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Recognizing Facial Expression using PCA and Genetic Algorithm

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***Abstract* -** This paper presents an efficient method of recognition of facial expressions in a video. The works proposes highly efficient facial expression recognition system using PCA optimized by Genetic Algorithm .Reduced computational time and comparable efficiency in terms of its ability to recognize correctly are the benchmarks of this work. Video sequences contain more information than still images hence are in the research subject now-a-days and have much more activities during the expression actions. We use PCA, a statistical method to reduce the dimensionality and are used to extract features with the help of covariance analysis to generate Eigen –components of the images. The Eigen-components as a feature input is optimized by Genetic algorithm to reduce the computation cost.

***Keywords* -** *Video Decoposition, Face Detection,PCA, Genetic Algorithm.*

I. INTRODUCTION

Modern multimedia technology has led to the growing demands of image and video applications in medicine, remote sensing, security, entertainment and education. Yet, effective image feature extraction, often regarded as a critical component in multimedia information processing, is not well attended. In order to efficiently retrieve an interested image in a large data base, it should be described by some keywords or automatically extracted visual features. However, in the case of a large image data base it will not be feasible to describe an image with keywords. This not only requires extensive labor, but also insufficient amounts of keywords exist to effectively characterize the contents of the image. Therefore automatic feature extraction and indexing of video images has been in a great demand. An efficient and effective image feature extraction algorithm, if successfully developed, can benefit greatly to emerging imagery applications such as biometric, medical diagnosis and geographical information system to cite a few.

Facial feature extraction plays an important role in law enforcement forensic investigation, low bit video coding, and security access control systems. State-of-the-art multimedia teleconferencing systems are based on digital video coding and transmission of television pictures. To better use the low bandwidth digital networks for this purpose, significant compression of data is mandatory. Images can be considered as having structural features such as contours and regions. These images have been exploited to encode images at low bit rates, while retaining sufficient visible structures in the reconstruction so as to maintain an acceptable level of quality .

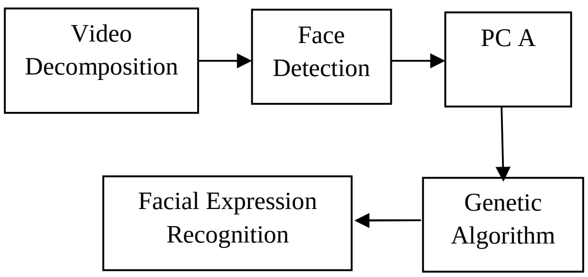
The method of Eigen faces uses Principal Components Analysis (PCA) to linearly project the image space to a low dimensional subspace (Eigen space). This subspace is defined by the principal components (Eigen faces) of the distribution of face images (i.e., the most important eigenvectors of the covariance matrix of the set of faces). Each face can be represented as a linear combination of the Eigen faces. Given an image, sub-images of different size are extracted at every image location. To classify an image as a face, its distance from the Eigen space vector is computed.

Facial expression plays an important role in recognition of human emotions. Basic facial expressions typically recognized by psychologists are happiness, sadness, anger, disgust and neutral. In the past, facial expression analysis was essentially a research topic for psychologists. However, recent progresses in image processing and pattern recognition have motivated significantly research works on automatic facial expression recognition. The recognition of facial expressions in image sequences with significant head motion is a challenging problem. It is required by many applications such as human-computer interaction and computer graphics animation. To classify expressions in still images many techniques have been proposed such as

Neural Nets, Gabor wavelets and active appearance models.

II. METHODOLGY

Block Diagram of Facial Expression Recognition using Genetic Algorithm



Video Decomposition:

The video (here .mpg file) is first decomposed into component frames and resized in a common size identical to the train database. The frames are then processed for noise reduction.

Face Detection

An important task to be carried out in the Systems of Recognition of Faces is to detect the presence of a face in a determined region of the image.

Methods of Face detection:

Knowledge Based:

This approach depends on using rules about human facial features to detect faces. Human facial features for examples as two eyes that are symmetric to each other, a nose and mouth, and

Features relative distances represent features relationships. After detecting features, a verification process is done to reduce false detection. This approach is good for frontal images. The difficulty of it is to translate human knowledge into known rules and to detect faces in different poses.

Image Based:

In this approach, there is a predefined standard face pattern is used to match with the segments in the image to determine whether they are faces or not. It uses training algorithms to classify regions into face or non-face classes.

Image-based techniques depends on multi-resolution window scanning to detect faces, so these techniques have high detection rates but slower than the feature-based techniques. Eigen faces and neural networks are examples of image- based techniques. This approach has advantage of being simple to implement, but it cannot effectively deal with variation in scale, pose and shape.

Features Based:

This approach depends on extraction of facial features that are not affected by variations in lighting conditions, pose, and other factors. These methods are classified according to the extracted features. Feature-based techniques depend on feature derivation and analysis to gain the required knowledge about faces. Features may be skin color, face shape, or facial features like eyes, nose, etc.... Feature based methods are preferred for real time systems where the multi-resolution window scanning used by image based methods are not applicable. Human skin color is an effective feature used to detect faces, although different people have different skin color, several studies have shown that the basic difference based on their intensity rather than their chrominance.

Preprocessing:

1) RGB to GRAY conversion: The original image is the rgb image. It is converted to gray scale image for further processing. The image is resized to get the size same as original image.
2) Noise Removal: Image is processed for noise removal.
3) Edge Detection: The edges are detected by sobel edge detector.
4) Round Object Estimation: The object with the maximum area and closest to ellipse is detected. The detected object is approximated to be the face.

Principal Component Analysis

Principal component analysis (PCA), or Kahunen-Loeve expansion, is applied to find facial aspects important in identification. Facial eigenvectors or, as they are sometimes called, Eigen pictures or Eigen faces, compactly represent whole faces, which is optimal for face reconstruction. Sirovich and Kirby first applied PCA in efficient face representation in which new co-ordinates are created for faces where coordinates are part of the eigenvectors of a set of face images. New faces are roughly reconstructed using only part of their projection onto new low-dimensional space. Matthew Turk and Alex Pentland expanded this idea to face recognition by encoding faces using a small set of weights corresponding to their projection onto new coordinates and are recognized by comparing them to those of known individuals.

Eigen faces work well in different expression changes. Improving PCA speed in face detection is required in real-time applications such as covert criminal surveillance. The PCA algorithm is applied to check for a face at each pixel in the input image. This search is realized using cross-correlation in the frequency domain between the entire input image and eigenvectors. This increases detection speed over normal PCA algorithm implementation in the spatial domain.

Using PCA Eigen vectors and Eigen features are identified and are then given to genetic algorithm to reduce the computational time. PCA calculates Eigen values with the help of covariance analysis. The Eigen vectors are sorted from high to low according to their corresponding Eigen values. The Eigen vector associated with the largest Eigen value is one that reflects the greatest variance in the image.

Genetic Algorithm

The Genetic algorithm is used in the proposed work to optimize the computational cost and to exploit the temporal correlation in the subsequent frames of a video sequence. The use of GA is explained partly here and partly in the simulation section.

The GA can be abbreviated in the following steps:
1. Initialization of the parent population
2. Selection of fit individuals
3. Crossover and mutation
4. Termination

1. Initialization of the Parent Population

The individual chromosome comprises of four sections:
1. The x coordinate of the centroid of the facial region
2. The y coordinate of the centroid of the facial region
3. The expression detected, i.e. the distance of the Eigen value of the given image frame to the average Eigen value of the 'NEUTRAL' test images. In the string representation this distance is rescaled by a factor of 100.
4. The frame number

Expression (4-Bits)	X-Coordinate (8 Bits)	Y-Coordinate (8 Bits)	Frame Number (8 Bits)

The initial population of 100 is taken. This population is not completely random as it carries deterministic information in the fourth part of its genome, i.e. the frame number. However the x and the y coordinates are chosen randomly. The expression is left zero for the initial parent population.

2. Selection of fit individuals, Crossover, Mutation and Termination

First of all, the fitness criteria need to be defined. To define the same, we calculate the actual x and y coordinates of the given video frame and compares it with the given individual. Also for every 10^{th} frame, we calculate the distance from the sample and here come the mutation. The expression string is mutated with a probability of 0.1. The mutation is a guided one and the mutated string takes the value generated from the PCA algorithm running over the same video frame. A population of 10 most fit individuals is selected from this initial population.

This fit population is now allowed to crossover. The individuals which have frame numbers nearer to each other have higher probability of crossover. The typical values taken in this model are 0.25 and 0.75, i.e. if the frame number falls within a distance of 50, the crossover probability is 0.75 and it decreases with 0.01 with unit increase in the distance. The lower limit of the probability is kept at 0.25.

The crossover is a two point crossover. The crossover is allowed to progress until the population reaches the 100 mark. Again the mutations are done and the fittest individual is computed. In this computation of fittest, the older generation does not participate. Though it does die outs only after reproducing 10 fit individuals. Else the process is repeated for a maximum of 10 times. After this the parent generation is termed to be incapable of producing fit individuals and hence dies out.

This process continues till there are at least 10 fit individuals in every 100 frames. Finally the expression recognition of the complete video sequence is done by approximating the expressions in the consequent frames. This approximation is more or less like extrapolating a linear line which is may be discontinuous but is not necessarily discontinuous.

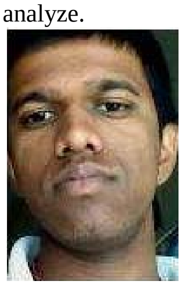
III. RESULTS AND CONCLUSION

The simulation is done in MATLAB environment. The algorithm was tested on a video of 408 frames. The details are tabulated in the following table

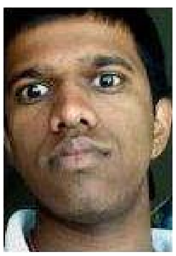
Expression	No of frame**	Time(in seconds)*	Error frames#
Sad	13	5	10
Anger	5	2	3
Happy	9	4	10
Neutral	5	2	4
Disgust	10	4	5
Total	**42**	**17**	**32**

The matlab code was run over a video of time duration 17 seconds with frame rate of 24 frames per second with dimension of 600 X 480. The code gave exact expressions for 15.5 seconds out of 17 seconds. Thus efficiency of this algorithm is 91.18 %. The maximum number of iterations required by the genetic algorithm was 8 with an average iteration of 3. Thus for a video of frame length 408, the PCA ran for 121 times as against 408 times in usual methods to detect expressions.

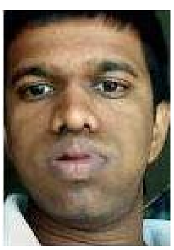
Thus the method is highly efficient and computationally 3 times cheaper than state of art algorithms. The proposed method gave very good results with a lesser computational costs. The run time of this algorithm was reduced to one third compared to that if PCA were to run over all the thousand frames. Thus this model can be further extended in near future to the expression in real time on a live surveillance system analyze.



NEUTRAL

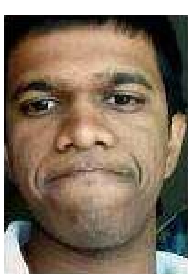


ANGER



DISGUST

HAPPY



SAD

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