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Facial Expression Recognition in Real Time

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Abstract: ***Automatic recognition of facial expression is a necessary step toward the design of more natural human-computer interaction systems. This work presents an approach for the recognition of facial expressions in real time image sequence or video sequences. The faces features are tracked using SDM (Supervised Descent Method) Classification of the expression in the video sequences are performed using a Rule Based and SVM classification methods. For SVM training we used TFEIM (Taiwanese Face Expression Image Database). We tested our approach and achieved good results.***

Keywords: Face Expression Recognition, Face Feature Extraction, Classification

1. Introduction

Facial expressions represent one of the most important ways for humans to transmit and recognize feelings and intentions. Paul Ekman's et.al [14] suggested that all emotions belong to a small set of categories. These "basic" emotions such as anger, disgust, fear, happiness, sadness, and surprise are expressed by the same facial movements across different cultures and therefore represent an appealing choice when designing automatic methods for facial expression classification.

Automated facial image analysis confronts a series of challenges. The face and facial features must be detected in video; shape or appearance information must be extracted and then normalized for variation in pose, illumination and individual differences; the resulting normalized features are used to segment and classify facial actions. Partial occlusion is a frequent challenge that may be intermittent or continuous. While human observers easily accommodate for changes in pose, scale, illumination, occlusion, and individual differences and other sources of variation represent considerable challenges for computer vision. In used regression techniques to fill out the missing information. Bettinger et al. [5] used a sampled mean shift and a variable length Markov model to generate person-specific sequences of facial expressions. Zalewski et al. [6] clustered the shape and texture components with a mixture of probabilistic PCA. Each cluster corresponds to a facial expression and clusters are used for FES. Chang et al. [7] introduced a probabilistic model to learn a nonlinear dynamical model on a manifold of expressions containing the neutral and six universal expressions.

3. Proposed Method

We propose a new method for recognizing facial expression. Our method contains three phases.

1. Face Detection
2. Face Feature Extraction
3. Classification of Facial Expression

this paper we proposed an approach to recognize facial expression using SDM (Supervised Descent Method) for facial landmarks tracking.

2. Related work

Liu et al. [2] proposed a geometric warping algorithm in conjunction with the Expression Ratio Image (ratio between the neutral image and the image of a given expression) to synthesize new expressions preserving subtle details such as wrinkles and cast shadows. Zhang et al. [3] synthesized facial expressions using a local face model. Each region of the face was reconstructed as a convex combination of the corresponding regions in the training set. The synthesized face regions were later blended along the region boundaries. Regression-based approach finds solution as the weighted combinations of the training data. However, it is unclear how the combination of training data can reproduce subtle local appearance features presented only in the testing samples such as wrinkles, glasses, beard, or pimples. Nguyen et al. [4] used extensions of Principal Component Analysis (PCA) to remove glasses and beards in images, and

3.1 Face Detection

The video input from the camera and uses the OpenCV library to analyze the video. If a face is detected in the video, the Open CV library will give the processing sketch and coordinates of the face. OpenCV uses a type of face detector called a Haar Cascade classifier. Given a frame, from a stored file or live video, the face detector examines each image location and classifies it as "Face" or "Not Face." Classification assumes a fixed scale for the face, say 50x50 pixels. Since faces in an image might be smaller or larger than this, the classifier runs over the image several times, to search for faces across a range of scales. The classification is very fast, even when it's applied at several scales. The classifier uses data stored in an XML file to decide how to classify each image location.

3.2 Face Feature Extraction

3.2.1 Landmarks Extraction

The landmarks of face are extracted using SDM (Supervised Descent Method) [1] method takes face co-ordinates detected using opencv as an input. In the first frame the method initialize the landmarks. Then it tracks the landmarks as shown in fig 1. The normalization is performed on the obtained landmarks [13].

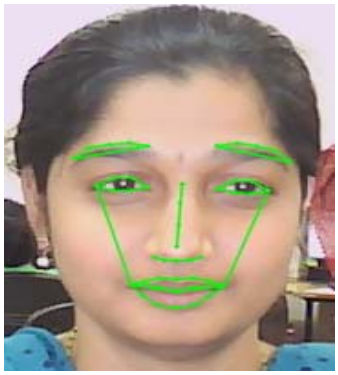


Figure 1: Detection of Facial Landmarks

3.2.2 Normalization Process

First, the coordinates of the center pixel in each eye were computed as the mean of the six corresponding landmarks (0 to 7 for the left eye, and 8 to 12 for the right eye). Second, the inter-eye distance d was computed and all landmark coordinates were multiplied by 50/d. This sets the inter-eye distance to 50 pixels.

3.2.3 SDM (Supervised Descent Method)

A Supervised Descent Method (SDM) [1] is used for localizing facial landmarks. At first, it takes an image with manually labeled landmarks, then it run through training images to give initial configuration of landmarks. It uses SIFT function to extract initial landmarks. In training phase, SDM tries to minimize difference between manually labeled landmarks and initially located landmarks by SIFT (Δx). This method does not learn any shape or appearance model in advance from training data. The SDM learns a series of descent direction and re-scaling factors to produce a sequence of updates.SDM directly learns descent direction from training data by learning a linear regression between, Δx and difference of SIFT value of manually and extracted landmarks ($\Delta\Phi$). In testing phase, based on descent direction and re-scaling factors learn in training SDM estimates landmarks. SDM learns descent direction without computing neither Jacobian nor Hessian matrix, which are computationally expensive. SDM is fast and accurate as compare to shape models.

3.3 Classification of Facial Expression

We used Multiclass LibSVM tool to classify the expressions (Normal, Sad, Smile, & Surprise). To classify the expression we used Distance as metric. The distance between interested landmarks is calculated and trained to SVM .The TFEID (Taiwanese Face Expression Image Database) is used to train the SVM. The calculated distance is used to predict the expression.

3.3.1 Multi Class SVM

The LibSVM [12] is used to train the dataset on the learned model created then evaluator is used to classify the emotions based on the learned model.

Steps for LibSVM

- Transform data to the format of an SVM package
- Conduct simple scaling on the data
- Consider the RBF kernel $K(x, y) = e^{-\gamma\|x-y\|2}$
- Use cross validation to find the best parameter C and γ
- Use the best parameter C and γ to train the whole training set

The RBF kernel nonlinearly maps samples into a higher dimensional space, unlike the linear kernel, can handle the case when the relation between class labels and attributes is nonlinear. The linear kernel is a special case of RBF. The polynomial kernel has more hyper parameters than RBF kernel. Most computational overhead resides in the training phase. However, due to the fact that the training set is interactively created by the user and hence limited in magnitude and that the individual training examples are of constant and small size, overhead is low for typical training runs. Training on different individuals lead to model being more of person independent nature. For training purposes we used five different features such as distance between lip end points, distance between two eye brows, distance between left eye and left eye brow, distance between right eye and right eye brow and distance between inner lips are used to recognize the four expressions such as Neutral, Smile, Sad, and Surprise. The fig 2 shows the flow chart for algorithm using facial Landmarks and SVM Classification

3.3.2 Algorithm for recognizing the facial expression

Input: Real time Input from Normal Camera or video
Output: Expression of the human standing in front of the camera or human in video.

Steps to identify the expression of the human

1. Identify the face using OpenCV face detector function
2. Apply SDM (Supervised Descent Method) method for initializing and tracking the landmarks.
3. Normalize the Landmarks to 50 0r 100 pixels
4. Calculate the distance metric using Euclidean Distance Method
   $D(p, q) = \sqrt{(p1 - q1)^2 + (p2 - q2)^2}$
   for the following
   a. Between the Lip End points.
   b. Between the Inner Lips.
   c. Between the Eyes and Eye Brows.
5. Apply the SVM classification or Rule-based classification on calculated distance metric in Step 4 to classify the expression like Surprise, Smile, Sad, & Normal.

The following rules are applied to classify the expression using Rule Based Classification.

IF (Distance between Lip End Points > 48)
THEN Expression = Smile
IF (Distance between Eyes and Eye Brows > 15 AND Distance between inner lips >20)
THEN Expression = Surprise

IF (Distance between Eyes and Eye Brows < 10 AND Distance between inner lips < 4)
THEN Expression = Sad

The Figure 2 shows the flow chart of the facial expression recognition system.

4. Experimental Results

Face Expression Recognition has been written in Windows Presentation Foundation technology with using VC++ language. To write and compile application code we used Visual Studio Professional 2010. The entire process of developing taken place on computer with Windows 7 system.

The Table 1 & 2 shows the Expression of the person using Facial Landmarks and SVM Classification
The Table 3 & 4 shows the Expression of the person using Facial Landmarks and Rule Based Classification
The Table 5 Shows Results analysis for SVM Classification and Table 6 shows Result Analysis of Rule Based Classification

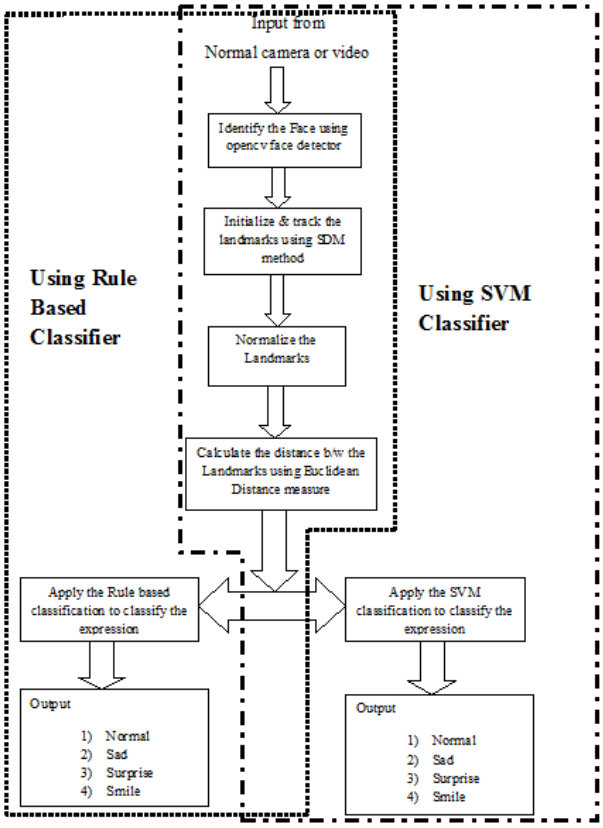


Figure 2: Flow chart for Facial Expression Recognition System

5. Conclusion

In this paper we presented the Facial Expression Recognition system based on Rule- Based and SVM Classification. From the experimental results the SVM classifier gives the satisfactory results for all type expression such as Normal, Sad, Surprise, and Smile compared to Rule-Based classifier.

Table 1: Set – I Results of Rule based Classifier

Normal Expression	*Surprise Expression*	*Sad Expression*	*Smile Expression*
			
Distance b/w Lip End Points= 38.00000 Dist b/w Two eye Brow= 28.07133 Dist b/w Eye Brows & eye(left)= 10.04987 Dist b/w Eye Brows & eye(right)=11.04536 Dist b/w inner lip= 1.414214	Distance b/w Lip End Points= 36.01388 Dist b/w Two eye Brow= 27.07397 Dist b/w Eye Brows & eye(left)= 15.13274 Dist b/w Eye Brows & eye(right)=15.13274 Dist b/w inner lip= 14.03566	Distance b/w Lip End Points= 41.01219 Dist b/w Two eye Brow= 23.19482 Dist b/w Eye Brows & eye(left)= 9.055386 Dist b/w Eye Brows & eye(right)=10.04987 Dist b/w inner lip= 2.000000	Distance b/w Lip End Points= 51.0881 Dist b/w Two eye Brow= 24.0208 Dist b/w Eye Brows & eye(left)= 11.0453 Dist b/w Eye Brows & eye(right)=11.0453 Dist b/w inner lip= 7.00000

Table 2: Set – II Results of Rule based Classifier

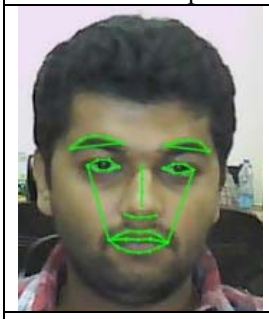
Normal Expression	Surprise Expression	Sad Expression	Smile Expression
			
Distance b/w Lip End Points= 37.01351 Dist b/w Two eye Brow= 28.28427 Dist b/w Eye Brows & eye(left)= 15.13274 Dist b/w Eye Brows & eye(right)=14.14213 Dist b/w inner lip= 1.000000	Distance b/w Lip End Points= 38.05259 Dist b/w Two eye Brow= 26.07680 Dist b/w Eye Brows & eye(left)= 22.80350 Dist b/w Eye Brows & eye(right)=23.08679 Dist b/w inner lip= 34.13209	Distance b/w Lip End Points= 37.33630 Dist b/w Two eye Brow= 28.28427 Dist b/w Eye Brows & eye(left)= 9.486833 Dist b/w Eye Brows & eye(right)=11.04536 Dist b/w inner lip= 1.414214	Distance b/w Lip End Points= 48.04164 Dist b/w Two eye Brow= 27.01851 Dist b/w Eye Brows & eye(left)= 20.88061 Dist b/w Eye Brows & eye(right)=19.02629 Dist b/w inner lip= 1.000000

Table 3 Set – I Results of SVM Classifier

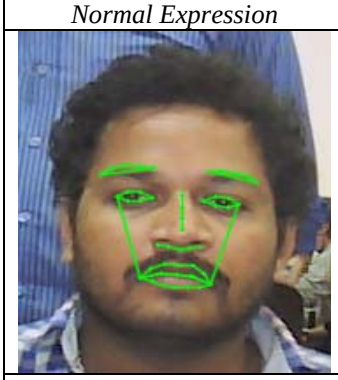
Normal Expression	*Surprise Expression*	*Sad Expression*	*Smile Expression*
			
Distance b/w Lip End Points= 41.10960 Dist b/w Two eye Brow= 31.14482 Dist b/w Eye Brows & eye(left)= 17.11724 Dist b/w Eye Brows & eye(right)=16.49242 Dist b/w inner lip= 2.000000	Distance b/w Lip End Points= 46.00000 Dist b/w Two eye Brow= 32.14031 Dist b/w Eye Brows & eye(left)= 14.03566 Dist b/w Eye Brows & eye(right)=17.11724 Dist b/w inner lip= 25.01999	Distance b/w Lip End Points= 44.01136 Dist b/w Two eye Brow= 28.00000 Dist b/w Eye Brows & eye(left)= 15.00000 Dist b/w Eye Brows & eye(right)=15.29705 Dist b/w inner lip= 4.000000	Distance b/w Lip End Points= 60.13318 Dist b/w Two eye Brow= 26.07680 Dist b/w Eye Brows & eye(left)= 13.15294 Dist b/w Eye Brows & eye(right)=14.00000 Dist b/w inner lip= 6.082763

Table 4 Set – II Results of SVM Classifier

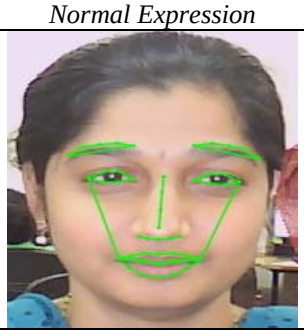
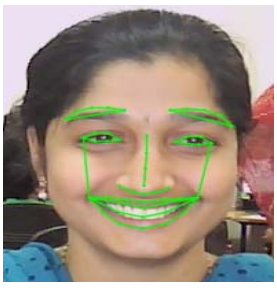
Normal Expression	*Surprise Expression*	*Sad Expression*	*Smile Expression*
			
Distance b/w Lip End Points= 38.01315 Dist b/w Two eye Brow= 29.00000 Dist b/w Eye Brows & eye(left)= 16.27882 Dist b/w Eye Brows & eye(right)=17.11724 Dist b/w inner lip= 1.000000	Distance b/w Lip End Points= 36.00000 Dist b/w Two eye Brow= 31.06444 Dist b/w Eye Brows & eye(left)= 20.09975 Dist b/w Eye Brows & eye(right)=19.23538 Dist b/w inner lip= 8.062258	Distance b/w Lip End Points= 39.00000 Dist b/w Two eye Brow= 22.02271 Dist b/w Eye Brows & eye(left)= 14.03566 Dist b/w Eye Brows & eye(right)=14.00000 Dist b/w inner lip= 0.000000	Distance b/w Lip End Points= 59.00000 Dist b/w Two eye Brow= 25.00000 Dist b/w Eye Brows & eye(left)= 17.02938 Dist b/w Eye Brows & eye(right)=17.26267 Dist b/w inner lip= 6.082763

Table 5: Result Analysis of SVM classification

Actual Expression \ Dectected Expression	*Normal*	*Sad*	*Surprise*	*Smile*
Normal	63.33%	16.66%	10.66%	9.35%
Sad	23%	66.33%	17.33%	-
Surprise	-	-	93.33%	6.6%
Smile	6.6%	-	10%	83.33%

Table 6: Result Analysis of Rule – Based Classification

Actual Expression \ Dectected Expression	*Normal*	*Sad*	*Surprise*	*Smile*
Normal	56.25%	12.15%	31.6%	-
Sad	37.75%	62.5%	-	-
Surprise	-	-	87.75%	12.5%
Smile	-	-	18.75%	81.25%

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