Tasneem Aslam
01-134131-091
Hassan Saeed
01-134132-063

Facial Expression Analysis from Hand Drawn Sketches for Human Figure Drawing Psychological Test

Bachelor of Science in Computer Science

Supervisor: Dr. Imran Siddiqi

Co-Supervisor: Ms Momina Moetesum

Department of Computer Science
Bahria University, Islamabad

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Certificate

We accept the work contained in the report titled "Facial Expression Analysis from Hand Drawn Sketches for Human Figure Drawing Psychological Test", written by Tasneem Aslam AND Hassan Saeed as a confirmation to the required standard for the partial fulfillment of the degree of Bachelor of Science in Computer Science.

Approved by . . . :

Supervisor: Dr.Imran Siddiqi (Associate Professor)

_____

Internal Examiner: Dr. Sumaira Kausar (Assistant Professor)

_____

External Examiner: Dr. Tauseef Jamal (Associate Professor)

_____

Project Coordinator: Dr. Arif Ur Rahman (Assistant Professor)

_____

Head of the Department: Dr.Faisal Bashir (Associate Professor)

_____

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Abstract

Human Figure Drawing Test (HFDT) is a popular instrument for the assessment of cognitive functioning of individuals. This and other similar brain functioning tests are used by psychologists to understand feelings, personality and reactions of individuals to different circumstances. Among different expressive behaviors, sketching is one of the simplest ways to study the feelings and personality of an individual. Not only subjects find the sketching activity interesting, it represents a good media for projection of psychological features of adults/children covering the literate as well as the illiterate population. Among different aspects of the HFDT, the focus of this study lies on the face of the drawn figure. A computerized system that analyzes the hand-drawn facial images to extract the expressions from the image is developed. Sketch of human face is drawn by the subject and then fed to the system, the image is then binarized and segmented into different facial components. Features (Gray level co-occurrence matrices, local binary patterns and histogram of oriented gradients) computed from the facial components are used to train an SVM classifier to learn to distinguish between four expression classes, happy, sad, angry and neutral. The system evaluated on a custom developed database of sketches realized promising results. The developed system could serve as a useful module toward development of a complete automated system to score human figure drawing test.

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Acknowledgments

"We think someone else, someone smarter than us,
someone more capable, someone with more resources will solve that problem.
But there isn't anyone else."

Regina Dugan

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Acronyms and Abbreviations

HFDT	Human Figure Drawing Test
DAP	Draw A Person
SVM	Support Vector Machine
GLCM	Gray Level Co-occurrence Matrix
HOG	Histogram Of Oriented Gradients
LBP	Local Binary Pattern

Chapter 1

Introduction

1.1 Introduction

1.1.1 Project Background

Human Figure Drawing Test (HFDT) is a popular instrument for the assessment of cognitive functioning of individuals. This and other similar brain functioning tests are used by psychologists to understand feelings, personality and reactions of individuals to different circumstances. Among different expressive behaviors, sketching is one of the simplest ways to study the feelings and personality of an individual. Not only subjects find the sketching activity interesting, it represents a good media for projection of psychological features of adults/children covering the literate as well as the illiterate population. In addition to personality profiling, this test is also used as a measure of intelligence in children [1].The Human Figure Drawing Test, also known as Draw-A-Person (DAP) test was introduced by Machover in 1948 and can be effectively employed to study anxiety, self-esteem and personality of the subject. There are many variants of this test. In some cases, subjects are asked to draw a picture of person followed by a picture of a person of opposite gender. In some cases, subjects may be asked to draw themselves or any of the family members too. To assess the subject, a quantitative scoring system has been developed by the psychologists. To score a drawing, fourteen different aspects of the drawn figure are analyzed including different body parts and clothing. The analysis involves inspecting for the presence or absence of attributes, level of detail and proportions. A total of 64 scoring attributes are analyzed and the final score is employed to come to a conclusion about different personal attributes of the subject. The recent developments in areas like image analysis and pattern classification allow computerized system to automate the analysis of these psychological tests. These automated systems can facilitate professional psychologists in scoring the sheets produced by subjects so that they can focus only on suspected cases. Naturally, the objective is not to replace the human examiners but to facilitate them by reducing the manual investigations. Among different aspects of the HFDT, the focus of this study

lies on the face of the drawn figure. We intend to develop a computerized system that will analyze the hand-drawn facial images to extract the expressions from the image. In addition, the scoring parameters including pressure, presence/absence and broken lines will also be analyzed. It is investigated problem to recognize facial expression from videos and different images. [2] Typically, features extracted from different components of the face which include lips ,eyes and nose that are used to train a classifier that learns to discriminate between different expression classes. [3] The expressions of the query face image are then recognized through the trained classifier. Classifiers that are used include neural network and support vector machine [4] have been explored for this problem. As opposed to images, recognition of faces and facial expressions from hand-drawn sketches is a much more challenging problem [5] and makes the subject of our study.

1.1.2   Problem Description

An important component of the human figure drawing test is the expression of the figure drawn by the subject. The proposed project is aimed at developing a computerized system to recognize the facial expression from a hand-drawn facial sketch. The system will take scanned images of hand-drawn faces as input, apply image analysis and pattern classification techniques and predict the facial expression in the sketch. Among various expressions, we consider four expression classes, happy, sad, neutral and angry. In addition to recognition of expressions, face based scoring attributes including variation of pressure, broken lines and omission of nose will also be determined. Automated scoring of facial sketches will serve to efficiently score the face drawings especially when a large number of subjects is to be analyzed.

1.1.3   Objective

The basic aim of this work is to build a system to extract different components from a hand-drawn facial sketch and recognize the facial expression. This automatic facial expression recognition could also serve to partially automate the HFDT by scoring the attributes related to face of the human figure.

1.1.4   Project Scope

The scope of the project is limited to the analysis of offline facial images only. The system will be provided with images of faces drawn by subjects and the system will segment its components and analyze it. The analysis of online drawings is beyond the scope of this project.

1.1.5   Order Of Document

This report is compiled in the following order. In second chapter, we present an overview of the literature and applications related to facial expression recognition. In third chapter presents requirement specications followed by system design in chapter four. Chapter five provides the implementation details while Chapter six summarizes the evaluations carried out to test the system. Finally, we conclude the document in Chapter seven.

Chapter 2

Literature Review

2.1 Introduction

Significant research has been carried out on facial expression recognition from images. This chapter presents and overview of some notable application developed for expression recognition from facial images using image processing techniques.

2.2 Literature Review

Facial expressions are produced as a result of changes that occur in the mood or behavior of a person due to some social interaction or a state of mind like happy, sad etc. Human face expression recognition system involves study of psychology and computer science domains especially image processing and pattern recognition. Facial expression analysis has become area of active search as it plays important role in human computer interaction and it has many application in social interaction. Major steps involved in facial expression recognition system are face detection, feature extraction and classification as summarized in Figure 2.1.
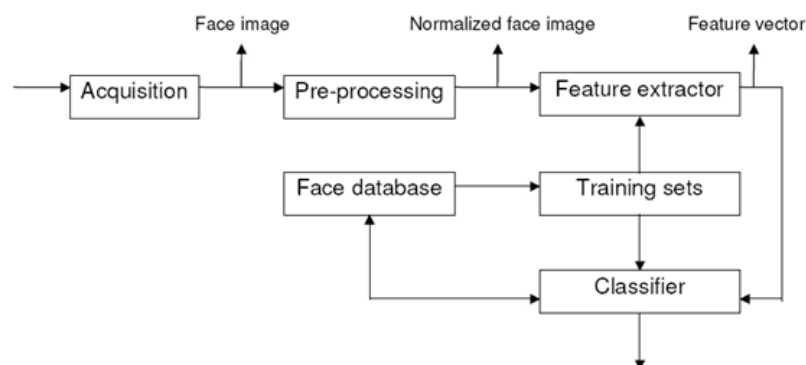
Figure 2.1: Steps

Among well-known techniques used for facial expression recognition, Principle Component Analysis (PCA), that is, eigen face approach has been widely employed. Another class specified method is Fisher's Linear Discriminant which helps in less percentage of scattering of samples and produces a global feature vector.Comparison of both these techniques is shown in comparison figure. 2.2 Results of expression recognition using Fisher LDA have been found to be better than those of PCA [6]

NAME	METHOD	PERFORMANCE	DISADVANTAGES
Low-Dimensional Procedure for Characterization of Human Faces	Principal Component Analysis	Recognition rate is low	Only single factor can be varied
Eigenfaces vs. Fisherfaces : recognition using class specific linear Projection	Fisher's Linear Discriminant	Recognition rate higher than PCA	Global feature vectors are generated
Recognizing Faces with PCA and ICA	Independent Component Analysis	Recognition rate is improved compared to PCA and FLD	Computationally expensive than PCA
Two-dimensional PCA: A new approach to appearance-based face representation and recognition	2-Dimensional Principal Component Analysis	Recognition rate is higher than PCA	Storage requirement is higher than PCA
The importance of the color information in face recognition	Global Eigen Approach using Color Images	YUV color space has highest recognition rate	RGB color space does not provide any improvement in recognition rate
A novel hybrid approach based on sub-pattern technique and E2DPCA for color face recognition	Subpattern Extended 2-Dimensional Principal Component Analysis	Recognition rate higher than PCA,2DPCA	Variation in lighting, pose are not considered
Face Recognition using a Color Subspace LDA approach	Color Subspace Linear Discriminant Analysis	Recognition rate is higher than 2DPCA and LDA	Variation of performance in color spaces is not evaluated
Multilinear Image Analysis for Facial Recognition	Multilinear Image Analysis	Recognition rate higher than PCA	Less performance than Color Subspace LDA
Gabor Filter Based Face Recognition Technique	2-Dimensional Gabor Filter Bank	Higher recognition rate than PCA, LDA,2DPCA,Global Eigen Approach	Low and high frequency component attenuation
Local binary patterns for multi-view facial expression recognition	Local Gabor Binary Pattern	Better recognition rate than Gabor filter bank	Color information is not included

Figure 2.2: Comparison

Detection of human face is the first part of automatic facial expression recognition systems. Most automated expression evaluation systems strive to recognize a small set of prototypic expressions, which include happiness, anger, surprise, and fear. Such prototypic expressions, however, show up as a substitute infrequently. Human feelings and intentions are extra often expressed via changes in few discrete facial features. , the authors In [7], the

authors enhance an automated face evaluation (AFA) machine to analyze facial expressions based on both everlasting facial elements (eyebrows, eyes, mouth) and temporary facial elements depending of facial expression.bIn face image with frontal view of face,the AFA gadget recognizes grained changes in facial expression into motion devices of the Facial Action Coding System (FACS), rather than of a few prototypic expressions. Multistate face and facial aspect fashions are proposed for tracking and modeling the more than a few facial features, consisting of eyebrows,lips, eyes and cheeks. During tracking, distinct parametric based descriptions of the facial points are extracted. With these parameters as the inputs, a group of motion gadgets (neutral expression, six top face AU and 10 lower face AU) are identified whether they happen on their own or in combinations. The application has completed average recognition prices of 96.4% for upper face Action Unit and 96.7% for decrease face AU. The generalizability of the application has been examined through using unbiased picture databases gathered and Facial action coding system coded for truth through specific research teams.

Face recognition has a wide range of applications in many daily interaction systems. Diverse face recognition algorithms have been purposed over the years. Common tasks in all of these algorithms are feature selection and classification. In [8], authors focus on the feature selection problem. Face recognition problem for face with complex variations can not be solved by using linear techniques PCA. The authors propose Kernel machine-based discriminant analysis method for multiview and complex face variation data-set. It provides solution to one of the small sample size issue in face recognition system.

Face expression recognition in uncontrolled lighting conditions is complex challenge [9]. Solution is achieved by using methods of nearby surface based face representations, removing change based coordinating, bit based element extraction and numerous element combination. First step is applying proficient prepossessing method that wipes out the vast majority of the impacts of changing enlightenment while as yet protecting the fundamental appearance points of interest that are required for acknowledgment, second step is Local ternary examples (LTP), a speculation of the neighborhood LBP nearby surface descriptor that is more discriminant and less delicate to clamor in uniform areas, and enhances the execution of LBP based expression recognition and third step is including the Kernel PCA. After several tests, it was demonstrated that this preprocessing technique beats a few existing preprocessors for a scope of capabilities, information sets and lighting conditions [9].

For last few years, detection of expression on face has been the subject of study by many researchers in the field of image processing and pattern recognition and various methods have been proposed for recognition of face expressions in order to recognize different

facial features. Face action units that consist of muscles on face which are responsible for production of expression on face, that lead to the discovery of Face action coding system. Authors in [4] use support vector machine classifiers for the purpose of analysis of face expression. Face expression analysis using multi-class SVM is performed that uses only geometrical techniques and data and this done in the absence of any data regarding face texture or surface. Then facial expression recognition using multi-class SVM is performed that works on the principle of finding whether face action units are present or not that are responsible for a certion face Classification expression [4].

In anohter study [10], authors present face expression analysis utilizing SIFT-PCA technique and the effect of Graph Based division calculation on analysis rate is also studied. The objective is to remove the vital data from the face information, to speak to it as an arrangement of new orthogonal factors called primary parts. The paper exhibits a proposed strategy for face acknowledgment in view of preprocessing face pictures utilizing division calculation and SIFT (Scale Invariant Feature Transform) descriptor. The calculation has been tried on fifty subjects. The proposed technique first was tried on ESSEX confront database and next on possess portioned confront database utilizing SIFT-PCA. The exploratory result demonstrates that the division in mix with SIFT-PCA has a beneficial outcome for face acknowledgment and quickens the Recognition of PCA strategy [10]. In [11], a novel neighborhood descriptor, nearby directional number example (LDN), for face expression investigation is proposed. LDN encodes the directional data of the face's surfaces. Structure of each smaller scale design is calculated. The face is separated into a few areas and concentration is maintained on the appropriation of the LDN highlights from them. At that point, these components are linked into an element vector and utilized as a face descriptor. The descriptor performs reliably under light, clamor, expression, and time slip by varieties.

Another technique for facial expression recognition is proposed in [12] based on two sets of features, texture features and global appearance features. Local binary patterns feature descriptor in both intensity and gradient are first set of features extracted. On the training face images linear discriminant analysis is used to get second set of features. In [13], authors discuss expression acknowledgment by utilizing appearance elements of chosen facial patches. During feature extraction only those patches of face are considered which are active during emotion and are used for classification. For every match of expressions, distinctive facial patches are chosen for various combined expression classes. Many classification methods are tested by giving as input these features. In [14], authors proposed expression recognition of six basic expressions and expression intensity with the help of two different models that are Active Appearance Model and the other one is Lucas picture alignment algorithms. This technique recognizes mixture ratio of basic facial

expression. Texture features that are used as input are of three kinds, texture based features of complete face which is used for detection of intensity feature of upside and downside face which are used as action points. For this purpose feed forward Neural networks is used for acquiring scoring of recognition which serves as basics for differentiating between different face expressions. Tests are carried out to check that those recommended technique can adequately perceive mixture proportion of six essential expressions and the expression intensity.

Chapter 3

Requirement Specifications

3.1 Requirement Specications

3.1.1 Existing System

Many people had worked on analysis of expressions of face and had developed many systems facial expression recognition which works on image of human face as input or extraction of human faces from videos. Mostly the work has been done on face recognition and similar techniques are used for facial expression recognition. Basically facial expression are the focal point of expressing human behavior and mood [15].Expression recognition has also been used for Human computer interaction for this purpose computer driven application has been developed that automatically identify person facial expression from human face image that is carried out by the comparison of features that are selected from the image and a image that is the database. [16]

3.1.2 Purposed System

Our purposed system aims at developing automated facial expression recognition system that will be used for human figure draw test (HFDT). This automated system can facilitate professional psychologists in scoring the sheets produced by subjects so that they can focus only on suspected cases. We intend to develop a computerized system that will analyze the hand-drawn facial images to extract the expressions from the image. In addition, the scoring parameters including pressure, presence/absence and broken lines will also be analyzed. The image fed to our system will be the sketch human face and then feature extraction will be performed from different component of face like eyes,nose,lips and will be used to train classifier(SVM classifier will be used) that learns to differentiate between different expression classes (happy, sad, neutral and angry expression classes for this system).On the basis of training of the system expression of the input image will be recognized.

3.1.3   Functional Requirements

1. **System Different modules:**

   - Prepossessing
   - Segmentation
   - Feature Extraction
   - Training
   - Classification

2. **Importance**
   System can serve for multipurpose , for any application that require facial expression analysis , it can also be used for human computer interaction and for different psychological personality disorder test.

3. **Benefit of System**
   The developed system could serve as a useful module toward development of an automated system to score human figure drawing test. The system could facilitate the practitioners and will also avoid subjective bias that may result in case of a human examiner. The system can also be employed by organizations interested in personality profiling of individuals for recruitment.

4. **Criticality**
   Acquiring correct data-set and feature extraction of facial component based on which system can analyze correct expression

5. **Risks**
   The system will not work properly and will give wrong results under following situations and conditions:

   - if the drawn image is distorted to such an extent that it does not resemble a face, the system would not be able to process it.
   - If the writing instrument produces very light strokes, some parts of the drawing could be missed during the Binarization process.
   - If image is inverted system would not be able to process it

6. **Hardware, Software and development requirement**

   - Optical Scanner for digitization of paper based sketches/drawings.
   - Desktop machines for software development
   - Visual Studio 2013
   - Development Platform: Csharp
   - Libraries: Accord.Net, EmguCV

3.1.4 Non Functional Requirements

1. **Availability** System will be available to only Professional Psychologist .

2. **Efciency** System will ensure efciency by providing correct results in minimum time. Users will get an accurate result.The application will also assist the psychologist.

3. **Robustness** System is expected to be robust and recover from crashes.

4. **Reliability** System will ensure reliability and develop user condence by providing accurate results for monitoring HFDT test

5. **Modifiable** System will have the potential for improvement of features and additional features may be added in the later releases of the system.

6. **Portability** The application is not portable because it is run on the desktop computers so the user cannot carry the computer.

7. **Flexibility** The system will be flexible for enough for some later requirements change or features enhancement.

8. **Usability** The interface and GUI design of the system will be user friendly with no training required to use the system.

Chapter 4

Design

This Chapter includes details of different aspects of our system.

4.1 System Architecture

The basic interaction of the application with other modules and hardware devices includes scanner for taking the sketch images and system with windows operating system with visual studio installed to appication.The interaction between different components within the application includes the AForge.Net and Accord libraries.

4.2 Design Methodology

An overview of the intended system with major modules is presented in Figure 4.1. The proposed system mainly rely on image segmentation, image analysis and pattern recognition techniques to generate the scoring sheet of hand-drawn human face.A supervised learning technique will be employed to recognize the facial expressions. A subset of the database will be used to train the system. Multiple images of each of the expression classes will be used in the training phase. The face images will be pre-preprocessed to remove noise and convert them into binary. Different components of the face will be segmented using edge based segmentation and features will be extracted from each of the components. These features will be used to train a classifier to learn the different expression classes.Facial expression recognition done by series of steps that are summarized 4.1
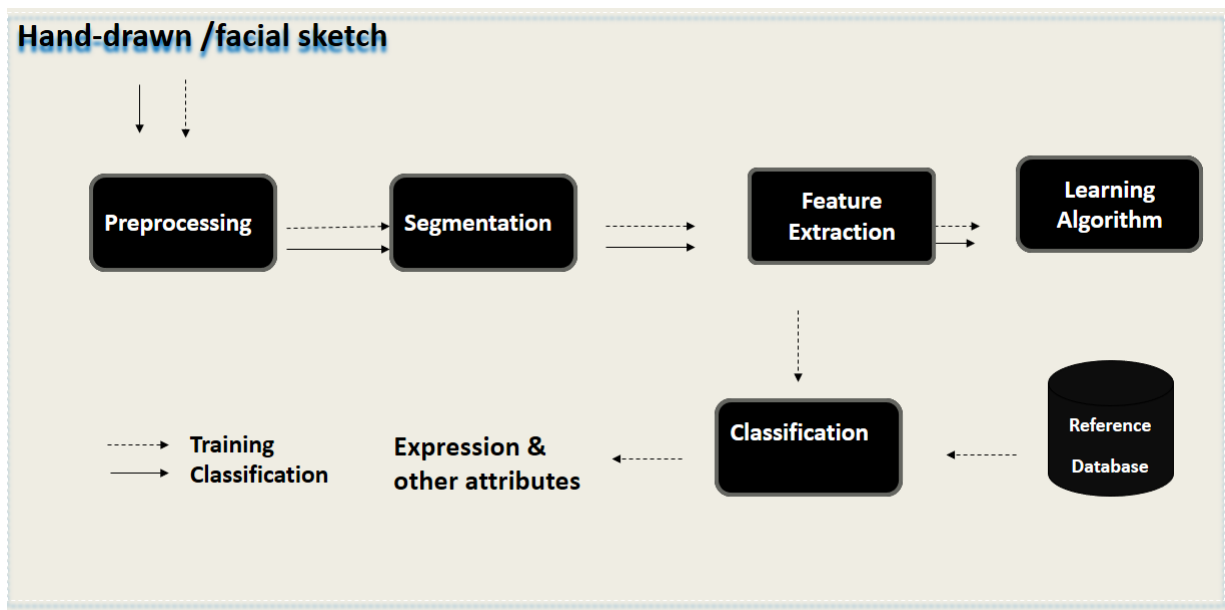
Figure 4.1: Methodology

4.3   High Level Design

A high level design explains the system's architecture with the help of abstract diagrams. It gives an overview of the platform, product, process and the services the system provides. This section gives details of the system's data flow, multiple modules that highlight principle methods and the execution architecture of the system including logical design and process

4.3.1   Package Diagram

An overview of the logical or conceptual design of the system in terms of component (package) diagram is presented in Figure 4.2.
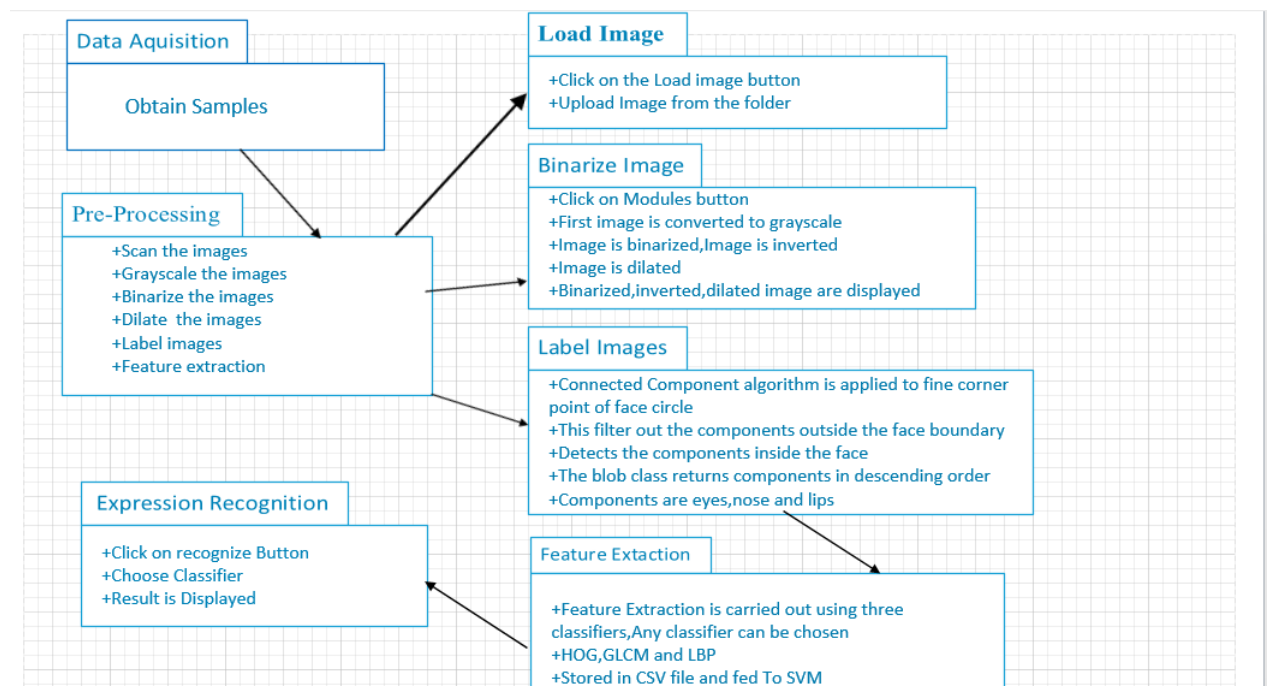
Figure 4.2: Component or Package Diagram

Package Diagram describes different packages which contribute the main model of Facial Expression Analysis.Data Acquistion,Pre-processing and expression recognition packages are shown along with their details Figure 4.2.Pre-processing package includes load image,Binarize image,label image and feature extraction details.

4.3.2 Block Diagram

Block Diagram displays the principal functions/modules of the system and relationship between them shown in Figure 4.3. Video frames from the users of the system are processed by detection module applying image processing techniques
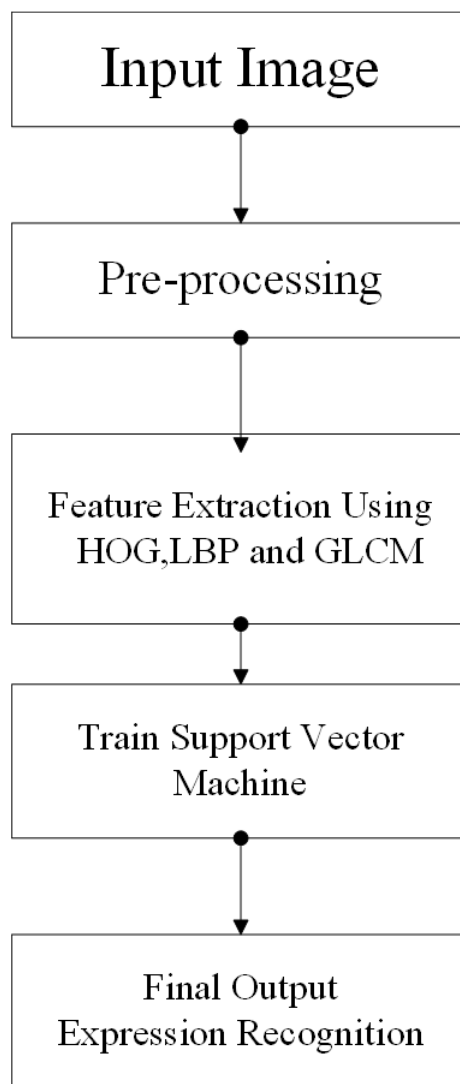
Figure 4.3: block diagram

4.4   Low Level Design:

4.4.1   Use Cases

The use case diagram illustrates list of actions and steps that define the interactions between the user (actor) and the system to achieve the system's objectives.The user's interaction with the system can be easily broken down into four use cases .The boundary of the system and the interaction of the users with the system is presented by the following use cases.

- **System Login**

- Enter user details

- Chose task from menu

- Set the system to perform task
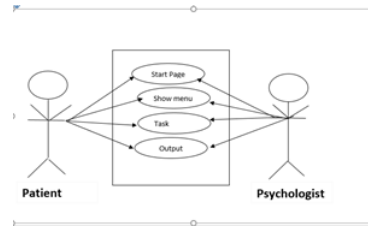
- View the output

Figure 4.4: Usecase :Start Application

This use case represents the interaction of user with the system that users loads the application and runs the system.System must be properly running so the user is directed the next screen when clicking on start up page.

Table 4.1: UC1: Startup page

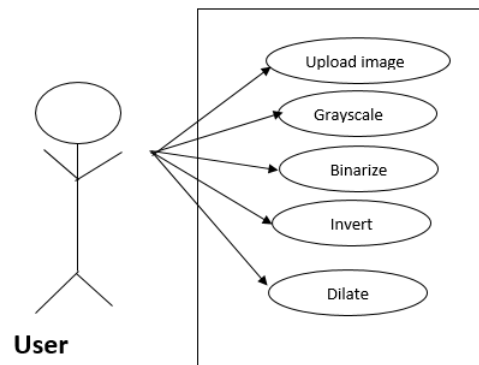| Use Case Name	UC1:Startup Page
Primary Actor	User
Roles	User can load the application and can start the application or exit application
	Description
User can load the application	
Pre-conditions	The system must be running
Post-conditions	Starting up the application must take the user to the next screen

4.4.2 Preprocessing

Figure 4.5: Usecase 2:Pre-procesing

This use case shows the interaction of the user with Project , here user has to upload a sketch from images folder and then perform different function on the image.Basically Pre-processing of image is performed in this stage .

Table 4.2: UC2: Upload Image

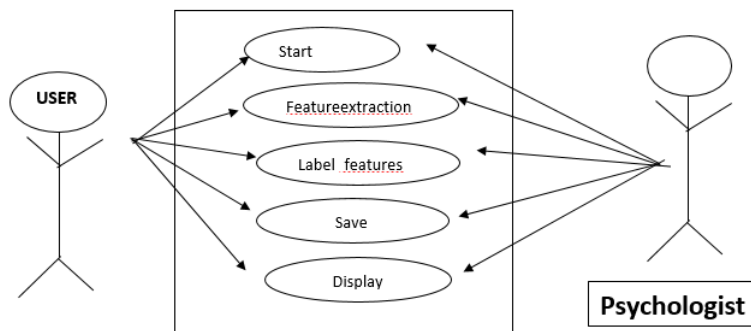| Use Case Name	UC2:Upload image and Pre-processing
Primary Actor	User
Roles	User can upload the image and apply pre-processing steps.
Description	This is use to perform pre-processing on the image
Main Steps Performed	1.The User upload image
	2.The User Selects binarization option.
	3.The User Selects the next option
	4.The ouput displayed is a. Image after binzrization b. Image after converting to greyscale c. Image after inversion d. Image after dilation
Pre-conditions	System should be running and executing different tasks.
Post-conditions	Task Form will Open

4.4.3   Feature extraction

Figure 4.6: Usecase3:feature extraction

Table 4.3: UC3: Feature Extraction

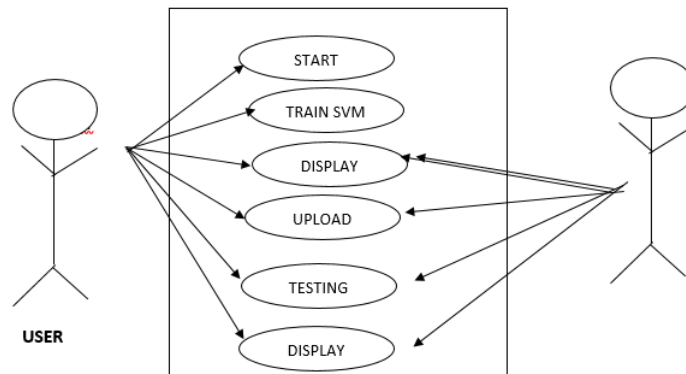| Use Case Name	UC3: Feature Extraction
Primary Actor	User
Roles	User has to perform feature extraction
Description	This is a Use Case used for performing feature extraction
Main Steps Performed	1. User start feature extraction by clicking on start button 2. User save the feature values by clicking on save button. 3.User press the button label feature 4. Features with their labels are displayed 5. The User Presses save to save 6. By pressing save ,feature values are saved to csv file 7. Feature values stored in form of table are displayed to user.
Pre-conditions	System should be running and pre-processing will be performed.
Post-conditions	Image with labels will be displayed

4.4.4 Training and Testing

Figure 4.7: Usecase4:Training and Testing

Table 4.4: UC4: Training and Testing

Use Case Name	UC4:Training and Testing
Primary Actor	User
Roles	User has access to data samples and train SVM
Description	This is a Use Case used for training and testing
Main Steps Performed	1.The User start training svm 2.Results are displayed after training. 3.User uploaded image and perform testing on it 4.Expression of the image is displayed
Pre-conditions	The System should be running and trained on data sample.
Post-conditions	Training form will open,then after training ,main form will be opened for testing

4.4.5 System sequence diagram

System Sequence Diagram provides the visual description of each use case specifying system users, methods invoked (by the user) and returned values (to the user). System is represented as a black box. Figure 4.8
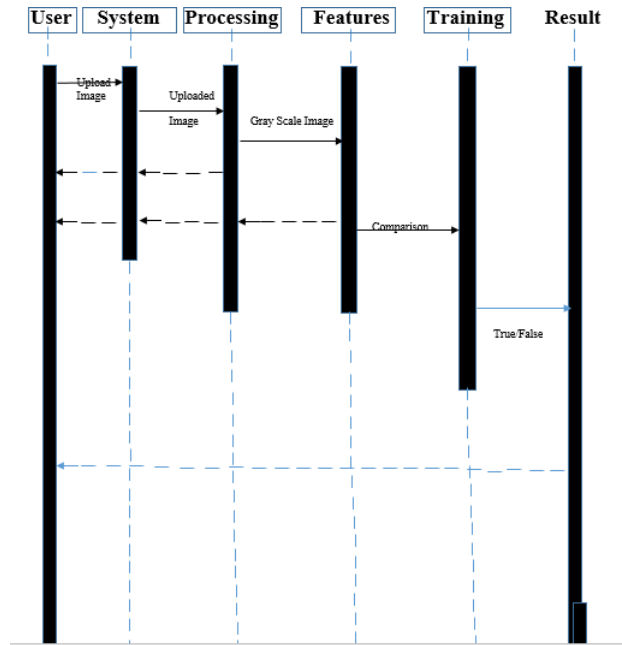

Figure 4.8: Sequence diagram

Figure 4.8 shows System Sequence Diagram for input image , user perform the preprocessing then feature extraction then training and then expression is anaylsed.

4.4.6 sequence diagrams

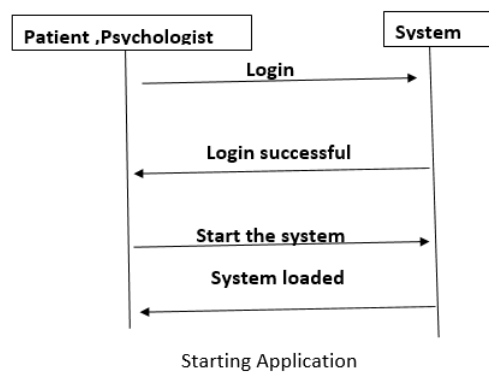

Figure 4.9: Sequence diagram

Figure 4.12 shows Sequence Diagram for start-up page of the application.Application is loaded when it is opened.
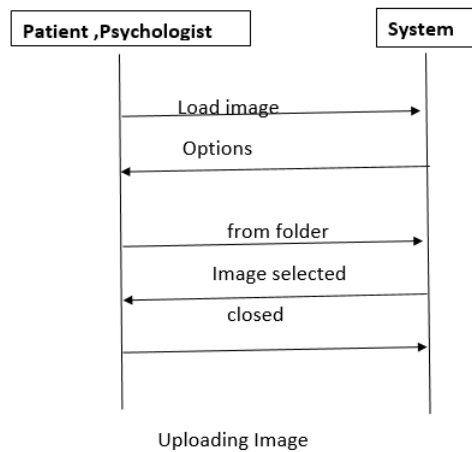
Figure 4.10: Sequence diagram

Figure 4.10 shows Sequence Diagram for uploading image of facial sketch that can be of any expression happy,sad,neutral and angry.
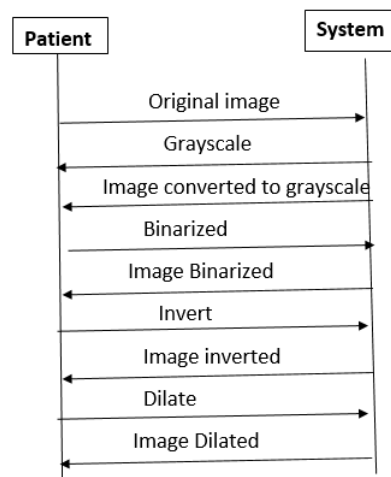

Figure 4.11: Sequence diagram

Figure 4.11 shows Sequence Diagram for applying preprocessing on image,first image is converted to gray-scale image then binarized after that binarized image is inverted and then dilated.
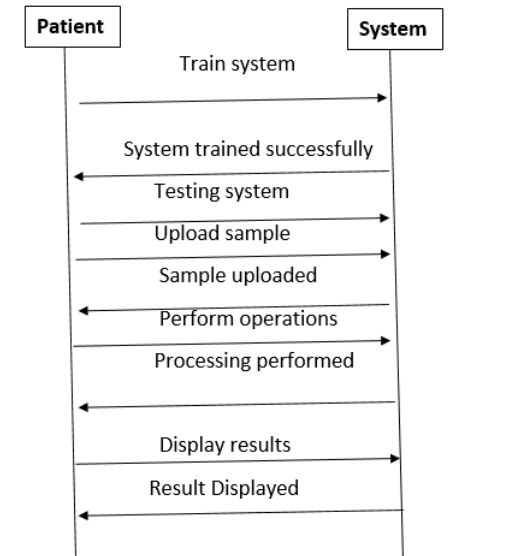
Figure 4.12: Sequence diagram

Figure 4.10 shows Sequence Diagram for training Support vector machine,images from data set are trained to the system then after tha classifier is trained ,testing is performed and expression of the image that is used for testing displayed. **UML Class Diagram** The class diagram shown in the figure 4.13 describes the structure of entire system with the help of classes, their different attributes, methods and relationships with each other.
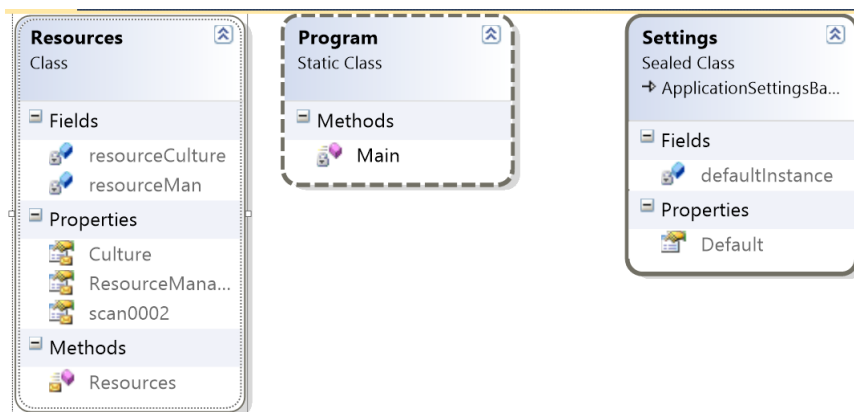

Figure 4.13: Class diagram

Figure 4.14: Classes in System,

4.5   GUI Design

User interface plays an important role in interaction of user with the system,if the interface is simple and user friendly client can easily learn the use of system.The users of our system are patients and psychologists which need guidance to use the system as they don't belong To computer science domain so interface of system should be self explanatory.There are two main modules of the system ,one is training and the other is testing.Main form presents options for loading sample,choosing classifier and displays results.The second form displays all the image processing operation applied on the image and there is another form which represent different options for training and fed data to SVM.
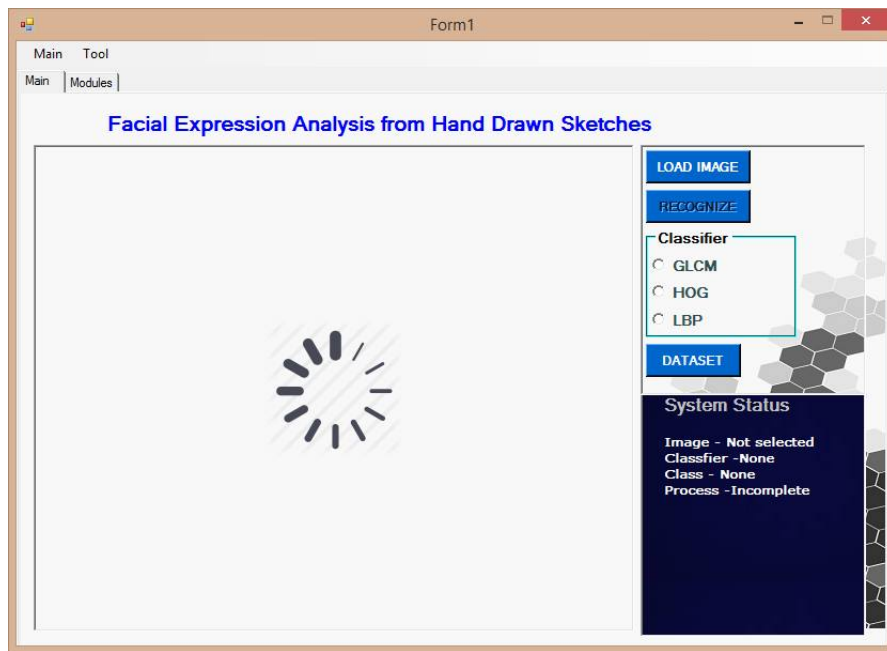

Figure 4.15: Startup Form,
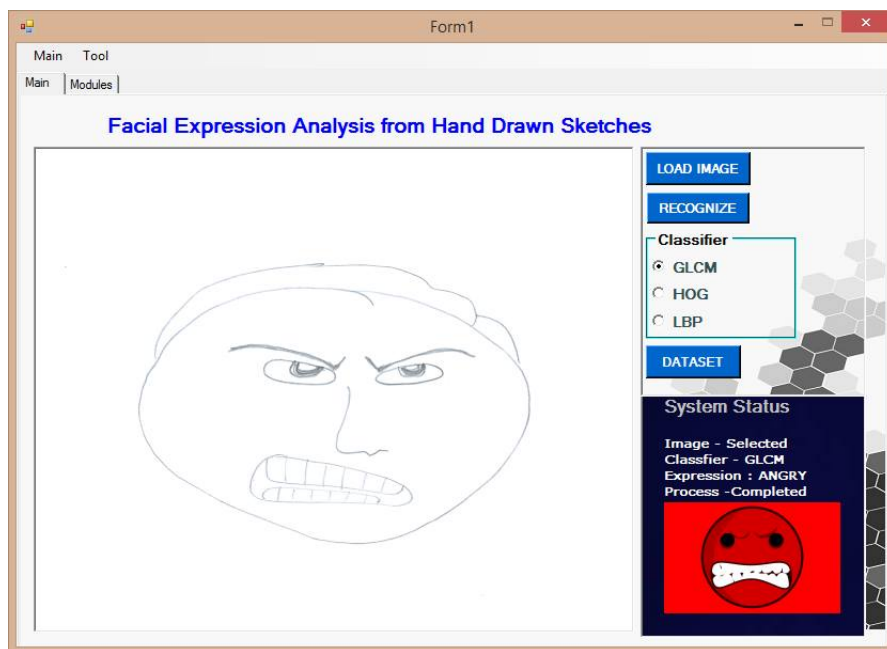
Figure 4.16: Load Image
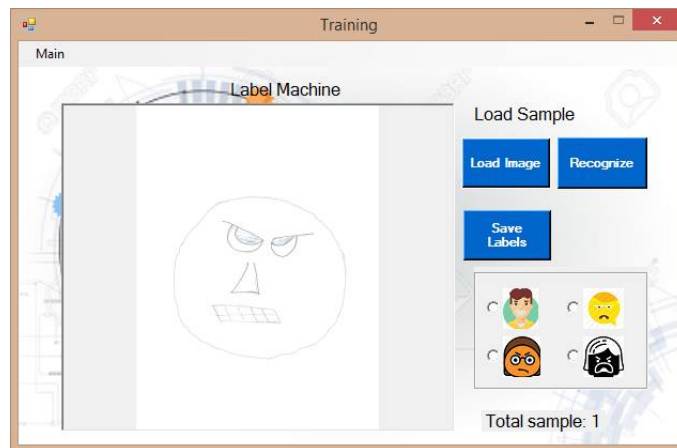

Figure 4.17: Result Displayed

Figure 4.18: ComponentsLabelled

Chapter 5

System Implementation

section* Implementation details of our system are discussed in this chapter including the tools, technologies and algorithm employed.

5.1 Tools and Technology

Following tools were employed in the development of the automated facial expression analysis system

5.1.1 Visual Studio 2012

Visual Studio 2012 is an integrated environment of Microsoft to develop software programs. Visual Studio supports multiple languages like C plus plus, C sharp etc. The proposed system is developed in C sharp.

5.1.2 AForge.NET

AForge.NET is a C sharp framework designed for developers and researchers in the fields of Computer Vision and Artificial Intelligence like image processing, neural networks, genetic algorithms, machine learning, robotics, etc. In Image Processing, Aforge is an image processing application written in C sharp, which includes different image processing filters and tools available in AForge.NET framework to analyze images.

5.1.3 Accord.NET

Accord.NET is a framework for scientific computing in .NET. The framework is comprised of multiple libraries encompassing a wide range of scientific computing applications, such as statistical data processing, machine learning, pattern recognition, including but not limited to, computer vision and computer audition. The framework offers a large number

of probability distributions, hypothesis tests, kernel functions and support for most popular performance measurements techniques.

- AForge.Imaging - In Accord.Imaging Interest point detectors (Harris, SURF and FAST), image matching and image stitching methods can create integral images and other image transformations, plus additional image filters for image processing an applications.

- Accord.Statistics -In Accord.Statistics Probability distributions, statistical models and methods such as Linear and Logistic regression, Hidden Markov Models, (Hidden) Conditional Random Fields, Principal Component Analysis, Partial Least Squares, Discriminant Analysis, Kernel methods and functions and many other related techniques.

- Accord.MachineLearning - In Accord.MachineLearning Support Vector Machines, Decision Trees, Naive Bayesian models, K-means, Gaussian Mixture models and general algorithms such as RANSAC, Cross-validation and Grid-Search for machine-learning applications.

  using Accord.Imaging.Filters;
  using Accord.Statistics.Kernels;
  using Accord.MachineLearning.VectorMachines;
  using Accord.MachineLearning.VectorMachines.Learning;
  using Accord.Imaging.Converters;
  using Accord.Controls;
  using Accord.Statistics.Visualizations;
  using Accord.Statistics.Analysis;

5.2 Development Environment/Languages Used

5.2.1 Image Load

Scanned images of the hand Drawn face sketches are loaded into picture box **??** The pictures and images are handled by C sharp with one of two objects, Image or Bitmap. Image objects are usually directed towards user interface operations, while Bitmaps are easier for image processing.
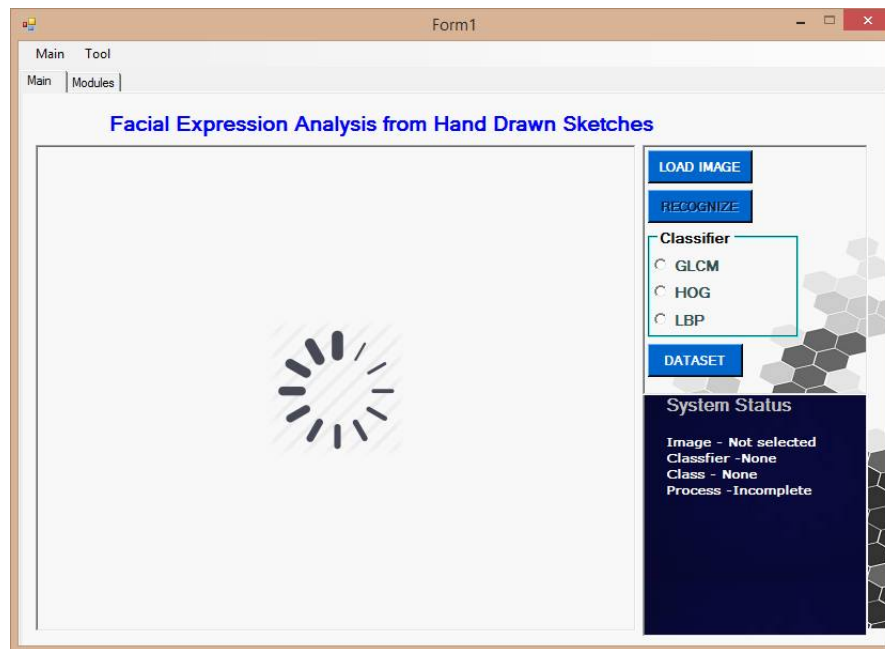
Figure 5.1: Load Image

5.2.2 Expression Analysis

Among different parts of the face to recognize expressions,bthe lips are best choice to analyze the facial expression. The lips are segmented from the face image and are primarily used for recognition. Overall, the process involves the following steps.

1. Segmentation of face components.

2. Feature extraction of lips.

3. Train the system using SVM.

4. Test the expression using test samples.

5.2.3 Segmentation

Segmentation process using aforge require various step which are listed in the following.
Gray-scale Conversion The initial image is 3 channel and is converted into single channel. The image is converted into grayscale using Aforge grayscale filter (Figure 5.2).
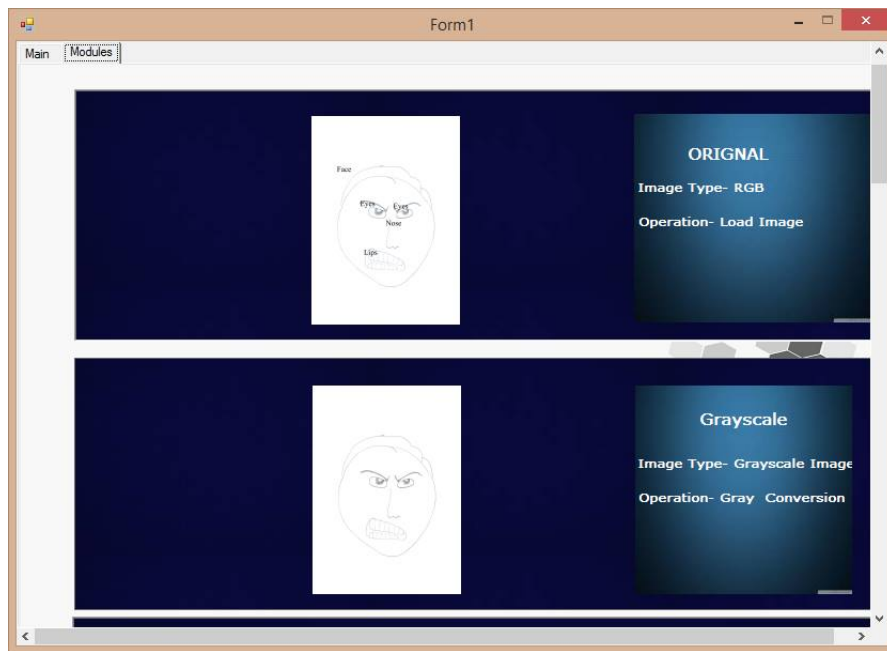
Figure 5.2: GrayScale Image

Binarization of image

Grayscale image is converted into binary using Aforge binarization filter (Figure 5.3). The simplest binariazation method is the regular thresholding, which just takes the specified threshold and separates image's pixels into black and white pixels according to the specified threshold.

AForge.Imaging.Filters.IFilter filter = new AForge.Imaging.Filters.Threshold(T);

Now image is white below threshold and black above threshold.

Figure 5.3: Binarized Image

Invert the binarize image

The filter inverts colored and grayscale images. The image in binarize form are inverted using aforge invert filter (Figure 5.4). The white and black pixel are inverted.
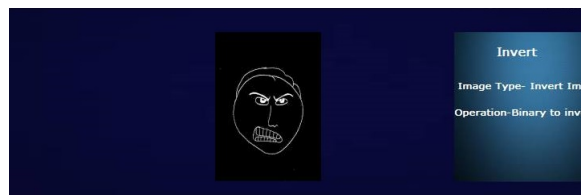
Figure 5.4: Inverted image

Image Dilation

The next step is to dilate the image. Small gap are filled with the help of dilation. This helps us to detect the face connected components easily. (Figure 5.5)
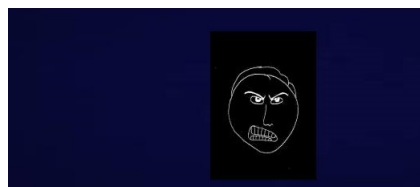

Figure 5.5: Dilated image

Connected Components in the Image

The component are extracted using the blob class which counts and extracts stand alone objects in images using connected components labeling algorithm (Figure 5.6).
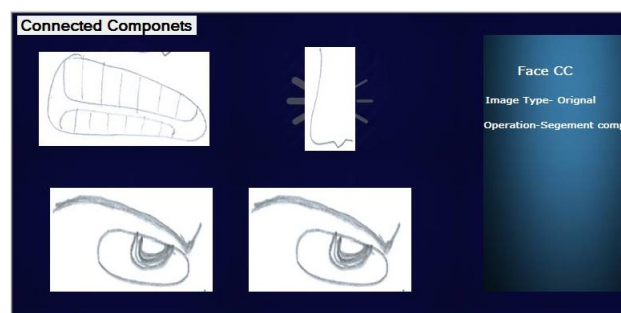
Figure 5.6: Connected Components in the Image

They are five object on face are extracted using blob class. The component are labeled using connected component labeling, This process involve two steps:

- Corners points of Biggest component: In first step is to find the corner points of face circle to filter the component outside the face (Figure 5.7). This point helps us to find the number of components inside the face area. If the component of area is bigger than face circle, the program will be able to detect the face.

- Label the components In second step, we again process the blob class which now returns the image using their y-axis values. The face component are removed by setting the condition that only those components are stored in image array which are inside the face corner. The blob first returns the component with smaller values of y-axis only if expected inside components of face are four, if less than four then missing component are detected. Which is further analyzed. The last y-axis inside component are lips. The next component is nose then eyes. All the components that are face, lips, nose and eyes are segmented and labeled using blob class 5.8. The next step is feature extraction. We now compare the components which are within this area.

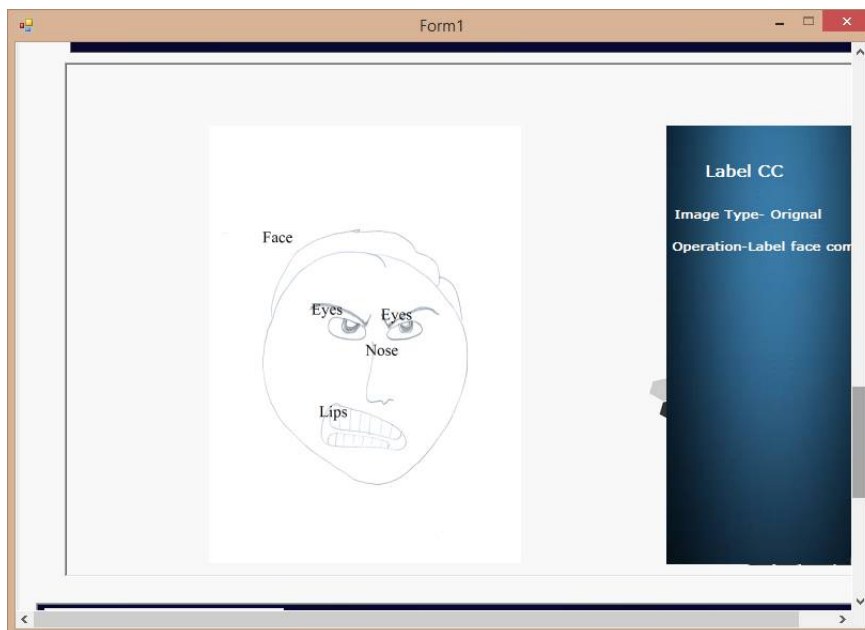Figure 5.7: Biggest Connected Component

Figure 5.8: Labeled components

5.2.4   Feature Extraction

The feature extraction of eyes, nose and lips is carried out for expression analysis. Using features of eyes and nose does not help much in recognizing expression so only values of features of lips are passed to classifier (Figure 5.9). All the lips images are re-sized

to a fixed siez. The feature extraction of lips is carried out by using GLCM, HOG and LBP classes in ACCORD.net. The data-set consist of hundred(100) samples twenty five for each class happy, sad, neutral and angry. Further, GLCM using thirteen (13) features, HOG using nine (9) features and LBP using 256 features. All the classifier features with class label are stored in separate CSV file.
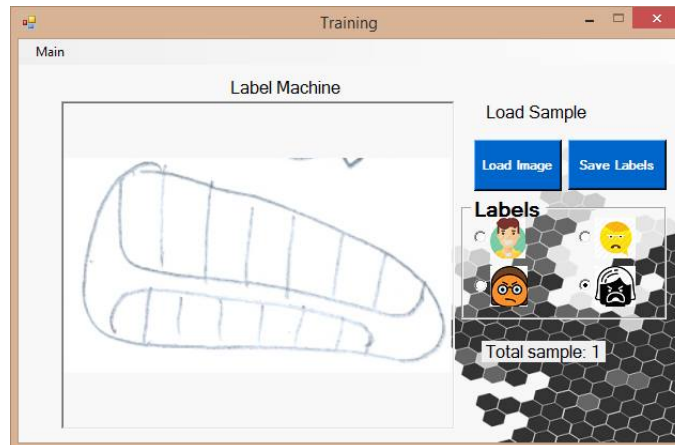

Figure 5.9: Lips for feature Extraction

1. Local Binary pattern Local binary pattern is a simple, fast and powerful feature descriptor for grayscale images. LBP divides the image into cells which consists of pixels. It then labels the center pixels of an image by comparing the neighborhood of each pixel and produce the result as a binary number. The pixel below threshold are zero and others are one. The image is transformed into a new image with labels and then histogram of this image is then constructed and is used as feature. The histogram is a 256-dimensional feature vector which can be normalized.(Figure 5.10)
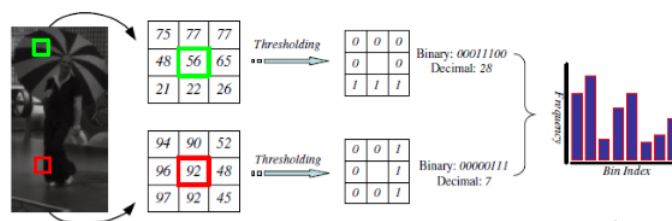
Figure 5.10: Local Binary Pattern

2. Gray Level Concurrence Matrix GLCM is matrix of frequencies at which two pixels, separated by a certain vector, occur in the image called co-occurrence matrix also referred as co-occurrence distribution. GLCM represents the distance and angular spatial relationship over an image sub-region of specific region of specific size and distance. The GLCM calculates, how often a pixel with gray-level value i occurs either horizontally, vertically, or diagonally to adjacent pixels with the

value.(Figure 5.11) GLCM of an image is computed using a displacement vector d, defined by its radius and orientation. Features computed from GLCM are textual information about the image proposed by Harlick. These are Energy, Entropy, Contrast, Correlation, Homogeneity, Angular Second Movement, Contrast, Correlation, Variance, Inverse Difference Moment, Sum Average, Sum Variance, Sum Entropy, Entropy, Difference Variance, Difference Entropy, Mean of Correlation.
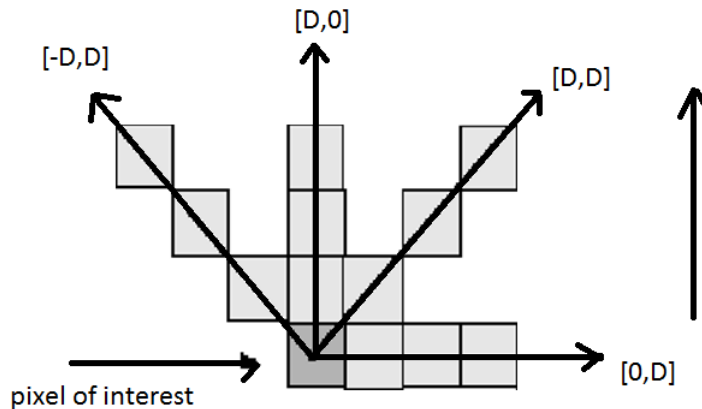
Figure 5.11: GLCM Computation

3. Histogram of Oriented Gradients HOG is a well-known computer vision descriptor. It divides the image into blocks which consists of number of cells. We operate on 8×8 pixel cells. These cells are organized into overlapping blocks. Within a cell, we compute the gradient vector at each pixel. The main function of this method is to compute the gradient orientation at each pixel and counts the occurrences of gradient orientations in each cell. We take the 64 gradient vectors and put them into a 9-bin histogram. The Histogram ranges from 0 to 180 degrees, so there are 20 degrees per bin.(Figure 5.12)
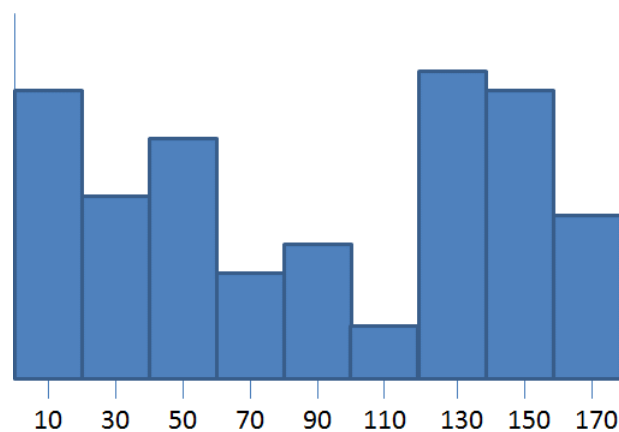
Figure 5.12: Histogram of Oriented Gradients

5.2.5   Machine Learning using SVM

SVM is supervised learning method employed extensively for classification and regression. SVM is given the labelled training examples which builds a model that represents examples as points in the feature space. Separate categories are divided into clear gap as wide as possible. Creating a gap by using the hyper plane in the high dimension space is often carried out. The choice of kernel decides the hyper plane dimensions. In our implementation, we train a separate SVM for each type of fetaures.(Figure 5.13)
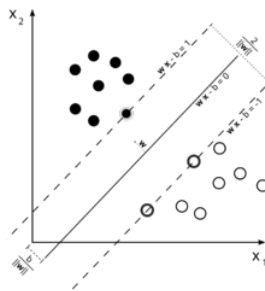

Figure 5.13: Support Vector Machine

This chapter presented in detail the system implementation along with the algorithmic details of the system including binarization, segmentation feature extraction and classification. The evaluations carried out to validate the proposed system implementation are presented in the next chapter.

Chapter 6

System Testing and Evaluation

Software testing is carried to make sure that the developed software fulfill the needs of its clients ,it evaluates whether the developed software is according to software requirement document.By software testing any part of the system that is malfunctioning can be figured out and can be corrected before handing over the software to he customer.It also guarantees that software developed has been build according to quality standards.There are many types of testing which are mentioned below

6.1   Graphical User Interface Testing

User interface plays an important role in interaction of user with the system,if the interface is simple and user friendly client can easily learn the use of system.The users of our system are patients and psychologists which need guidance to use the system as they don't belong To computer science domain so interface of system should be self explanatory.There are two main modules of the system ,one is training and the other is testing.Main form presents options for loading sample,choosing classifier and displays results.The second form displays all the image processing operation applied on the image and there is another form which represent different options for training and fed data to SVM.

Figure 6.1: Startup Form,
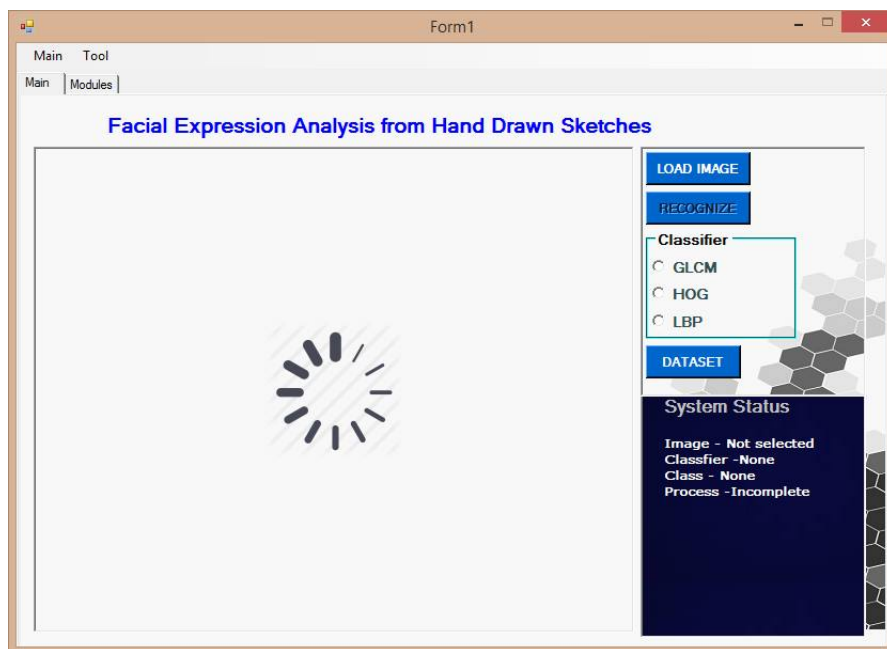
Figure 6.2: Load Image

Figure 6.3: Result Displayed

Figure 6.4: ComponentsLabelled

6.2 Usability Testing

The system developed is easy to use and developed under standards.System has been used and tested by four subjects and have given feedback on the system efficiency , usability and on different aspects of interface.They did not find any errors or bugs in the system and felt satisfied by using the system,

6.3   Software Performance Testing

Software performance testing is carried out to ensure that system developed is delivering the desired functionality,efficient and reliable.Expression recogni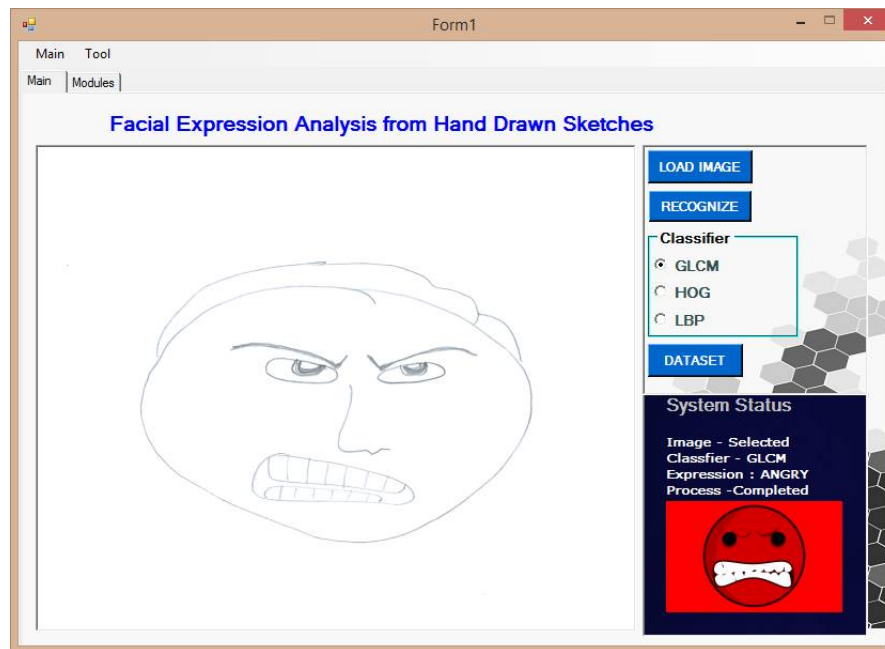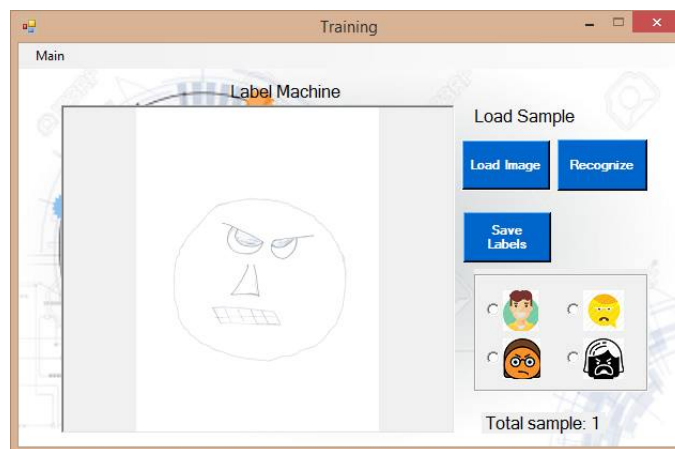tion is based on correct segmentation, detection and labeling of features and recognition of expression to help psychologist is scoring of HFDT test.Performance rate o our system is 80,as mentioned in below given table.

Table 6.1: LBP

Class	Training	Testing /percentage
Angry	14/21	6/6
Happy	18/20	5/7
Sad	05/20	3/7
Neutral	15/20	5/5
Total	52/81	19/25
Percentage	64	76

Table 6.2: HOG

Class	Training	Testing /percentage
Angry	20/21	5/6
Happy	20/20	4/7
Sad	19/20	5/7
Neutral	20/20	4/5
Total	80/81	18/25
Percentage	98.7	72

Table 6.3: GLCM

Class	Training	Testing /percentage
Angry	15/21	4/6
Happy	15/20	5/7
Sad	16/20	5/7
Neutral	16/20	4/5
Total	62/81	18/25
Percentage	76.5	72

6.4   Compatibility Testing

Compatibility testing is a process to ensure that system run on different operating system and is compatible with different versions of windows operating system.Current system is developed on visual studio 2012 which is compatible with different version of windows.

6.5   Exception Handling

The system may generate an exception if the AForge.NET DLLS are not placed in the resource file of the project. The DLLS must therefore be added correctly to avoid this exception.If inappropriate image is fed to the system,message box is shown .

6.6   Load Testing

Load Testing is done to check the system behavior at normal condition as well as heavy load condition.The system should operate in both conditions.The system can be heavily loaded when the sketch image is of very high resolution. In most cases, however, a very high resolution image is not required for this system. The features can be easily segmented and recognized in the normal resolution images.

6.7   Installation Testing

Installation testing is carried out to check whether the application is installed on the system for which it is developed successfully.The application is tested on different platforms and it is insured that any major issue donot occur while application is run-ed on different platforms that can be different versions of windows.

6.8   TestCases

6.8.1   Test Case 1: Load Image

Table 6.4: Test Case 1

Test Case ID:	TC1
Unit of Test:	Test to verify that a image is loaded successfully
Steps to be executed	Click on 'Load' button and select an image
Expected Result:	image loaded successfully
Actual Result:	image loaded successfully
Status:	Pass

6.8.2   Test Case 2: Binarize And Invert Image

Table 6.5: Test Case 2

Test Case ID:	TC2
Unit of Test:	Test to verify that images are binarized and inverted
Steps to be executed:Click on the module button	
Expected Result:	images should be binarized and inverted.
Actual Result:	images are binarized and inverted
Status:	Pass

6.8.3 Test Case 3: Identify component and labelling

Table 6.6: Test Case 3

Test Case ID:	TC3
Unit of Test:	Test to verify that image labelled on GUI
Steps to be executed:	Component eye, nose and lip are labelled w.r.t their position using algorithm
Expected Result:	Nose,eyes and lips are labelled on GUI
Actual Result:	All the objects nose ,eye and lip are labelled by algorithm on GUI
Status:	Pass

6.8.4 Test Case 4: Feature Extraction

Table 6.7: Test Case 4

Test Case ID:	TC4
Unit of Test:	Test to verify if extraction of features is carried out
Steps to be executed	Chose GLCM,HOG or LBP
Expected Result:	All features should be extracted from the images.
Actual Result:	All features are extracted from the images
Status:	Pass

6.8.5 Test Case 5: Training of Svm

Table 6.8: Test Case 5

Test Case ID:	TC5
Unit of Test:	Test to verify the four expression classified by the SVM
Steps to be executed:	feature from csv file with class labeled are passed to SVM.
Expected Result:	SVM trained by the input data
Actual Result:	SVM sucessfully trained
Status:	Pass

6.8.6   Test Case 6: Recognition of expression

Table 6.9: Test Case 6

Test Case ID:	TC6
Unit of Test:	Test to verify if expression are recognized correctly
Steps to be executed:	Click on 'Recognize button
Expected Result:	Result will be same as the real expression
Actual Result:	Approximately 80% of the expression are correctly recognized
Status:	Pass

Chapter 7

Conclusions

Conclusion

Human Figure Drawing Test (HFDT) is a popular instrument for the assessment of cognitive functioning of individuals. This and other similar brain functioning tests are used by psychologists to understand feelings, personality and reactions of individuals to different circumstances. Among different expressive behaviors, sketching is one of the simplest ways to study the feelings and personality of an individual.This study was aim at Expression recognition by hand drawn sketches using computational image processing algorithm.Sketch of human face is drawn by the subject and then fed to the system,the image is then binarized,then segmented and then feature extraction is carried out by GLCM,HOG and LBP and then CSV file is fed to support vector machine and results are displayed.Application is developed to recognize four basic expression happy,sad,neutral and angry.The system is evaluated on many sketches and produced promising result.

7.1 Perspectives

The current system realizes promising expression recognition rates of around 80%. These can be further enhanced by using more advanced techniques of image processing.The developed system could serve as a useful module toward development of an automated system to score human figure drawing test. The system could facilitate the practitioners and will also avoid subjective bias that may result in case of a human examiner. The system can also be employed by organizations interested in personality profiling of individuals for recruitment.The current system only recognize expression for Human Figure draw Test,more work can be carried out to tell gender,missing face components,sketchy strokes and whol Human figure Draw Test can be automated to assist psychologist.Likewise, in

addition to offline images of sketches, the system can be extended to an online version where the subjects can directly produce the sketch on a digitizing device without the need of a paper sheet and writing instrument. It is expected that this study will contribute towards the development of a complete diagnostic tool which will reduce the work load of psychologists by automatically screening the subjects. The authors also hope that the system developed during this academic project will be helpful for researchers and developers aiming to automate other similar tests.

Chapter 8

Appendix

Sample sketch Images

Figure 8.1: Sample Image - Expression Happy

Figure 8.2: Expression happy

Figure 8.3: Expression happy

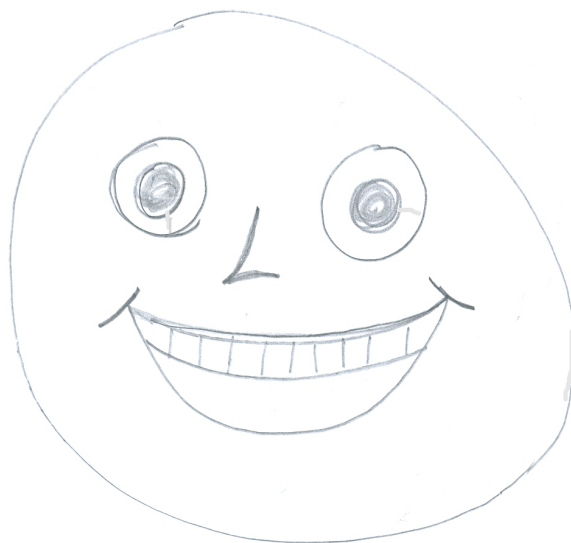Figure 8.4: Expression happy

Figure 8.5: Expression happy

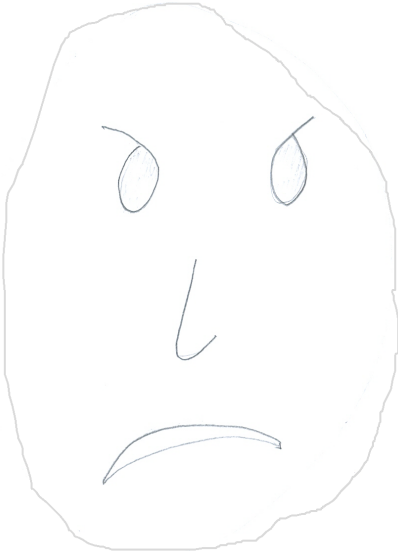Figure 8.6: Sample Image - Expression Sad

Figure 8.7: Sample Image - Expression Sad

Figure 8.8: Sample Image - Expression Sad

Figure 8.9: Sample Image - Expression Sad

Figure 8.10: Sample Image - Expression Sad

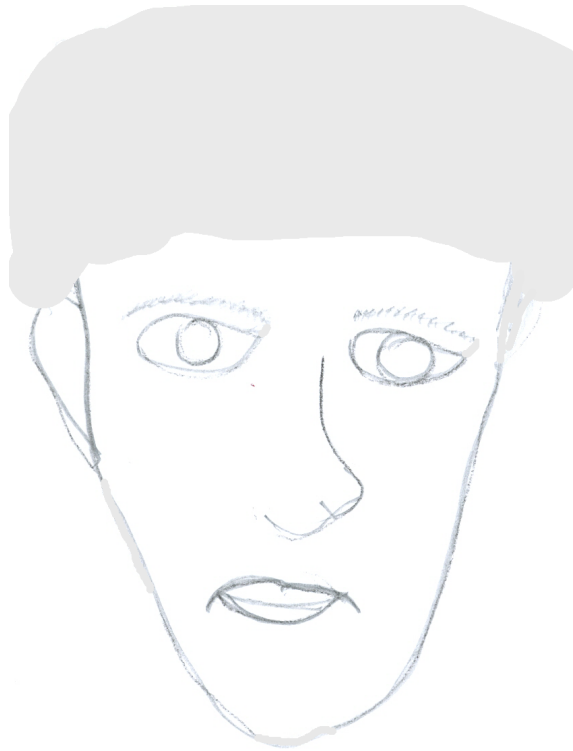Figure 8.11: Sample Image - Expression Neutral

Figure 8.12: Sample Image - Expression Neutral

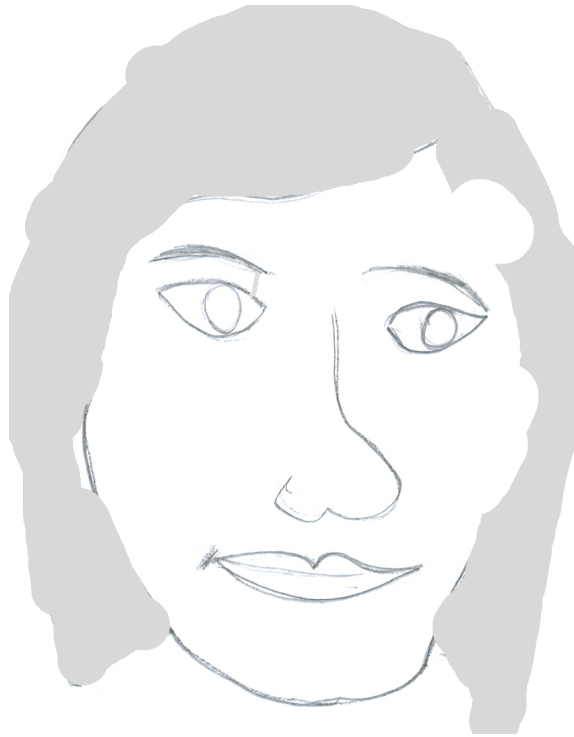Figure 8.13: Sample Image - Expression Neutral

Figure 8.14: Sample Image - Expression Neutral

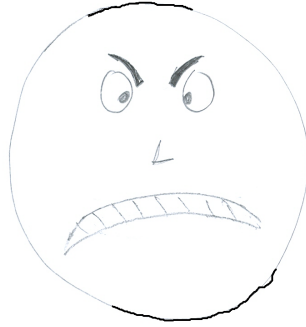Figure 8.15: Sample Image - Expression Neutral

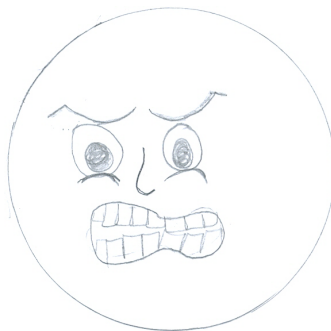Figure 8.16: Sample Image - Expression Angry

Figure 8.17: Sample Image - Expression Angry

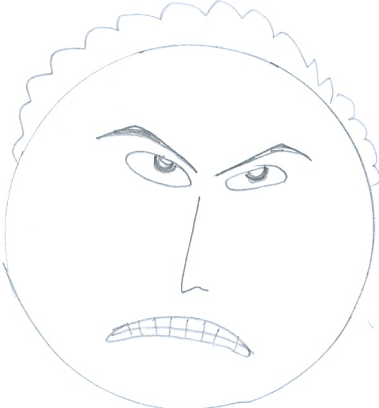Figure 8.18: Sample Image - Expression Angry

Figure 8.19: Sample Image - Expression Angry

Figure 8.20: Sample Image - Expression Angry

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