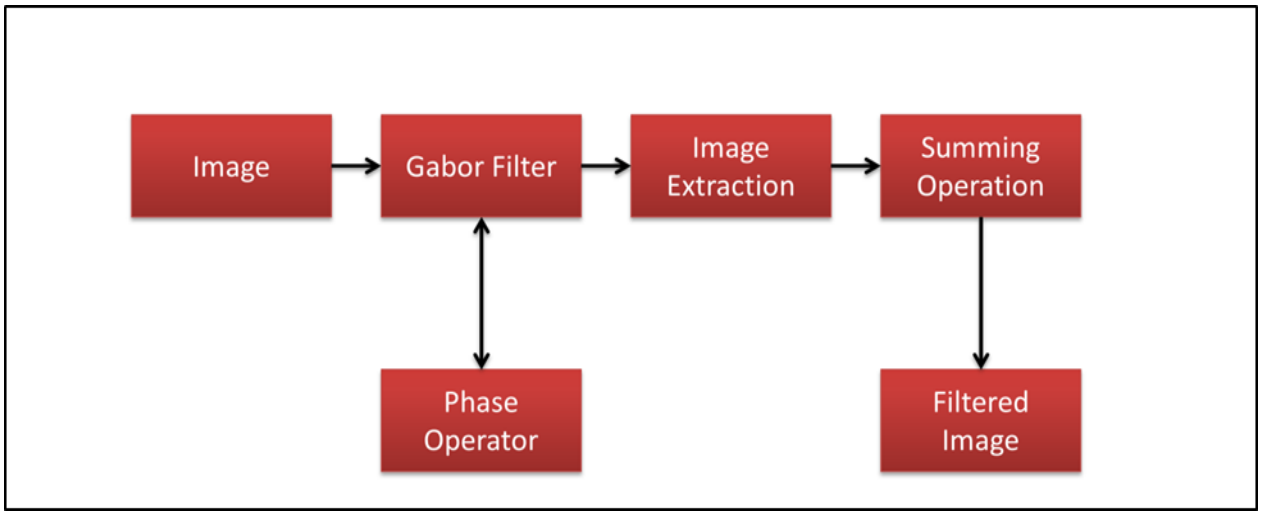

Fig 4: Processing of Gabor Filter

TABLE III
Gabor Filter Based Methods

Sr. No.	Method Name	Supporting Technique	Procedure	Comparison	Recognition rate
1.	Facial expression using Gabor and Log-Gabor [22]	PCA and Gabor Filter	Used maximum frequency (0.4) and scale factor 2 for Gabor and frequency 4,2 for Log-Gabor	Gabor Filter Log-Gabor filters	85.72- 86.10 % 85.22- 85.53 %
2.	Extraction of human emotions from video sequence [23]	CNN and Gabor filter	Used Gabor filter to find local features from the face and passed these features to the CNN classifier.	multiclass-SVM KNN CNN	83.39 % 97.78 98.89
3.	Gabor Motion Energy Filters based facial expression recognition [24]	Gabor Energy filters (GE) and spatiotemporal Gabor Motion Energy filters (GME).	The facial expression diminuendos of video sequences in the dataset begin with neutral expression and reach up to the extreme intensity of some expression.	GE with GME	GME is 7 % more accurate than GE

VI. CONCLUSIONS

Facial expression perception has increasing demand in various application areas. This work represents an extensive overview of work done in the field of facial expression recognition. Among the SVM based classifiers mic-micro pattern provides best results. For dissimilar scales and alignments of the Gabor filter, the input picture is intricate with Gabor filters and from this picture feature vectors were classified. Through Gabor filter, the distinct features from the input image can be produced. Gabor Motion Energy filters with early combination are better than Gabor Energy with Delayed Combination spatial Gabor filters. Cautious imagining of the well-learned SVM masses and examination of classification enactment exposed the reason of superiority of GME over GE in terms of their capability to seize both stationary and active texture statistics..

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