Emotion Detector

Dinesh Kumar.K, Ganesh Kumar.M, Karthik Raja.M[1]
IV Year UGStudents, Dept. of ECE
Sri Shakthi Institute of Engineering and Technology
Coimbatore, Tamilnadu, India

S.Raja[3]
Assistant Professor, Dept. of ECE
Sri Shakthi Institute of Engineering and Technology
Coimbatore, Tamilnadu, India
Email:raja.s@siet.ac.in

Mr.T.Sivaprakasam[2]
Assistant Professor, Dept. of ECE
Sri Shakthi Institute of Engineering and Technology
Coimbatore, Tamilnadu, India
Email:tsivaprakasam@siet.ac.in

Abstract—Face plays significant role in social communication. This is a 'window' to human personality, emotions and thoughts. Verbal part contributes about 7% of the message, vocal – 34% and facial expression about 55%. Due to that, face is a subject of study in many areas of science such as psychology, behavioral science, medicine and finally computer science. In the field of computer science much effort is put to explore the ways of automation the process of face detection and segmentation. Several approaches addressing the problem of facial feature extraction have been proposed. The main issue is to provide appropriate face representation, which remains robust with respect to diversity of facial appearances. The objective of this report is to outline the problem of facial expression recognition, which is a great challenge in the area of computer vision. Advantages of creating a fully automatic system for facial action analysis are constant motivation for exploring this field of science and will be mentioned in this thesis.

Keywords*-Face , detection and segmentation, facial expression recognition , computer vision.*

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I. INTRODUCTION

Face plays significant role in social communication. This is a 'window' to human personality, emotions and thoughts. Verbal part contributes about 7% of the message, vocal – 34% and facial expression about 55%. Due to that, face is a subject of study in many areas of science such as psychology, behavioral science, medicine and finally computer science. In the field of computer science much effort is put to explore the ways of automation the process of face detection and segmentation. Several approaches addressing the problem of facial feature extraction have been proposed. The main issue is to provide appropriate face representation, which remains robust with respect to diversity of facial appearances. The objective of this report is to outline the problem of facial expression recognition, which is a great challenge in the area of computer vision. Advantages of creating a fully automatic system for facial action analysis are constant motivation for exploring this field of science and will be mentioned in this thesis.

The Feature Engineering Problem

Even once we get over the hurdle of choosing a framework for understanding emotion and acquiring well-labeled training data, there's still another issue before diving into algorithms: nobody is quite sure what the features should be.

In Machine Learning, we use a dataset as an input to predict and create some sort of output. The dataset has features: think of these as the columns in a spreadsheet. For a normal and simple dataset, features might be “inches of rain today” or “number of engagements for a customer.” But when we're dealing with Affective Computing, there are only 3 possible inputs – text, speech, and image/video – and none follow the traditional data format.

Feature engineering, or deciding what the best possible inputs for our model are, is also a complex issue in Sentiment Analysis, which is the broad parent topic of emotion recognition. It might help, for example, to include whatever the previous sentence was along with the current sentence as an input. Adding that type of context to each data is what feature engineering or feature extraction is all about. For more detail on feature engineering around sentiment analysis, check out our post about the topic.

Unsupervised Emotion Recognition

While most of the work in Affective Computing has been done using labeled datasets and supervised learning, a few research efforts have centered around a less top-down approach – segmenting the data we have automatically and seeing what kinds of emotions result. These methods often also take context and sentence structure into account to reach tighter classifications.

Some also explicitly try to expand beyond the often confining limits of FACS, like this paper released at a conference in 2012. According to the abstract, "The proposed methodology does not depend on any existing manually crafted affect lexicons such as WorldNet-Affect, thereby rendering our model flexible enough to classify sentences beyond Ekman's model of six basic emotions." Another approach using the dimensional model is proposed.

II. LITERATURE SURVEY

[1] The system that is designed for automatic analysis of facial actions is usually called Facial Expression Recognition System (FERS). The FER system is composed of 3 main elements: face detection, feature extraction and expression recognition. Different methods were proposed for each stage of the system, however, only the major ones will be mentioned in the report. More in-depth study and comparison of related work can be found in surveys done by Pantic and Rothkrantz as well as by Zeng et al. Firstly, I would like to outline the basic idea of the FER system and explain the most important issues which should be taken under consideration in the process of system design and development. Then, each FER system stage will be described in details, namely: main task, typical problems and proposed methods. Furthermore, the recent advances in the area of facial expression analysis will be listed.Finally, some exemplary applications of FER systems will be mentioned to show that they are widely used in many fields of science as well as in everyday life.[2]Face recognition presents a challenging problem in the field of image analysis and computer vision. The security of information is becoming very significant and difficult. Security cameras are presently common in airports, Offices, University, ATM, and Bank and in any locations with a security system. Face recognition is a biometric system used to identify or verify a person from a digital image. Face Recognition system is used in security. Face recognition system should be able to automatically detect a face in an image. This involves extracts its features and then recognize it, regardless of lighting, expression, illumination, ageing, transformations and pose, which is a difficult task. [3] In recent years, the biometrics has achieved a great attention on a world level. A Biometric System operates by getting biometric information from a personal that extracts a feature set from the data which is acquired, and helps in comparing this feature set against the template stored in the database. There are biometric technologies which could either be physiological or behavioral. Face Recognition is having the importance to provide biometric authentication with easy image acquisition that can be used for online and offline applications.[4] There are number of existing approaches for biometricfacial recognition and classification. This paper gives a review on some of the common and reliable approaches which include PCA, LDA, SVM, SIFT, SURF, etc., Biometrics refers to the automatic identification of a person based on his or her physiological or behavioral characteristics. This identification method is preferred over traditional methods involving passwords and PINs for several reasons including the person to be identified is required to be physically present at the point of identification and/or identification based on biometric techniques obviates the need to remember a password and carry a token. [5]The face detection is the process of extracting the face region from the position of the face in the image. This step is require because images having a different scales. Input image having a complex backgrounds and variety of lightning conditions can be also quite confusing in tracking. Face expression recognition tends to fail if the test image has a different lighting condition than that of the training images. For that Facial point can be detected inaccurately for that pre-processing step is required.

III. EXISTING SYSTEM

In 1960s, the first semi-automated system for facial recognition to locate the features (such as eyes, ears, nose and mouth) on the photographs.. In 1970s, Goldstein and Harmon used 21 specific subjective markers such as hair color and lip thickness to automate the recognition. In 1988, Kirby and Sirovich used standard linear algebra technique, to the face recognition.

IV. PROPOSED SYSTEM

The goal of this project was to design and implement the facial expression recognition system. On a basis of the extensive study of different approaches to the problem of face action representation, appropriate algorithms were selected for each stage of a system. The proposed system is built in traditional manner and consists of 3 stages: face detection and tracking, face expression representation and expression recognition. System operates on both static images and image sequences. Static images are used in training and testing procedures but the interaction with a system is designed for video analysis.

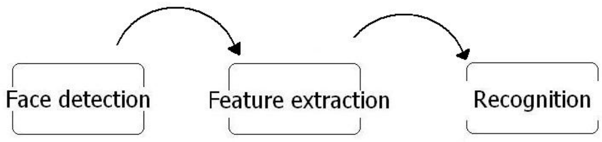

Figure 1: The Structure Of EM System

Methodology

The detection and recognition implementation proposed here is a supervised learning model that will use the one versus- all (OVA) approach to train and predict the seven basic emotions (anger, contempt, disgust, fear, happiness, sadness, and surprise).The overall face extraction from the image is done first using a Viola-Jones cascade object face detector. The Viola-Jones detection framework seeks to identify faces or features of a face (or other objects) by using simple features known as Haar-like features. The process entails passing feature boxes over an image and computing the difference of summed pixel values between adjacent regions. The difference is then compared with a threshold which indicates whether an object is considered to be detected or not. This requires thresholds that have been trained in advance for different feature boxes and features. Specific feature boxes for facial features are used, with expectation that most faces and the features within it will meet gener1al conditions. Essentially, in a feature-region of interest on the face it will generally hold that some areas will be lighter or darker than surrounding area. For example, it is likely that the nose is more illuminated than sides of the face directly adjacent, or brighter than the upper lip and nose bridge area. Then if anappropriate Haar-like feature, such as those shown in Figure 1, is used and the difference in pixel sum for the nose and the adjacent regions surpasses the threshold, a nose is identified. It is to be noted that Haar-like features are very simple and are therefore weak classifiers, requiring multiple passes.

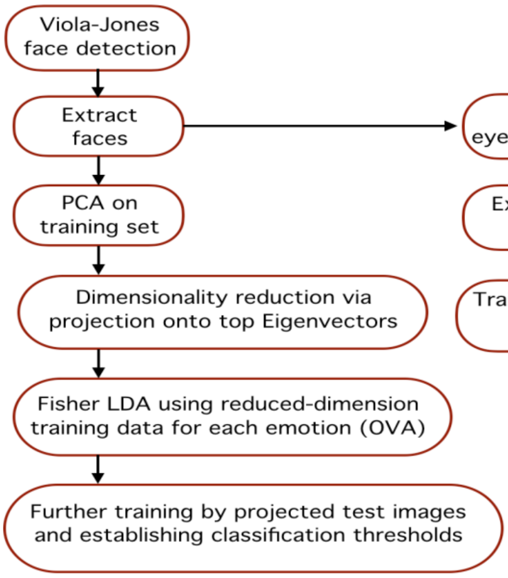

Figure 2: Training Pipeline

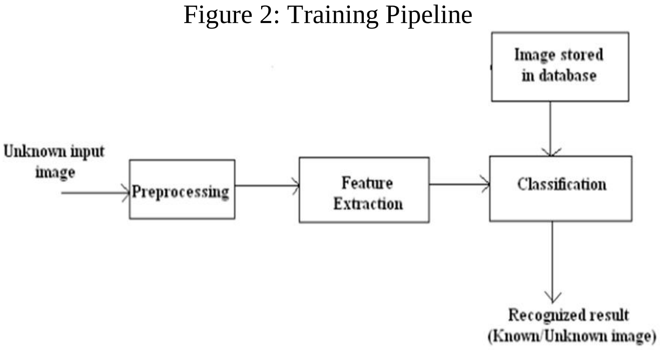

Figure 3: Block Diagram

Face Detection and Tracking

As it was mentioned before, FER system consists of 3 stages. In the first stage, system takes input image and performs some image processing techniques on it in order to find the face region. System can operate on static images, where this procedure is called face localization or videos where we are dealing with face tracking. Major problems which can be encountered at this stage are different scales and orientations of face. They are usually caused by subject movements or changes in distance from camera. Significant body movements can also cause drastic changes in position of face in consecutive frames what makes tracking harder. What is more, complexity of background and variety of lightning conditions can be also quite confusing in tracking. For instance, when there is more than one face in the image, system should be able to distinguish which one is being tracked.

PCA(Principal Component Analysis):

Principal Components Analysis (PCA) creates Eigen Vectors and Eigen values of given image. This takes few steps with many calculations to calculate it. Principal Components Analysis (PCA) is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences.

PCA also known as Karhunen Loeve projection). It is one of the more successful techniques of face recognition. In this project we use PCA after applying Viola Jones method on the image. When you apply viola jones it extracts the feature of image. Classify the features by numbering them. There are two types of features that are usually used to describe facial expression: geometric features and appearance features. Geometric features measure the displacements of certain parts of the face such as brows or mouth corners, while appearance features describe the change in face texture whenparticular action is performed. Apart from feature type, FER systems can be divided by the input which could be static images or image sequences. The task of geometric feature measurement is usually connected with face region analysis, especially finding and tracking crucial points in the face region. Possible problems that arise in face decomposition task could be occlusions and occurrences of facial hair or glasses. Furthermore, defining the feature set is difficult, because features should be descriptive and possibly not correlated.

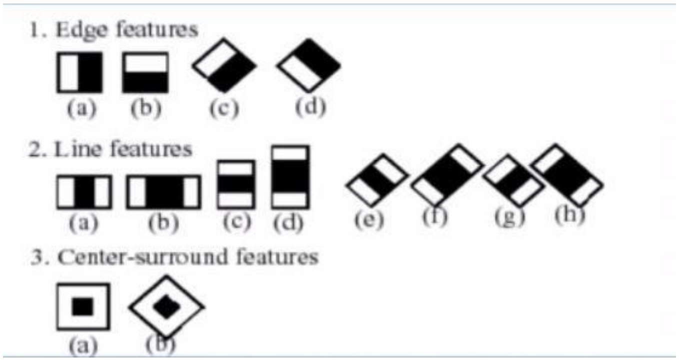

Figure4:Examples of Haar-Like Features

Feature value is calculated by subtracting sum of the pixels covered by white rectangle from sum of pixels under gray rectangle. Two rectangular features detect contrast between two vertically or horizontally adjacent regions. Three rectangular features detect contrasted region placed between two similar regions and four rectangular features detect similar regions placed diagonally.Input image is transformed into integral image in which each pixel is a sum of all pixels above and to the left. This is computed in one pass, thus feature can be computed rapidly because the value of each rectangle requires only 4 pixel references. Having the representation of the image in rectangular features, the classifier needs to be trained to decide if the image contains searched object (face) or not. The number of features is much higher than the number of pixels in the original image. However, it was proven that even a small set of well-chosen features can build a strong classifier.

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Figure 5: Face Detection Procedures

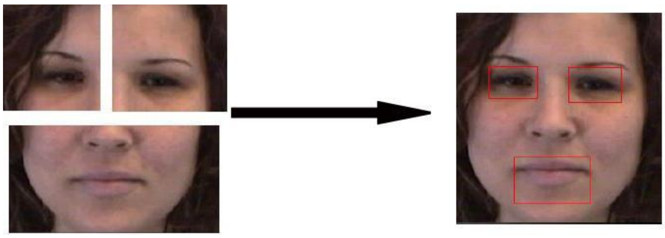

Figure 6: Face Elements Localization

Having locations of the face and facial landmarks, the face representation can be formed. If there are more faces detected in the image, the algorithm takes the biggest one for further processing.

Feature Extraction

After the face has been located in the image or video frame, it can be analyzed in terms of facial action occurrence.

There are two types of features that are usually used to describe facial expression: geometric features and appearance features. Geometric features measure the displacements of certain parts of the face such as brows or mouthcorners, while appearance features describe the change in face texture when particular action is performed. Apart from feature type, FER systems can be divided by the input which could be static images or image sequences. The task of geometric feature measurement is usually connected with face region analysis, especially finding and tracking crucial points in the face region. Possible problems that arise in face decomposition task could be occlusions and occurrences of facial hair or glasses. Furthermore, defining the feature set is difficult, because features should be descriptive and possibly not correlated.

LBP Encoding

Local Binary Patterns were introduced by Olaja et al. as an effective texture descriptors.Input image is transformed into LBP representation by sliding window technique where value of each pixel in the neighborhood is threshold with value of central pixel. Central pixel is encoded with LBP code (binary or decimal) in corresponding LBP image pixel. Binary codes are so called 'micro-texton' that represents texture primitives such as curved edges, flat or convex areas.

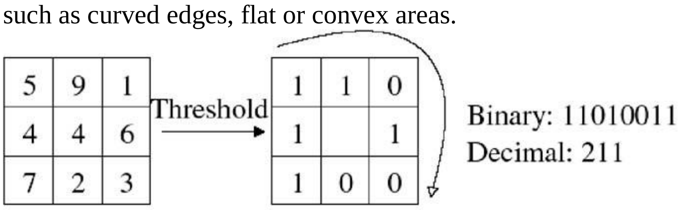

Figure 7: LBP Encoding

Basic version of LBP uses 3x3 sliding window to code the texture. Recently, the operator has been extended to different sizes and shapes (circular neighborhood). The size of the neighborhood directly influences the range of code values. Having operator of size P and radius R, the range of possible codes are from 0 to 2P. The image texture is described by a 2P bin histogram of corresponding LBP image. Encoding facial texture features can be done in holistic or analytic way. Holistic approach encodes whole face region with LBP features. The disadvantage of this approach is that spatial information about texture is lost. In the second method face region is divided into a grid of patches and each patch is transformed to LBP histogram separately. The latter method encodes the spatial information about the face texture. However, many patches consist of data that is not affected by expression like hair or neck parts. That is why, in my system the LBP operator is applied on two regions that are highly involved in face activity. Those regions are forehead-eyes area and chin-mouth-cheeks area. Regions are estimated with regard to face representation created in the first module of my system.

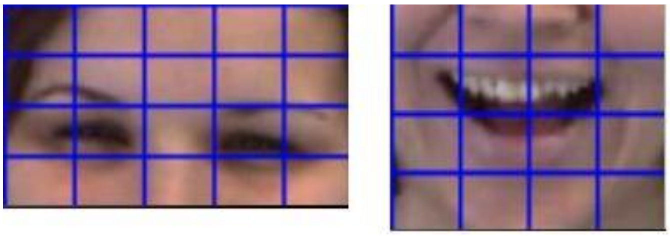

Figure 8: Face Region Grids

Figure 9: Visualization of Feature Set

The last part of the FER system is based on machine learning theory; precisely it is the classification task. The input to the classifier is a set of features which were retrieved from face region in the previous stage. The set of features is formed to describe the facial expression. Classification requiressupervised training, so the training set should consist of labeled data. Once the classifier is trained, it can recognize input images by assigning them a particular class label. The most commonly used facial expressions classification is done both in terms of Action Units, proposed in Facial Action Coding System and in terms of universal emotions: joy, sadness, anger, surprise, disgust and fear. There are a lot of different machine learning techniques for classification task, namely: K-Nearest Neighbors, Artificial Neural Networks, Support Vector Machines, Hidden Markov Models, and Expert Systems with rule based classifier, Bayesian Networks or Boosting Techniques

V. SOFTWARE DESCRIPTION

MATLAB

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include:

- Math and computation
- Algorithm development
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics
- Application development, including Graphical User Interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar no interactive language such as C or FORTRAN.

THE MATLAB LANGUAGE

This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw-away programs, and "programming in the large" to create complete large and complex application programs.

THE MATLAB WORKING ENVIRONMENT

This is the set of tools and facilities that you work with as the MATLAB user or programmer. It includes facilities for managing the variables in your workspace and importing and exporting data. It also includes tools for developing, managing, debugging, and profiling M-files, MATLAB's applications.

HANDLE GRAPHICS

This is the MATLAB graphics system. It includes high-level commands for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level commands that allow you to fully customize the appearance of graphics as well as to build complete Graphical User Interfaces on your MATLAB applications.

The Mat lab Mathematical Function Library

This is a vast collection of computational algorithms ranging from elementary functions like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigenvalues, Bessel functions, and fast Fourier transforms.

The Mat lab Application Program Interface (API)

This is a library that allows you to write C and FORTRAN programs that interact with MATLAB. It include facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files.

The goal of FERS is to imitate the human visual system in the most similar way. This is very challenging task in the area of computer vision because not only it requires efficient image/video analysis techniques but also well-suited feature vector used in machine learning process. The first principle of FER system is that it should be effortless and efficient. The constraints about facial hair, glasses or additional make-up should be reduced to minimum. Moreover, handling the occlusions problem seems to be a challenge for a system and it should be also taken into account.

Other important features that are desired in FER system are user and environment independence. The former means that, any user should be allowed to work with the system, despite of skin color, age, gender or nation. The latter is connected with handling the complex background and variety in lightning conditions. Additional benefit could be the view independence in FERS, which is possible in systems based on 3D vision.

Facial Expressions Evolutionary Reasons

A common assumption is that facial expressions initially served a functional role and not a communicative one. I will try to justify each one of the seven classical expressions with its functional initially role:

Anger

Involves three main features- teeth revealing, eyebrows down and inner side tightening, squinting eyes. The function is clear- preparing for attack. The teeth are ready to bite and threaten enemies, eyes and eyebrows squinting to protect the eyes, but not closing entirely in order to see the enemy.

Figure10: Anger and Disgust

Disgust

Involves wrinkled nose and mouth. Sometimes even involves tongue coming out. This expression mimics a person that tasted bad food and wants to spit it out, or smelling foul smell.

Fear

Involves widened eyes and sometimes open mouth. The function- opening the eyes so wide is supposed to help increasing the visual field (though studies show that it doesn't actually do so) and the fast eye movement, which can assist finding threats. Opening the mouth enables to breath quietly and by that not being revealed by the enemy.

Surprise

It is very similar to the expression of fear. Maybe because a surprising situation can frighten us for a brief moment, and then it depends whether the surprise is a good or a bad one. Therefore the function is similar.

Sadness

It involves a slight pulling down of lip corners, inner side of eyebrows is rising. Darwin explained this expression by suppressing the will to cry. The control over the upper lip is greater than the control over the lower lip, and so the lower lip drops.

Contempt

It involves lip corner to rise only on one side of the face. Sometimes only one eyebrow rises. This expression might look like half surprise, half happiness. This can imply the person who receives this look that we are surprised by what he said or did (not in a good way) and that we are amused by it. This is obviously an offensive expression that leaves the impression that a person is superior to another person.

Happiness

Usually involves a smile- both corner of the mouth rising, the eyes are squinting and wrinkles appear at eyes corners. The initial functional role of the smile, which represents happiness, remains a mystery. Some biologists believe that smile was initially a sign of fear. A smile encourages the brain to release endorphins that assist lessening pain and resemble a feeling of wellbeing.

VI. RESULTS AND DISCUSSIONS

I have analyzed each of the seven facial expressions, and compared the success percentage of men and women in each part of the experiment.

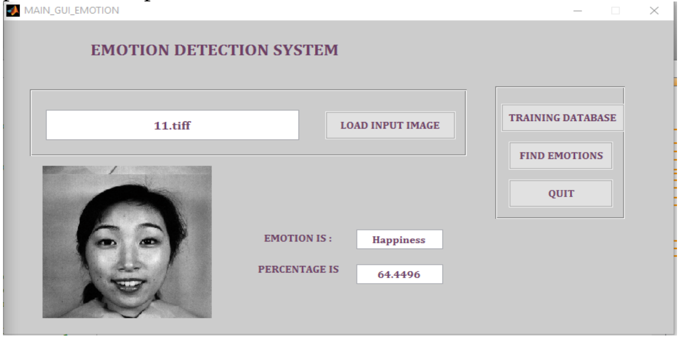

Figure 11:Emotion Detection

As we can see in the graph, women and men identified happiness in similar percentages.The most interesting part, in my opinion, is that happiness was identified in almost 100% success. My assumption n is that happiness, being a positive emotion, is a mood that people wants to be around. Happy people project their feelings to others and help to create good vibes in their surroundings.

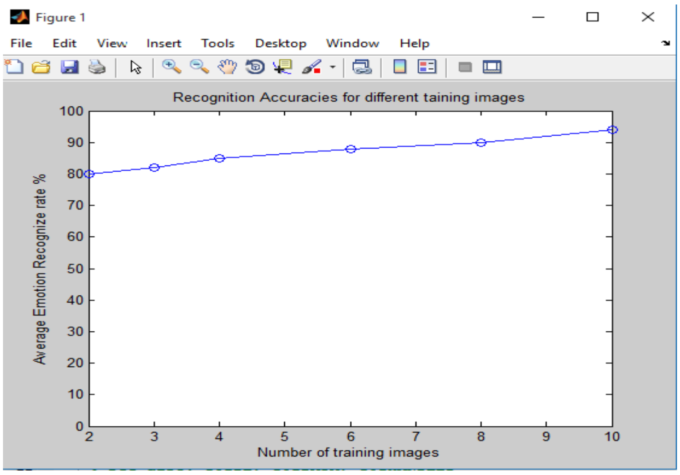

Figure 12:Graph of Recognition Accuracy

The graph shows that though women recognized sadness better than men in full facial images, men recognized it better in the facial features images. This expression was difficult to recognize for both men and women. In the first part of the experiment, most of the mistakes were labeling sadness instead of contempt.Those three expressions- Fear, Disgust and Anger, were recognized better by women, and we can see that most of the times the difference in percentage of success between men and women are significant. I believe that the shape of the eyebrows got people to confuse contempt with sadness in the first part. This expression is a tricky one, and I have expected confusions in its identification.An interesting question that should be asked is- why are those specific emotions were recognized better by women. The most common two special features that helped the participants to decode the expression and the emotion behind it were the lips and the eyebrows. I have also found out that most of the times, in the second part of the experiment, the recognition took less than 4 seconds. This means that there are special features for each emotion, and if we focus on that features alone we will be able to decode the expression faster.

VII. CONCLUSION

The facial expression recognition system presented in this researchwork contributes a resilient face recognition model based on the mapping ofbehavioral characteristics with the physiological biometric characteristics.The physiological characteristics of the human face with relevance to various expressions such as happiness, sadness, fear, anger, surprise and disgust are associated with geometrical structures which restored as base matching template for the recognition system. Thebehavioral aspect of this system relates the attitude behind different expressions as property base. The property bases are alienated asexposed and hidden category in genetic algorithmic genes. The gene training set evaluates the expressional uniqueness of individual faces and provide a resilient expressional recognition mode in the field of biometric security. The design of a novel asymmetric cryptosystem based on impactbiometrics having features like hierarchical group security eliminates the use of passwords and smart cards as opposed to earlier cryptosystems. It requires a special hardware support like all other biometrics system. This research work promises a new direction of research in the field of asymmetric biometric cryptosystems which is highly desirable in order to get rid of passwords and smart cards completely. Experimental analysis and study show that the hierarchical security structures are effective in geometric shape identification for physiological traits.

VIII. ACKNOWLEDGMENT

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