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Face Expression and Analysis

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Abstract: This paper presents a system for human face expression recognition in a real time background world for a large homemade dataset of persons face. The task is inspiring as the real time expression recognition from human faces is still a challenge. Tallying to this there is a vast variation in human face expression in terms of similar facial features. The system proposed collapses most of this variance. To detect genuine human face AdaBoost with Haar cascade is used to recognize the faces detected. To diagnose the expressions from real human face, facial action coding system(FACS) is used from a learning data set. This biometric system is a real time expression recognition system based on the human face recognition with a simple and fast algorithms and gaining a high accuracy rate.

Keywords – Adaboost, Haar Cascade, FACS, Biometric system

I. INTRODUCTION

Physiognomy is the assessment of a person's character or personality from their outer appearance, especially the face. Study on facial expression has become very active topic.

A detailed note on the various expressions and movement of head muscles was given in 1649 by John Bulwer in his book *"Pathomyotomia"*.The first step towards the automatic recognition of facial expressions was taken in 1978 by Suwa et al. Suwa and his colleagues. They presented a system for analyzing facial expressions from a sequence of images (movie frames) by using twenty tracking points. The automatic recognition of facial expressions requires robust face detection and face tracking systems. These were research topics that were still being developed and worked upon in the 1980s. By the late 1980s and early 1990s, cheap computing power started becoming available. This led to the development of robust face detection and face tracking algorithms in the early 1990s. At the same time, Human-Computer Interaction and Affective Computing started gaining popularity. Researchers working on these fields realized that without automatic expression and emotion recognition systems, computers will remain cold and unreceptive to the users' emotional state. All of these factors led to a renewed interest in the development of automatic facial expression recognition systems.

In this paper we will further see how the faces will be detected and the expressions will be recognized using HAARCASCADE CLASSIFIER algorithm and Facial action units.

II. AIM and OBJECTIVE

Face recognition is one of the most relevant applications of image analysis. It's a true challenge to build an automated system which equals human ability to recognize faces. Although humans are quite good identifying known faces, we are not very skilled when we must deal with a large amount of unknown faces. The computers, with an almost limitless memory and computational speed, should overcome humans limitations.

There are some FaceReader tools available from few of the companies which are expensive in terms of facilities provided.

The proposed system covers the following aspects to overcome the drawbacks.

1. To implement the better and faster application.
2. To reduce the time of execution.
3. Highly qualified system to be developed at a latter phase.

III. LITERATURE SURVEY

3.1 *FACE DETECTION*

Different techniques of face recognition for still images are divided into three main groups such as holistic approach, feature-based approach, and hybrid approach.

1. Holistic Approach: - In this approach, input is taken as the whole face region in face detection system to perform face recognition.

2. Feature-based Approach: - In this approach, local features on face such as nose and eyes are segmented and then given to the face detection system to ease the task of face recognition.

3. Hybrid Approach: - In this approach, input is given both local features and the whole face to the face detection system. It is more similar to the behaviour of human being to recognize the face.

Face detection is a technology to determine the locations and size of a human face in a digital image. It only identifies facial expression and rest all is treated as background in the image and is subtracted from the image. It is a special case of object-class detection or in more general case as face localizer. Face-detection algorithms concentrated on the detection of frontal human faces, and also unravel the multi-view face detection problem. The various techniques used to detect the face in the image are as follows:

1. Face detection as a pattern-classification task: **-** In this technique there is a binary-pattern classification task. In which, the content of a given part of an image is transmuted into features, after which a classifier skilled on example faces decides whether that particular region of the image is face, or not.
2. Controlled background: **-** In this technique the background is motionless or is fixed. It removes the background and only the faces will be left, assuming the image contains a frontal face only.
3. By colour: **-** This technique is susceptible. In this skin color is used to segment the color image to find the face in the image. But the only drawback is that the still background of the same color will also be segmented.

3.2 FACE RECOGNITION

1. *Geometrical Feature Matching*: **-** This technique is based on the set of geometrical features of face from the image. The complete configuration can be defined by a vector demonstrating the position and size of the main facial features, such as eyes and eyebrows, shape of face outline, mouth, nose. One of the innovative works on automated face recognition by using geometrical features was ended by T. Kanade. Their system attained a peak performance of 75% recognition rate on a database of 20 people using two images per person, one as the model and the other as the test image. I.J. Coxel introduced a mixture-distance method which achieved 95% recognition rate on a query database of 685 individuals. In this method, each of the face was embodied by 30 manually extracted distances. First the matching process consumed the information presented in a topological graphics illustration of the feature points. Then the second after that will be reimbursing for the different centre location, two cost values which are, the topological cost, and similarity cost, are evaluated. In short, geometrical feature matching based on exactly measured distances between features which will be most useful for finding probable matches in a large database.

2. *Eigenfaces:* **-** Eigenface is a one of the most systematically examined method for face recognition . It is also known as Karhunen-Loeve expansion, principal component, eigenpicture and eigenvector. L. Sirovich and M. Kirby used principal component analysis to efficiently represent pictures of faces. Any face image could be approximately reassembled by a small collection of weights for each face and a standard face picture, that is, eigenpicture. The weights here are the obtained by projecting the face image onto the eigenpicture. In mathematics, eigenfaces are the set of eigenvectors used in the computer vision problem of human face recognition. The principal components of the distribution of faces, or the eigenvectors of the covariance matrix of the set of face image is the eigenface. Each face can be represented exactly by a linear combination of the eigenfaces. The best M eigenfaces construct an M dimension (M-D) space that is called the "face space" which is same as the image space discussed earlier. Illumination normalization is usually necessary for the eigenfaces approach. L. Zhao and Y.H. Yang proposed a new method to compute the covariance matrix using three images each was taken in different lighting conditions to account for arbitrary illumination effects, if the object is Lambertian A. Pentland, B. Moghaddam extended their early work on eigenface to eigenfeatures corresponding to face components, such as eyes, nose, mouth. Eigenfeatures combines facial metrics (measuring distance between facial features) with the eigenface approach . This method of face recognition is not much affected by the lighting effect and results somewhat similar results in different lighting conditions.

Adaboost Algorithm

AdaBoost is used as a short form for Adaptive Boosting, which is a widely used machine learning algorithm and is formulated by Yoav Freund and Robert Schapire. It's a metaalgorithm, algorithm of algorithm, and is used in conjunction with other learning algorithms to improve their performance of that algorithm(s). In our case abaBoost is combined with haar feature to improve the performance rate. The algorithm, AdaBoost is an adaptive algorithm in the sense that the subsequent classifiers built is tweaked in favor of instances of those misclassified by the previous classifiers. But it is very sensitive to noise data and the outliers.

In boosting, weights are also assigned to each training tuple. A series of k classifiers is iteratively learnt. After a classifier, Mi, is learned, the weights are updated to allow the subsequent classifier, Mi+1, to "pay more attention" to the training tuples that were misclassified by Mi. the final boosted classifier, M*, combines the votes of each individual classifier, where the weight of each classifier's vote is a function of its accuracy.

Suppose we want to boost the accuracy of a learning method. We are given D, a data set of d class-labeled tuples, (X1,y1),(X2,y2),….,(Xd,yd),where yi is the class label of tuple xi. Initially, AdaBoost assigns each training tuple an equal weight of 1/d. Generating k classifiers for the ensemble requires k rounds through the rest of the algorithm. In round i, the tuples from D are sampled to form a training set, di , of size d. Sampling with replacement is used- the same tuple may be selected more than once. Each tuples chance of being selected is based on its weight. A classifier model, Mi is derived from the training tuples of Di .Its error is then calculated using Di as a test set. The weights of the training tuples are then adjusted according to how they are classified.

If a tuple was incorrectly classified, weight is increased. If a tuple was correctly classified, its weight decreased. A tuples weight reflects how difficult it is to classify-the higher the weight, the more often it has been misclassified. These weights will be used to generate the training samples for the classifier of the next round. The basic idea is that when we build a classifier, we want it to focus more on the misclassified tuples of the previous round. Some classifiers may be better at classifying some "difficult" tuples than others.

Algorithm: AdaBoost. A boosting algorithm-create an ensemble of classifiers.
Each one gives a weighted vote.
Input:
D, a set of d class-labeled training tuples;
K, the number of rounds(one classifier is generated per round);
A classification learning scheme.
Output: A composite model.

Method:
Initialize the weight of each tuple in D to 1/d;
for i=1 to k do //for each round:
sample D with replacement according to tuple weights to obtain Di ;
use training set Di to derive a model Mi ;
compute error (Mi),the error rate of Mi ;
if error (Mi)>0.5 then
go back to step 3 and try again;
endif
for each tuple in Di that was correctly classified do
multiply the weight of the tuple by error (Mi)/(1-error(Mi));//update weights
normalize he weight of each tuple;
endfor

HAAR Cascade Classifier

A Haar Classifier is also a machine learning algorithmic approach for the visual object detection, originally given by Viola & Jones. This technique was originally intended for the facial recognition but it can be used for any other object. The most important feature of the Haar Classifier is that, it quickly rejects regions that are highly unlikely to be contained in the object. The core basis for Haar cascade classifier object detection is the Haar-like features. These features, rather than using the intensity values of a pixel, use the change in contrast values between adjacent rectangular groups of pixels. The variance of contrast between the pixel groups are used to determine relative light and dark areas. The various Haar-like-features are shown in the figure. The set of basic Haar-like-feature is shown in figure, rotating which the other features can be generated. The value of a Haar-like feature is the difference between the sum of the pixel gray level values within the black and white rectangular regions, i.e., *f(x)=Sumblack rectangle (pixel gray level) – Sumwhite rectangle (pixel gray level)*

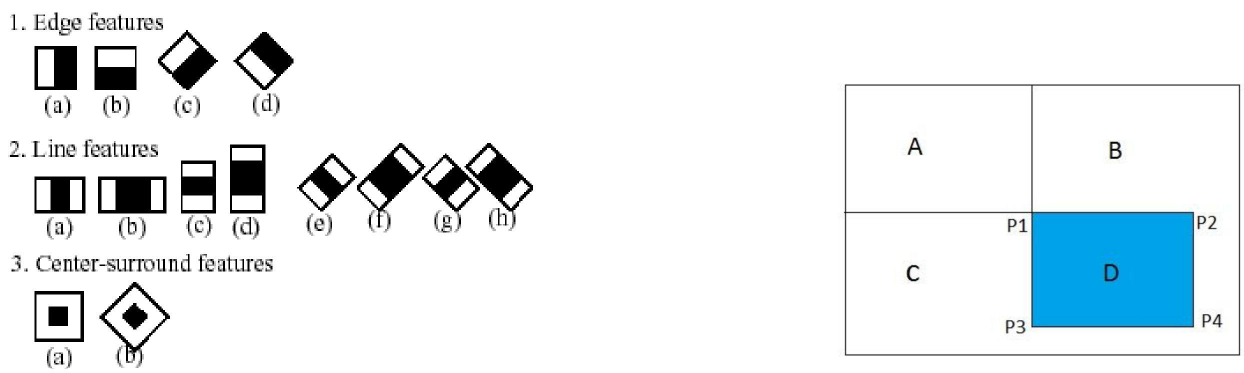


Figure 1: Haar – like features[1]

Comparing with the raw pixel values, Haar-like features can reduce/increase the in-class/out-of class variability, and thus making classification much easier. The rectangle Haar-like features can be computed rapidly using "integral image". Integral image at location of x, y contains the sum of the pixel values above and left of x, y, inclusive:
The sum of pixel values within "D":

$$p(x,y) = \sum_{x' \leq x, y' \leq y} i(x', y')$$

$P_1 = A$, $P_2 = A+B$, $P_3 = A+C$, $P_4 = A+B+C+D$
$P_1+P_4-P_2-P_3 = A+A+B+C+D-A-B-A-C = D$

Using this Haar-like features the face detection cascade can be designed as in the figure 3, below. In this Haar cascade classifier an image is classified as a human face if it passes all the conditions, {f1, f2…, fn}. If at any stage any of one or more conditions is false then the image does not contain the human face.

3.3 *FACIAL FEATURE EXTRACTION*

Facial feature extraction is essential for identification of an individual face on a computer. As facial features, the shape of facial parts is spontaneously extracted from a frontal face image. There are three methods of facial feature extraction which are as follows :

1. Geometry-based: **-** This technique is proposed by Kanada. The eyes, mouth and nose base are localized using the vertical edge map. This techniques requires threshold, which gives the prevailing sensitivity, and it may adversely affect the achieved performance.
2. Template-based: **-** This technique equals the facial components to formerly designed templates using appropriate energy functional. Genetic algorithms have been projected for more efficient searching times in template matching.
3. Color segmentation techniques: **-** This technique uses skin color to isolate the facial and non-facial part in the image. Any non-skin color region within the face is viewed as a candidate for eyes or mouth.

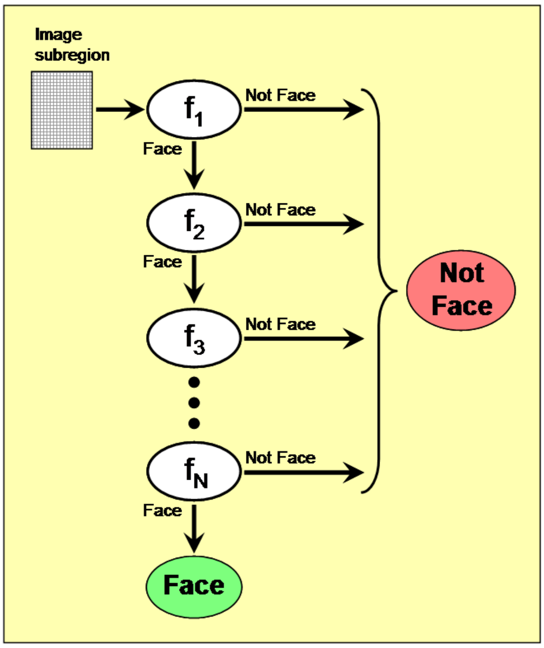


Figure 3: The cascade classifier classified face and non-face[1]

We have included the following basic set of emotions which have large difference in their geometry, so they are easy to be recognized.

Primary Emotions	Secondary Emotions
Neutral	**Neutral, Relief**
Smile	**Joy, Cheerfulness**
Surprise	**Surprise, Amazement**
Anger	**Irritation, Rage, Disgust, Envy**
Sadness	**Disappointment, Shame, Suffering**
Fear	**Horror, Nervousness**

Table 1: Basic emotions attained

Contraction of the facial muscles produces changes in both the direction and magnitude of the motion on the skin surface and in the appearance of permanent and transient facial features. Examples of permanent features are the lips, eyes, and any furrows that have become permanent with age. Transient features include any facial lines and furrows that are not present at rest. We assume that the first frame is in a neutral expression. After initializing the templates of the permanent features in the first frame, both permanent and transient features can be tracked and detected in the whole image sequence regardless of the states of facial components. The tracking results show that our method is robust for tracking facial features.

Lip features: A threestate lip model is used for tracking and modeling lip features. As shown in Table 2, we classify the mouth states into open, closed, and tightly closed. Different lip templates are used to obtain the lip contours. Currently, we use the same template for open and closed mouth. Two parabolic arcs are used to model the position, orientation, and shape of the lips. The template of open and closed lips has six parameters: lip center (xc, yc), lip shape (h1, h2 and w), and lip orientation (_). For a tightly closed mouth, the dark mouth line connecting lip corners is detected from the image to model the position, orientation, and shape of the tightly closed lips. After the lip template is manually located for the neutral expression in the first frame, the lip color is obtained by modeling as a Gaussian mixture. The shape and location of the lip template for the image sequence is automatically tracked by feature point tracking. Then, the lip shape and color information are used to determine the lip state and state transitions.

Eye features: Most eye trackers developed so far are for open eyes and simply track the eye locations. However, for recognizing facial action units, we need to recognize the state of eyes, whether they are open or closed, and the parameters of an eye model, the location and radius of the iris, and the corners and height of the open eye. As shown in Table 2, the eye model consists of "open" and "closed". The iris provides important information about the eye state. If the eye is open, part of the iris normally will be visible. Otherwise, the eye is closed. For the different states, specific eye templates and different algorithms are used to obtain eye features.

For an open eye, we assume the outer contour of the eye is symmetrical about the perpendicular bisector to the line connecting two eye corners. The template, illustrated in Table 2, is composed of a circle with three parameters (x0; y0; r) and two parabolic arcs with six parameters (xc; yc; h1; h2;w; _). This is the same eye template as Yuille's except for two points located at the center of the whites. For a closed eye, the template is reduced to 4 parameters for each of the eye corners. The default eye state is open. Locating the open eye template in the first frame, the eye's inner corner is tracked accurately by feature point tracking. We found that the outer corners are hard to track and less stable than the inner corners, so we assume the outer corners are on the line that connects the inner corners. Then, the outer corners can be obtained by the eye width, which is calculated from the first frame. Intensity and edge information are used to detect an iris because the iris provides important information about the eye state. A halfcircle iris mask is used to obtain correct iris edges. If the iris is detected, the eye is open and the iris center is the iris mask center (x0; y0). In an image sequence, the eyelid contours are tracked for open eyes by feature point tracking. For a closed eye, we do not need to track the eyelid contours. A line connects the inner and outer corners of the eye is used as the eye boundary.

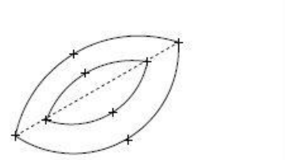
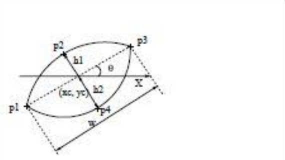
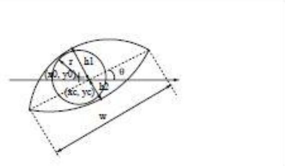
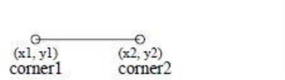
Component	State	Description/Feature
Lip	Opened	
	Closed	
	Tightly closed	
Eye	Open	
	Closed	

Table 2: facial component models

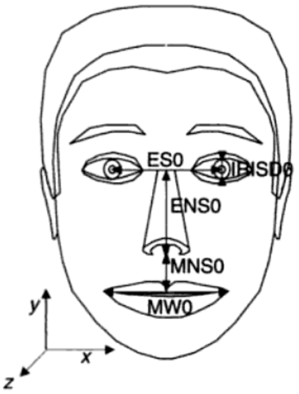


Figure 4: Multistate model for AU.

FACIAL ACTION UNIT DEFINITIONS

Ekman and Friesen developed the Facial Action Coding System (FACS) for describing facial expressions by action units (AUs) or AU combinations. 30 FACS AUs are anatomically related to contraction of a specific set of facial muscles. Of these, 12 are for upper face, and 18 are for lower face. Action units can occur either singly or in combinations. The action unit combinations may be additive, in which case combination does not change the appearance of the constituents, or non-additive, in which case the appearance of the constituents does change. Although the number of atomic action units is small, more than 7,000 combinations of action units have been observed.

IV. IMPLEMENTATION DETAILS

The overall system is divided into three basic modules: face detection, face recognition and expression generator. The third module which uses the values from the data base to generate expression.

The combined flowchart of all the modules are as follows:

- Image is taken as input supporting the .jpg and .png formats.
- The image is scanned for skin colour.
- Then the largest connected region is found.
- Face is detected in the largest available region.
- The available portion is skimmed for the facial features.
- If the facial features are available then organize it as left eye, right eye and lips.
- Find the coordinates of the eyes and lips.
- Match the coordinates with the database to recognise the Expression.

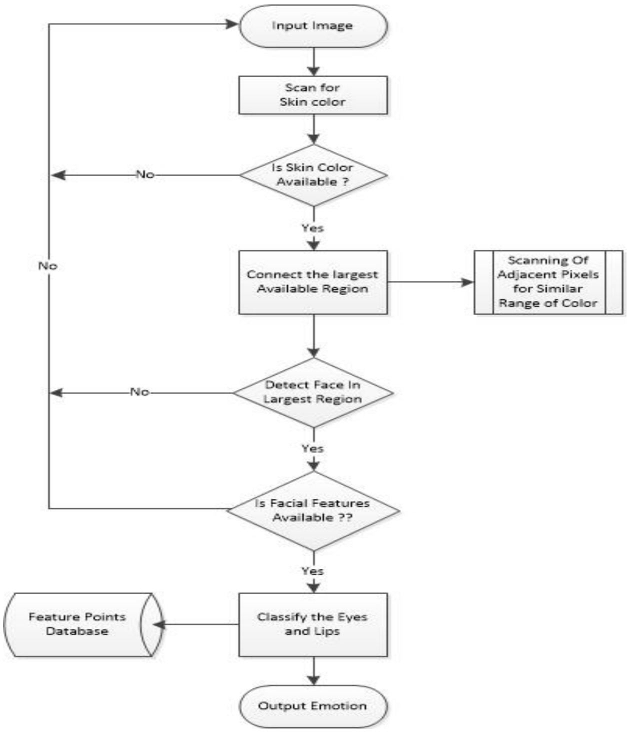
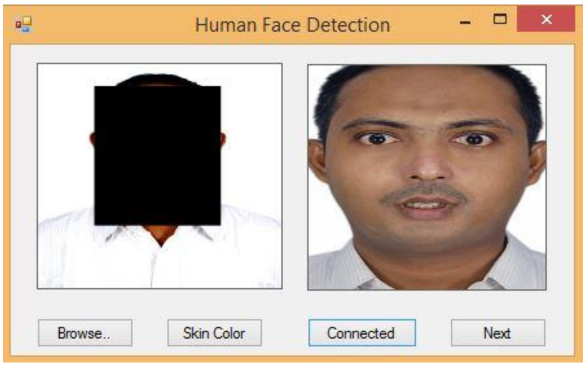
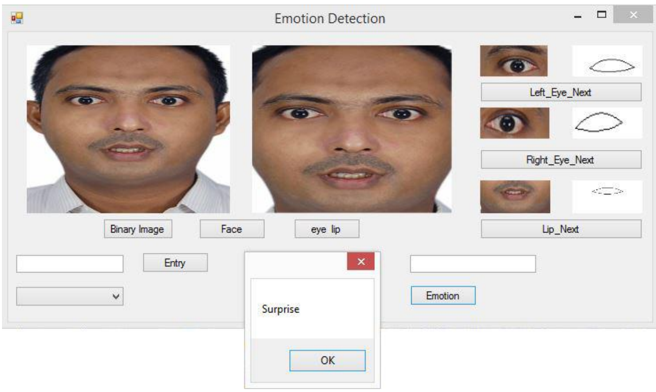


Figure 4: Flowchart of workflow

Sample Images for learning

Browse: Insert the image in the format of .jpg or .png. It gets inserted to the first left jpanel.
Skin Colour: On Clicking the button of skin colour it calls the method of Haar Classifier to connect the largest available region Of same Colour.
Connected: After scanning for skin Colour and connecting the largest area we enhance the portion of the face.





Binary Image: when we get the face in the image we convert it to binary image to extract the borders containing the facial features.
Feature Extraction: The next step is to retain the facial area which contains all the features through the help of binary image.
The next step to extraction is to create binary images from the classified features of the given face.

After creating the classified features like left, right eyes and lips the algorithms calculates the coordinates of eyes and lips respectively. Since we have using the Adaboost technique we can also enter the new name for the expression. The coordinates are saved for the next use off the application along the entered name.
When we access the emotion button on the window to get the expression, the expression is generated to the trained accuracy of the object.

V. CONCLUSION

The system has been verified on a wide variety of face images, with many emotions and many different angles other than frontal face image and to provide the safekeeping of person entry or out form the room or lab, whether the person is lawful or not. The system is highly accurate. The system is skilled of using multi-cameras as the capturing device simultaneously and providing the detail of person of recognize whether it is valid or invalid.
Face expression recognition systems has improved rapidly over the past decade. The focus has definitely moved from posed expression recognition to spontaneous expression recognition. The next decade will be interesting since it is possible that robust impulsive expression recognizers will be developed and organized in real-time systems and used in constructing emotion sensitive HCI interfaces. This will have an impact on our day to day life by improving the way we interact with computers or in general, our surrounding living and work spaces. Recognizer is much more than transformations and expression equivalence. The infrastructure for recognizer is significant. We completed the module by deploying the user interface of our application. Designing effective and correct transformations is hard, developing a robust cost metric is elusive, and building extensible enumeration architecture is a significant undertaking. Despite many days of work, significant open problems remain. However, an understanding of the existing engineering framework is necessary for making effective contribution to the area of expression recognizer. While much research has been focused on heuristics and histogram to reduce the search space enumerated by expression recognizers, and on optimizing for parallel execution of queries, we believe that our work is the first to successfully explore parallelizing the process of optimizing queries.
We believe that this work lays the foundation for future studies on parallel expression recognizer. The future work includes parallelizing different types of recognizers such as top-down recognizer as well as comparing the quality of plans produced by the randomized approach and our parallelized DP approach using the same running time.

FUTURE SCOPE

1. Automatic face expression recognition systems find applications in several interesting areas. With the recent advances in robotics, especially humanoid robots, the urgency in the requirement of a robust expression recognition system is evident. As robots begin to interact more and more with humans and start becoming a part of our living spaces and work spaces, they need to become more intelligent in terms of understanding the human's moods and emotions. Expression recognition systems will help in creating this intelligent visual interface between the man and the machine.
2. Facial expression recognition systems find uses in a host of other domains like Telecommunications, Behavioral Science, Video Games, Animations, Psychiatry, Automobile Safety, Affect sensitive music juke boxes and televisions, Educational Software, etc.
3. Recent advances in neuroimaging (Neuroimaging includes the use of various techniques to either directly or indirectly image the structure, function/pharmacology of the brain.) have facilitated examination of brain

development, and have allowed for exploration of the relationships between the development of emotion processing abilities, and that of associated neural systems.

4. Facial expressive behavior is of interest to many researchers investigating emotion and its relationship to other aspects of behavior, such as emotional experience, physiological arousal, and communication.
5. Facial expressive behavior is important in a number of treatments that target social skills training for patients diagnosed with schizophrenia, depression, social anxiety disorder.

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