RESEARCH ARTICLE OPEN ACCESS

Facial Expression Recognition Using Feature Extraction And Classification Technique

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ABSTRACT
The system-based identification of facial expressions has been a vital area of research in the literature for a long time. The most meaningful way humans exhibit emotions is byfacial expressions. The presented work confers a new framework for facial expressions recognition from video files by selectingthe Gabor features on video frames. A set of dimensionality reduction technique, Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) is used to minimize the computational complexity. These feature vectors are compared with the trained vectors of different facial expressions in the database and finally, a Support Vector Machine is used to classify different kinds of facial expressions belonging to the face video frames. This method reveals a better performance ratio.

Key Words: Facial expressions, Principal Component Analysis, Linear Discriminant Analysis, Support Vector Machine, Gabor features.

Date of Submission: 10-02-2018 Date of acceptance: 28-02-2018

I. INTRODUCTION

Face plays a crucial role in human communications. Facial emotions often mediate and facilitate interactions among human beings. Thus, understanding emotion often brings context to seemingly bizarre and/or complex social communication. Emotion can be recognized through a variety of means such as voice intonation, body language, and more complex methods such as ElectroEncephaloGraphy (EEG). However, the easier, more practical method is to examine facial expressions. By identifying the facial appearance from facial images, a number of applications in the field of human-computer interaction can be facilitated. Human behavior recognition, systems for psychological studies (Pain or stress detection), emotion detection system used by the disabled to assist a caretaker, mobile application to automatically insert emotions in chat applications and sign language recognitions are the applications of facial expression recognition. On the whole, from these applications, it is apparent that facial expression detection structure would be inefficient unless they are made to work in real-time.

Many research works have been carried out for FER's, either from images or videos, but many issues like occlusion, pose, low resolution, scale & variations in illumination level still remain unaddressed. Last two decades, the developments, as well as the prospects in the field of multimedia signal processing have attracted the attention of many computer vision researchers to concentrate on the problems of the facial expression recognition. The pioneering studies of Ekman in late70s have given evidence to the classification of the basic facial expressions. As stated by these studies, the primary facial expressions are happiness, sadness, anger, fear, surprise, disgust and neutral. Ekman and Friesen implemented a Facial Action Coding System (FACS) to code facial emotions in which the movements of the face are described by action units. This work inspired many researchers to analyze facial expressions in 2D by means of image and video processing, by tracking of facial features and measuring a number of facial movements, they attempt to classify different facial expressions.

Current works on facial expression research and recognition have used these seven basic expressions as their basis for the established systems. Almost all of the methods originated to use a 2D distribution of facial features as inputs into a classification system, and the outcome is one of the facial emotion classes. They vary mainly in the selected facial features and the classifiers used to discriminate among the different facial expressions. There are many methods have been proposed for human facial expression recognition from static images (image database) to image sequence (video).

The proposed work provides a framework for facial expression recognition. The input is given in the form of video. The Gaussian filter is applied on the extracted video frames as a preprocessing technique. Secondly, the face detection and tracking are done using KLT algorithm covering all the video frames. Then the feature extraction is carried out using Gabor filter method and finally, the facial expression recognition is classified using SVM classification technique.

Need for facial expressions recognition

Facial Expression Recognition has received significant attention, especially during the last few years. Recently it gains special importance because of its strong need in few application areas. There are at least two causes for this development: The first is the wide range of commercial and mobile applications. Second is the availability of practical technologies after 30 years of research. Facial expression recognition has substantial potential in two areas:

- It is used in psychological studies to detect the patient's emotions. For example, Stress or Pain detections.
- It is used in Human behavior recognition.

However, automated facial expression recognition can be used in a lot of areas other than Human behavior recognition and psychological studies, such as computer entertainment and customized computer-human interaction. The interest for automated facial expressions recognition and a number of applications will most likely increase even more in the future. This could be due to increased penetration of technologies, such as digital cameras and the internet. Facial expression recognition has become one of the most challenging tasks in the pattern recognition.

Issues for face recognition are addressed in detail in the previous report. In the generation of face recognition system, the existing sparse representation based classification technique is a method which leads to misclassification. The further geometric descriptor model is uncovered only for primary-level categories, they cannot capture the detailed visual features for sub-categories. So a new technique was developed based on dense graph mining algorithm for face detection, and SVM classification algorithm for face recognition, which classifies the test image. The proposed work is the extended part of the face recognition. Here the face expressions are identified after the detection and recognition of face from the video files.

The main objective of our project is

• To detect and track face from the video sequence and to extract features from video frames.

• To recognize the person and his/her facial expressions using SVM classification technique.

II. RELATED WORK

Recognition of facial expression involves phases such as face detection and tracking, feature extraction and classification. Most of the researchers attempt to classify six basic expressions such as Anger, Disgust, Fear, Happy, Surprise and Sad using distinct algorithms for these individual phases. In the literature survey, existing algorithms for different phases are discussed for facial expression. For example, face detection and tracking are achieved by using algorithms such as adaptive skin color, mean shift algorithm, Stereo Active Appearance Model (STAAM) etc. A few of the algorithms for feature extraction are Local Binary Pattern (LBP), Guided Particle Swarm Optimization (GPSO) etc., along with classification algorithms such as two nearest neighbor, random forest, decision tree, Naïve Bayes, Distance Ratio-based Classifier (DRC) and HMM.

Face Detection and Tracking

Face detection is the first important step of FER. In this stage, the image is segmented into two parts: one containing faces and the other representing non-face regions. There are various approaches for face detection in real-time such as adaptive skin color, Adaboost, and contour points.

Vasavi and Pratibha (2014) presented a method of detecting human faces irrespective of different ethnicities. It uses adaptive skin color approach to detect skin regions over the entire image. This method detects faces among various facial expressions, different face orientations and demonstrates successful face detection over the FERET benchmark database and acquired images. But it fails in different levels of illumination. It leads to high computational complexity and is not suitable in a real-time environment.

Viorel suse and Dan Ionescu (2015) presented a new hardware architecture for pattern detection and classification specific for human face detection. The Adaboost algorithm using Haar features are calculated in parallel being implemented in hardware. AdaBoost approach has higher accuracy, but slower speed and skin color segmentation method has a faster speed of detection, but lower accuracy.

Face tracking is used to follow a face through a sequence. To take in, the face becomes different over time, in terms of changes in scale, position and to localize the search for the face, it is essential to exploit the temporal correspondence between frames. Tracking exploits the temporal content of image sequences. Face tracking can be divided into two categories: (i) head tracking and (ii) facial feature tracking. Head tracking methods focus on the movement of the complete head, whereas feature tracking methods focus on tracking the features extracted from the face. Feature tracking indirectly leads to head tracking.

A Regional Hidden Markov Model (RHMM) for automatic facial expression recognition in video sequences is proposed by Sun and Akansu (2014). Facial action units are described by RHMMs for the states of facial regions: eyebrows, eyes, and mouth registered in a video. Mean shift algorithm is used for tracking. The tracked facial feature points in the spatial domain forms observation sequences that drive the classification process. Mean shift algorithm approach gives good accuracy as algorithms locate the features of the target window by adaptive skin color and find the similarity between target window and candidate window. It is an iterative method due to which the time complexity increases and thus are less suitable in a real-time environment.

Sung et al (2006) proposed a real-time person independent facial expression recognition in two parts: one is a model fitting part using a stereo active appearance model (STAAM) and another is a person independent facial expression recognition using a layered Generalized Discriminant Analysis (GDA) classifier. The STAAM fitting algorithm uses multiple calibrated perspective cameras to compute the 3D shape and rigid motion parameters. STAAM is a vision system and is calibrated with two cameras which help to construct a 3D model of the face. STAAM increases accuracy as it does not depend on the stability of the camera, however, also increases computational complexity due to the use of 3D shape and appearance model.

A method for facial expression recognition using motion information for face tracking is proposed by Geetha et al (2009). Face localization, feature extraction, and modeling are the major issues in automatic facial expression recognition. A face is located by extracting the head contour points using the motion information. A rectangular bounding box is fitted for the face region using those extracted contour points. Among the facial features, eyes are the most prominent features used for determining the size of a face. Motion information approach is suitable in real-time because it is computationally efficient and is highly accurate. The limitation of motion information for face tracking method is that it assumes only one face is moving in the image.

Feature Extraction

The next step toward facial expression identification is an extraction of features from video frames. Facial feature extraction can be defined as a process to locate specific features in a facial image such as points or contours. The features to be extracted can be physical such as eyes, eyebrows, mouth, nose etc. Most of the existing methods for facial feature extraction assume that the face is already detected. If the face is located, the computational complexity of the facial feature extraction can be significantly reduced. Usually, possible feature candidates are roughly located within a facial region and then a high-level analysis is performed to detect the correct ones. The high-level analysis is typically based on a template generated by training. There are mainly two approaches – appearance based and geometric-based. 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 the real-time environment as features can be tracked easily. These algorithms use the Facial Action Coding System (FACS) developed by Ekman and Friesen (2008), FACS consists of over 45 distinct action units corresponding to a distinct muscle or muscle group. It is most widely used language to describe facial activity at the muscle level. Hybrid features use both geometric- and appearance-based approaches to extract features.

Praseeda Lekshmi V. et al. (2008) used Principal component analysis for feature extraction and weight vectors for classification. Skin color detection was used to detect skin region. At the time of pre-processing 14 marking points were mentioned on feature face. In PCA, facial images were projected into a feature space or Eigen space. They have combined geometric and Eigen faces at classification phase. ShishirBashyal et al. (2008) used Gabor filter and learning vector quantization to develop a facial expression recognition system. Gabor filter was used to extract the feature from JAFFE database images. This paper proposed that Learning Vector Quantization (LVQ) performs better in recognition of fear expressions than Multi-Layer Perceptron (MLP). Caifeng Shan et al. (2009) used Linear Binary Pattern for feature extraction and Support Vector Machine (SVM) for classification. Developed a system that works against illumination changes and take less time as others existing system. Linear Binary Pattern (LBP) tolerant illumination and takes less time in computation. The performance of the system was about 89% for sadness. Some expressions were not classified correctly.

Two Dimension Principal Component Analysis for feature extraction and K-Nearest Neighbor are used for classification by Luiz S. Oliveira et al. (2011). They tried to solve some problems of the PCA which affects recognition problem. As PCA works on vector image while 2DPCA works on the whole image. But in 2DPCA coefficient are more so, we need to select feature for classification.

Dahmane M. et al. (2011) developed a system to implement the general expression model (even when a person poses at the different time). They used Histograms of Oriented Gradients (HOG) and Support Vector Machine (SVM). The baseline method was used. HOG is used to extract the appearance feature by gradient magnitudes for a set of orientations. The performance of the system was about 70%.

FER system for comparing the use of two types of features extracted from face images for recognizing facial expression is presented by Ali et al (2012). Geometric positions of a set of fiducial points and multi-orientation appearance-based parameters are extracted from the two approaches used for feature extraction. The combined information approach leads to higher accuracy. Appearance-based algorithms include Gabor wavelet, LBP, pixel-pattern-based texture, pyramid LBP and Mouth Intensity Code Value (MICV). Geometric-based algorithms are canny edge detection, AAM and Multi-Resolution Active Shape Model (MRASM).

Han Jing et al (2015) proposed a cognitive-emotional model in elderly service robot, where the expression of positive stimulus is used to reduce the negative emotional state of the robot. In this paper, Gabor filter is used for feature extraction. Gabor filters consider each pixel of the image as features. Thus, the dimension of the filtered vector can be very large, which leads to expensive computation and storage cost. Gabor feature algorithm has high accuracy due to high discriminative power but is not suitable in real-time due to high computational speed and memory requirement.

An informative region extraction model, which models the importance of facial regions based on the projection of the expressive face images onto the neutral face images, is implemented by Sunil Kumar et al (2016). It uses Local Binary Pattern (LBP) for feature extraction. Hence, it is difficult to implement in real time due to time complexity and the facial features are extracted from neutral face images, so this method cannot recognize facial expressions for partially occluded face or side views.

Classifier

There are two phases in the classifier. The first phase of the classifier is training phase in which the input is the set of instances with its reduced set of feature values and class label as one of the emotion. The training data includes the examples of every emotion with sufficient data for training. The second phase is classification which categorizes the emotion into different classes (i.e. happy, sad, fear, disgust, angry etc.) with the given set of reduced feature vector. In real-time, the classification algorithm performance should be high in terms of both accuracy and efficiency. There are various approaches for classification in a real-time domain for FER. The system uses grey-scale frontal face images of a person to classify six basic emotions: namely, happiness, sadness, disgust, fear, surprise and anger. There are many classification algorithms or classifier such as least-square method, Hidden Semi-Markov Model (HSMM), two nearest neighbors, random forest, decision tree, Naïve Bayes, Distance Ratio-based Classifier (DRC) and HMM.

Zhao-yi et al (2010) proposed a method for real-time facial expression recognition using Least-square method for classification. This method meets the real-time requirement in terms of achieving lesser computational complexity but at the cost of accuracy as there is an ambiguity in recognizing some expressions such as anger and disgust. Le Hoang Thai et al. (2011) used Canny, Principal Component Analysis and Artificial Neural Network for classification of facial expression. Canny was applied for a pre-processing phase to locate the region of detection. After that PCA was applied to extract the facial features. At last Artificial Neural Network applied to classify the facial expression.

HSMM based facial expression recognition implemented by Zhao-yi et al (2009) delivered good results in partly hidden faces. Sun and Akansu (2014) proposed a face emotion recognition using hidden markov model. This HMM is mostly employed in conjunction with image motion extraction method. The idea is that expressions have a unique temporal pattern and recognizing this pattern can lead to improved classification results. With HMM classifier, recognition accuracy is good and expressions such as ‘neutral’ and ‘disgust’ cannot be distinguished well. It is claimed that most of the real-time systems are restricted to recognize only frontal views of the expression.

Jun Wang, Lijun Yin (2007) used topographic context (TC) and linear discriminant analysis (LDA). This system works as robust and person-independent. A Topographic analysis treats the image as a 3D surface and labels each pixel by its terrain features. Topographic context describes the distribution of topographic labels in a region of interest of a face (split face into a number of expressive regions). These regions are combined with the terric map. LDA was used as a classifier and performance of the system was about 82.61%.

The techniques used by researchers previously had certain problems. Some of them only give a good result for person- dependent test. If the test input was not from the trained database then the results were different. In many techniques, miss-classification of facial expressions was common, due to the low intensity of expressions. Results were good for particular expression only like- only neutral, only sad, only happy etc. The evolution of the classifier in real-time causes most computational overhead to reside in the training phase due to the fact that the training set is interactively created by the user. This allows an approach to perform classification both directly on user request and continuously in real-time for every frame in the video stream, with the current result being constantly reported back to the user.

OBSTACLES IN THE RELATED WORK:

Issues for face expression recognition are addressed in detail in the previous section by analyzing the existing work based on different methods. In the generation of FER systems, most of the existing methods used appearance based approaches for facial feature extractions. Appearance-based algorithms have high discriminative power but are less suitable for real-time applications, as the computational complexity and memory requirement of the algorithm are high. Geometric-based algorithms are more suitable in the real-time environment as features can be tracked easily. The proposed method uses KLT face detection algorithm for face detection and tracking. The feature extraction is carried out using Gabor feature extraction technique. Since it consumes more time and memory space, the dimensionality reduction technique is PCA and LDA. Finally, the SVM classification algorithm is used to identify the person and to classify the facial expression.

III. PROPOSED WORK

Facial expressions give important information about emotions of a person. Understanding facial expressions accurately are one of the challenging tasks for interpersonal relationships. Automatic emotion detection using facial expressions recognition is now the main area of interest within various fields such as computer science, medicine, and psychology and to improve the human-computer interaction (HCI) to be as good as human-human interaction, building an efficient approach for human emotion recognition is required. Proposed work provides a framework for facial expression recognition. The major contributions included in this system are: First, preprocess the input video sequence and secondly detect and track the facial features. Thirdly, extract the facial feature vectors from the video frames and store in training data. Finally, classify the test image based on SVM classification technique. This will recognize the person's verification process and identifies the facial emotions.

IV. METHODOLOGY

It is the structural area when the abstract model is changed into an acting structure.

In this process, the test video is given as input. The Gaussian filter is used for preprocessing, which removes noise in the video sequence. The video frames are extracted from the video and stored in the database. The first frame from the video is taken for detecting the face and identifying the facial features to track.

Secondly, the features are extracted from the video sequences by using Gabor feature extraction technique. Since the vectors extracted requires a large amount of space. So we reduce it by using PCA (Principal Component Analysis) plus LDA (Linear Discriminant Analysis). These feature vectors are stored in the training set which is used for the classification process.The person's face image is first verified, whether he/she is an authorized or unauthorized person. Then the facial expression of

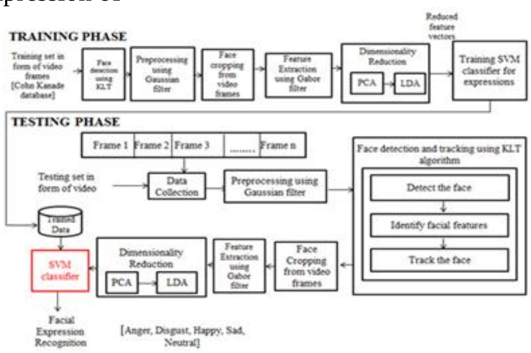

Figure 1: Face Expression Recognition Architecture

the verified person is recognized using the SVM classification technique. Figure 1 illustrates the overall architecture of the proposed system. In training phase, the video sequence dataset named Cohn-Kanade dataset is used. The frames are preprocessed using the Gaussian filter. Then the face is detected using KLT algorithm. Features are extracted using Gabor filter and those features are reduced using PCA and LDA. Finally, the SVM classifier is trained for five expressions. In the testing phase, the video set is given as a query. From this video, the frames are gathered and used for expression recognition process. The feature extraction technique used in this process examines video frames to extract features that are unique to objects in the image, in such a manner that we are able to detect an object based on its features in different images. The SVM classification outperforms in the real-time environment as it recognizes with very high accuracy in real-time.

4.1 Data Collection and Preprocessing

During pre-processing, a training set and video frames are created. Then pre-processing technique is applied which makes the frames easier to process and increase the chances of getting correct matches. Better chances of success with changes in illumination, pose, expression and picture quality. And also it decreases the processing time. Here Gaussian low pass filter technique is used for preprocessing.

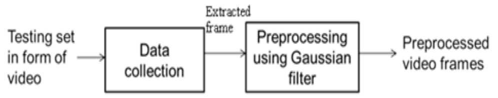

Figure 2: The Block Diagram of Preprocessing video frames

Pre-processing is the first step in FER system. The input video frames are pre-processed using the Gaussian filter. It will reduce the noise and smoothens the video frames for better performance.

4.2 Face Detection and Tracking

The KLT tracking approach calculates the movements of the object in consecutive video frames when the image brightness constancy constraint is fulfilled and image movement is small. Object detection and tracking are vital in most of the vision applications including motion recognition, safety precaution, and observation. This face detection and tracking algorithm track the face throughout the video frames even when the person tilts his head, moves away or towards the camera. It detects the face only once and then tracks across the video frames. Here, face tracking method is categorized into three parts: Detect a face, Identify facial features to track and Track the face.

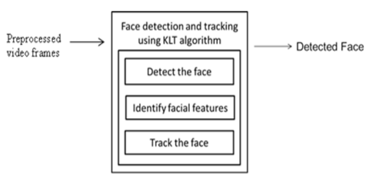

Figure 3: The Block Diagram of Face Detection and Tracking

Figure 3 illustrates the process for face detection and tracking from the video file. In this process, the algorithm is divided into three parts. In the first part, the face is detected from the video frame by using cascade object detector which is also known as viola jones detection algorithm. In the second part, the features are identified from the detected face which is used for tracking purpose. In the third face, with the identified features the point tracker will track the face across the video frames. Finally, the detected face with the identified features is constructed.

4.3 Facial Feature Extraction and Dimensionality Reduction

The real part of Gabor feature vectors with eight orientations and five frequencies are created and features are extracted from those filtered images. It will contain a huge number of information. This can be reduced using dimensionality reduction methods.

One approach to coping with the problem of excessive dimensionality is to reduce the dimensionality by linear combining features. In effect, linear methods project the high-dimensional data onto a lower dimensional space, we call it feature compression. There are two classical approaches to finding effective linear transformations, which are Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). PCA seeks a projection that best represents the original data in a least-squares sense, and LDA seeks a projection that best separates the data in a least-squares sense.

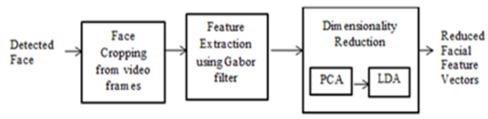

Figure 4: The Block Diagram of Facial Feature Extraction and Dimensionality Reduction

Figure 4 describes the Gabor feature extraction technique. The features are extracted from the preprocessed and detected face in the video frame. After face detection, the cropping process needs to be done. It will provide better and accurate results for feature extraction. Since the features are extracted only from the face part, the classification process will be accurate and the recognition rate will be high. Though the features are high in dimensions, it is reduced using PCA and LDA. This will reduce the computational complexity.

4.4 Facial Expression Recognition

After formalizing the representation of each video frames the last step is to recognize the identities of the faces and to recognize the facial expression recognition. In order to achieve automatic recognition, a training database is required to build. For each video, several frames are taken and their features are extracted and stored in the database. Then when an input video comes in, face detection and tracking and feature extraction is performed and compares its feature to each input frames stored in the database. Support Vector Machine (SVM) for Classification is used here.

Figure 5 describes the facial expression recognition technique using SVM classifier. The extracted facial feature vectors are used for the classification technique. Key points from the input video frames will be matched with the training data's and the process of facial emotion recognition is done using the classification technique.

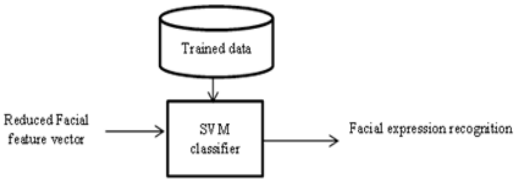

Figure 5: The Block Diagram of Classification Process for Facial Expression Recognition

V. XPERIMENTAL RESULTS

In this work, we have used static images of Cohn-Kanade database for training process and different videos are taken from the internet for the testing process. The CK database consists of images of 100 university students that they ranged in age from 18 to 30 years. Image sequences for the frontal views are digitized into 640 x 490 pixel array with 8 bits grayscale.

Figure 6: Examples of Original Images from Cohn-Kanade Database

Figure 6 shows the images of an individual which are taken from Cohn-Kanade database. Each display began and ended in a neutral face with any exceptions noted. Image sequences for frontal views and 30-degree views were digitized into either 640x490 or 640x480 pixel array with 8- bit grayscale or 24-bit color values. 95 subjects which have five expressions for each subject and for each expression six video frames are assigned which are used for training the system.

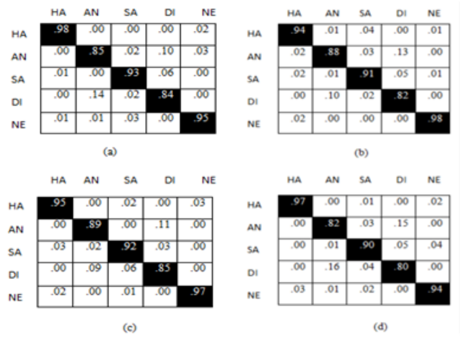

Figure 7: Experimental Results of ConfusionMatrices

In figure 7 (a)-(d) describes the confusion matrices corresponding to five facial expressions from different videos. A confusion matrix is often used to describe the performance of a classification model on a set of test data for which the values are known.

TABLE I. OVERALL RECOGNITION RATES WITH RESPECT TO DIFFERENT FACIAL EXPRESSIONS

	PREDICTED (%)					
ACTUAL (%)	EXPRESSIONS	Happiness	Anger	Sad	Disgust	Neutral
	Happiness	96	0.25	1.75	0	2
	Anger	0.5	86	2	12.25	0.75
	Sad	1.5	1	91.5	4.75	1.25
	Disgust	0	12.25	3.5	82.75	0
	Neutral	2	0.5	1.5	0	96

Table I describes the overall recognition rates with respect to different facial expressions. The average recognition rate and the error rate for four video files are listed in the table I. From this the happiness and neutral expressions contains the highest recognition rate.

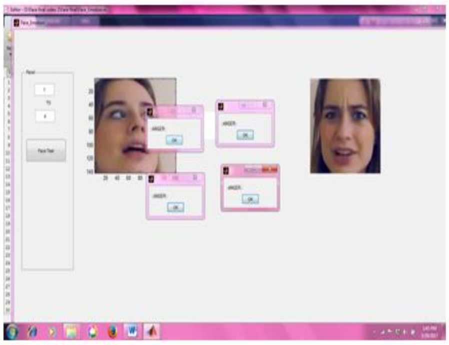

Figure 8: Recognition of Facial Expression

Figure 8 displays the identified expression (Anger) from a test video. The proposed methodology provides the advantage of selecting any number of video frames on the particular test video for identifying the expressions on that particular frames. The primary requirement of facial expression system is good quality face images and a good quality is one which is collected under expected conditions. The input video used in this process is taken from the internet.

VI. CONCLUSION

The main focus of this proposed system is to identify the facial expressions from the video streams. The methods used in this work for expressions recognitions are KLT face detection and tracking algorithm which uses "viola jones" detection algorithm for face detection and identifies the face features to track and then uses point tracker for face tracking, secondly the Gabor feature extraction technique is used to extract the feature vectors. The CK+ dataset is used for training purpose and the video streams are used for testing purpose. PCA and LDA dimensionality reduction technique is used for vector reduction since the features extracted can consume more time and memory space. Finally, the SVM classification technique is used for classifying various expressions. The result generated from this work clearly presents about using these approaches for expression identification from the video stream is highly suggested. The proposed method resulted in an average of 90% correct classifications with 10% error rate. Overall, the performance and recognition rate is high for the proposed method.The work may further extend to other complex expressions, synthetic face and synthetic expressions.

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J. Lethisia Nithiya "Facial Expression Recognition Using Feature Extraction And Classification Technique "International Journal of Engineering Research and Applications (IJERA) , vol. 8, no.02, 2018, pp. 37-45