1. INTRODUCTION

1.1 EMOTIONAL INTELLIGENCE:

There exist quite a large number of contemporary theories on emotional intelligence. These theories have been developed from different angles of understanding emotions. Naturally, researchers of different domains attempted to interpret the phenomena of emotions, its arousal and control from the point of views of respective subject domains. For example, physiologists co-relate emotions with the changes in the neurological and hormonal activity of the humans, which are caused by the various physiological conditions of the human body, including blood pressure, blood circulation, respiration, body temperature, gastrointestinal activity and many others. Psychologists, on the other hand, consider emotion to have four main evolvable phases, such as cognition, evaluation, motivation and feeling. Philosophers are mainly concerned with the issues of emotion and rationality. [2]

Figure 1.1 Emotion from facial features

Emotional intelligence (EI) is a new discipline of knowledge. Philosophically, it refers to the competence to identify and express emotions, understand emotions, assimilate emotions in thought and regulate emotions in the self and in others. The word competence in the present context, perhaps, indicates the degree or relative power of judgment of persons to recognize/understand emotions. The power of representing emotions in thoughts, according to the definition, also is a measure of EI. Control/regulation of emotion too is considered as a measure to qualify the term competence in this context. There exists a vast literature on EI considering one or more aspects of the above emotional attributes toward intelligence. Most of the literature considers emotions from philosophical and/or psychological standpoint, and ignores the scope of possible automations to detect and regulate human emotions. Naturally, people with a high level of emotional intelligence may not have high intelligent quotient (IQ). Apparently the hybrid term “Emotional Intelligence” seems to be contradictory as it includes emotions, conveying the idea of irrational passion and intelligence, which is characterized by rationality of thoughts. In fact, since the beginning of the era of emotional intelligence, the conflict between emotion and rationality was given much importance, and no legitimate solution to this problem could be traced until the beginning of this decade. Most of the researchers in the last few decades emphasized the importance of intellect at the expense of emotion. This trend, however, is being changed as the experimental research on emotions demonstrated many promising results, citing the need of the emotional component over the intellect component of EI.[2]

1.2 EMOTION DETECTION:

Emotion detection is an integral part of modern biometric image processing applications. Emotions were considered as useless and hence undesirable entity, which are frequently negative in nature and thus disrupt normal activities of the mind, and often lead to disorganized behavior. Recent advances in experimental psychology reveal that emotions are useful and valuable function of our mind and its manifestation provides us an opportunity to detect the physiological conditions of our biological living organism. There exist two types of emotions: simple and complex. A simple emotion includes only one emotional state, while a complex emotion includes more than one concurrent emotional state. The emotions are identified based on the results obtained by the analysis of a subject’s facial features.[1]

1.3 INTERACTION BETWEEN EMOTIONS:

When two or more emotions are aroused at the same time due to multiple external stimuli, they either compete with each other or coordinate. The resultant emotion is the one of the more dominant emotion. When two or more emotions interact to give a dominant emotion, the person's psychological state decides on giving a normal emotion. A change in the physiological states accelerates or retards the growth in emotion arousal. Let Xi, Xj and Xk be three representative emotional states that describe the concentration of individual emotions. [1]

Suppose Xj for some j co-operates with Xi, while Xk, for some k, competes with Xi. In other words, the growth rate of Xi will be accelerated with an increase in Xj, but will be decelerated with an increase in Xk.

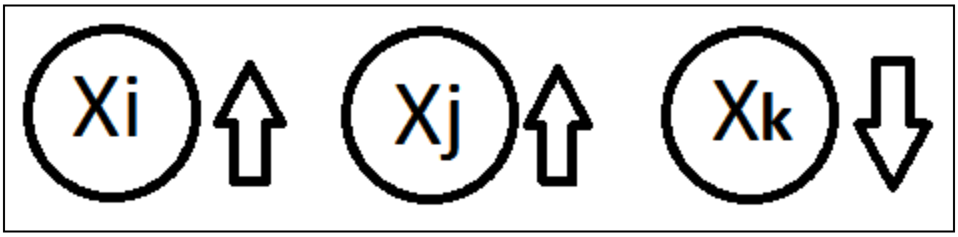


Figure 1.2 Multi-Emotional Interactions

1.4 STABILITY ANALYSIS:

The World Health Organization defines mental health as "a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community". It was previously stated that there was no one "official" definition of mental health. Cultural differences, subjective assessments, and competing professional theories all affect how "mental health" is defined. There are different types of mental health problems, some of which are common, such as depression and anxiety disorders, and some not so common, such as schizophrenia and Bipolar disorder. Mental stability can be identified and analyzed conventionally by using tests such as electroencephalogram (EEG), functional magnetic resonance imaging (fMRI) and positron emission tomographic (PET Scan) images. These show the brain activity or the absence thereof.[1]

1.5 APPLICATIONS OF EMOTION AND STABILITY IDENTIFICATION:

Stability analysis could be used to detect unstable patients who have been through recent trauma or epilepsy. The most interesting and useful application of the proposed objective of emotional parameters selection, perhaps, is the detection of psychological disorder from emotional parameters.

Emotional expressions sometimes carry information about anti-social motives of the people. Anti-social motives refer to execution of tasks, causing pains and anxiety to others. Humans as rational agents, even when performing anti-social activities, usually suffer from a consciousness about negative feelings, reproducing self-anxiety in their emotional exposure. Naturally, with a slightest external perturbation to the emotional brain of the anti-social people, the psychological motives become apparent in their emotional expression. The emotional expression for these people engaged in anti-social activities may come up in different form depending on situations, their personality and the external influence that causes them to regenerate their emotional expression. Sometimes, they express these emotions in the sudden change of their voice or their facial expression, gesture and posture. An analysis of the dynamics reveals that it may demonstrate chaos, limit cycles and stable behavior, depending on the range of parameters of the dynamics. The proposed method of determining parameters of emotional dynamics thus makes sense, as it helps us in determining the growth rate of certain emotional parameters and the power of withstanding stress of common humans. These parameters have significant impact in many real world problems involving humans. For instance, in medical/other welfare services, such as nursing, baby sitting etc. selection of persons with strong power of withstanding stress but having soft personality can be ensured by the proposed method of emotional parameter selection Stability analysis can also be used as a human resource tool to identify the psychological states of recruits in an organization.[2]

1.6 SCOPE OF THE PROJECT:

The major intent of the project is to understand the human behavior and to interpret the emotions of a particular subject. This project paves a new direction to control human emotions using music, video and voice messages, thus acting as a novel approach to model the emotional dynamics of a person. This project may serve as a great stress detector comparable to the conventional methods and also aid in e-learning aspects.

1.7 CHAPTER ORGANIZATION:

The various chapters are organized as follows:

- The 2nd chapter gives a review about the references used for this project.
- The 3rd chapter compares the existing system with the proposed system and gives an algorithm for the system designed.
- The 4th chapter lists out the requirements needed for designing the system and also gives architecture and module design of the system and elaborates on it.
- The 5th chapter describes steps in implementing this project.
- The 6th chapter briefs on various test cases and errors faced while testing the project.
- The 7th chapter gives an outline of future enhancements possible.

2. LITERATURE REVIEW

Madhumala Ghosh, Aruna Chakraborty, Amit Konar and Atulya Nagar and R.Janarthanan, 2008, “Chaos and Stability in the Dynamic Behavior of the Multi-emotion Interactions”, IEEE vol. 978-1-4244-2963-9/08/$25.00,2008. [1] have proposed a method to analyze a subject for stability or chaos using a multi-emotion interaction model, which then uses the pixel values obtained from the image faces and using them in the Lyapunov equation. They give sample experimental analysis of two voluntary subjects. The paper gives an instance for a stable and unstable subject. It is identified using the time difference equations obtained using the Lyapunov analysis and by charting the values onto a graph. If the values remain positive for all values for an emotion, it indicates chaos in that subject.

A. Chakraborty and A. Konar, 2005, “Emotional Intelligence: A Cybernetic Approach”, Springer- Verlag, Heidelberg. [2] begins with an introduction to Emotional Intelligence, and explores the mathematical models for emotional dynamics to study the artificial control of emotion using music and videos, and also to determine the interactions between emotion and logic from the points of view of reasoning. The later part of the book covers the chaotic behavior of coexisting emotions under certain conditions of emotional dynamics. Finally, the book attempts to cluster emotions using electroencephalogram signals, and demonstrates the scope of application of emotional intelligence in several engineering systems, such as human-machine interfaces, psychotherapy, user assistance systems.

D. Shukla and R. Singhai, 2011, “Analysis of Users Web Browsing Behavior Using Markov chain Model” give a brief usage of the Markov chain procedures and transition probabilities. The paper illustrates the usage of the model in the case of the setup of two browsers, considering a pre-defined level of popularity and reputation. The user’s inclination towards the usage of a particular browser is observed by means of prediction via transition probabilities and a graphical study is taken in this work to explain the inter relationship between user behavior parameters and browser market popularity parameters. The results are concluded by depicting that a company which is lowest in terms of browser failure and lowest in terms of quitting probability will enjoy a better popularity and user proportion.

M. Ghosh, A. Chakrabarty, A. Konar and A. Nagar, “Prediction of the Interactive Dynamics of Stimulated Emotions: Chaos, Limit Cycles and Stability” attempts to model the interactive dynamics of competitive/cooperative emotions aroused by audio-visual stimulus. Parameter variations of the dynamics results in three specific dynamic behavior including Chaos, Limit Cycles and stability. An analysis of the dynamics yields the parametric conditions for Stability and Chaos. Known audio-visual stimulus is used to predict the emotive state of the dynamics from the external manifestation of emotions in the facial expressions of the subjects.

Jean-Marc and Fellous, “The Neuromodulatory Basis of Emotion” reviews the experimental evidence showing the involvement of the hypothalamus, the amygdala and the prefrontal cortex in the stimulation of emotion. This paper shows the important role of various neuromodulatory systems in mediating emotional behavior. The paper also suggests that behavioral complexity is partly due to diversity and intensity of neuromodulation and hence depends on emotional contexts. Rooting the emotional state in neuromodulatory phenomena allows for its quantitative and scientific study and possibly the emotional characterization.

M.Kaur and R.Vashisht, “Comparitive Study of Facial Expression Recognition Techniques”, explores and compares techniques for automatically recognizing facial actions in sequences of images. The paper also discusses the concepts of five universally accepted principal emotions-Angry, Happy, Sad, Disgust and Surprise along with Neutral.

3. PROBLEM DEFINITION AND METHODOLOGIES

3.1 EXISTING SYSTEM:

The current system demonstrates methods to identify chaos and stability using conventional techniques such as electroencephalogram (EEG), functional magnetic resonance imaging (fMRI) and positron emission tomographic (PET Scan) images. Lyapunov exponent method has also been used to model the stability analysis of the discrete dynamical system. Such methods, albeit having sufficiently accurate results, are time and cost consuming. Hence there is a need for a quicker and simpler diagnostic test to model the chaos and stability of any subject.[1]

3.2 PROPOSED SYSTEM:

In the first phase, the project proposes a technique for analyzing the stability of a subject based on the existing Lyapunov exponent analysis. An observation video is obtained by recording the reactions of the subject to the stimuli video to detect the face, extract the facial features and its areas and infer if a person is psychologically stable or chaotic.

The secondary work for this project proposes to make use of the Markov chain model to model the stability of the individual's emotions based on the transition probabilities. A performance comparison is made between these two methods to find a reliable one amongst them.

3.3 LIMITATIONS:

While the analysis gives appropriate results, the tool is only to be used for an instant diagnostic test. Further tests such as electroencephalogram (EEG), functional magnetic resonance imaging (fMRI) and positron emission tomography (PET Scan) images, along with external manifestation of emotion in gesture/posture and facial expressions are required for accurate determination of emotional parameters.[1]

3.4 ALGORITHM:

Begin

Step1: Create Stimuli Video

Step2: Obtain Observation Video by making the subject watch the stimuli video.

Step3: Extract frames from the observation video.

Step4: Detect and isolate the face from the extracted frames.

Step5: Extract the facial features for analysis.

Step6: Compute the area for each facial feature.

Step7: Detect the emotion by cross referencing with reference table.

Step 8: Analyse stability using Lyapunov analysis.

Step 9: Draw a state transition diagram for the exhibited states.

Step 10: Analyze stability using the transition probabilities of Markov model

Step 11: Determine the percentage of stability of the subject.

Step 12: Compare the performance of the two methods.

End

Figure 3.1 Algorithm for determining User's Behavior

4. DESIGN PROCESS

4.1 REQUIREMENTS:

4.1.1 SOFTWARE REQUIREMENTS:

4.1.1.1 OPERATING SYSTEM:

The operating system that is used is Windows 7.

Table 4.1 System Requirements

Processor	Pentium Core 2 Duo 2.5 GHz
Operating System	Windows XP/7, Vista
Hard Disk	160 GB
RAM	2GB and above
Monitor	SVGA color
Programming Language	MatLab(v2012a)

4.1.1.2 BASIC SOFTWARE:

The files are used to run the analysis

Table 4.2 Brief Description Of Files

File name	Description
Main.m	To process the video and extract the frames
imp.m	Detects the face and plots a box around it.
cropping.m	It crops the detected face.
croppingparts.m	It crops the detected face into two halves.
croppingeyes.m	It tracks the eye region and crops it.

eyewidth.m	Computes the width of the eyes using edge detection.
eyebrowconstriction.m	Computes the relative position of the eyebrow.
croppingmouth.m	It computes the mouth region from the lower half of the face.
LIP.m	Computes the area of the mouth.
emotionIdentification.m	Analyses the stability of a subject.
finalgraph.m	Draws the performance comparison graph between the running times of two methods

4.1.1.3 MATLAB (vR2012a):

MATLAB is a programming environment for algorithm development, data analysis, visualization, and numerical computation. MATLAB can be used to solve technical computing problems faster than with traditional programming languages, such as C, C++, and Fortran. Matlab is used to do the image processing and emotion identification.

4.1.2 HARDWARE REQUIREMENTS:

- A PC or Laptop
- 160GB hard disk.
- Web cam with a good pixel resolution.
- Headphone
- 2 GB RAM

4.2 ARCHITECTURE DIAGRAM:

The basic architecture diagram is given as follows:

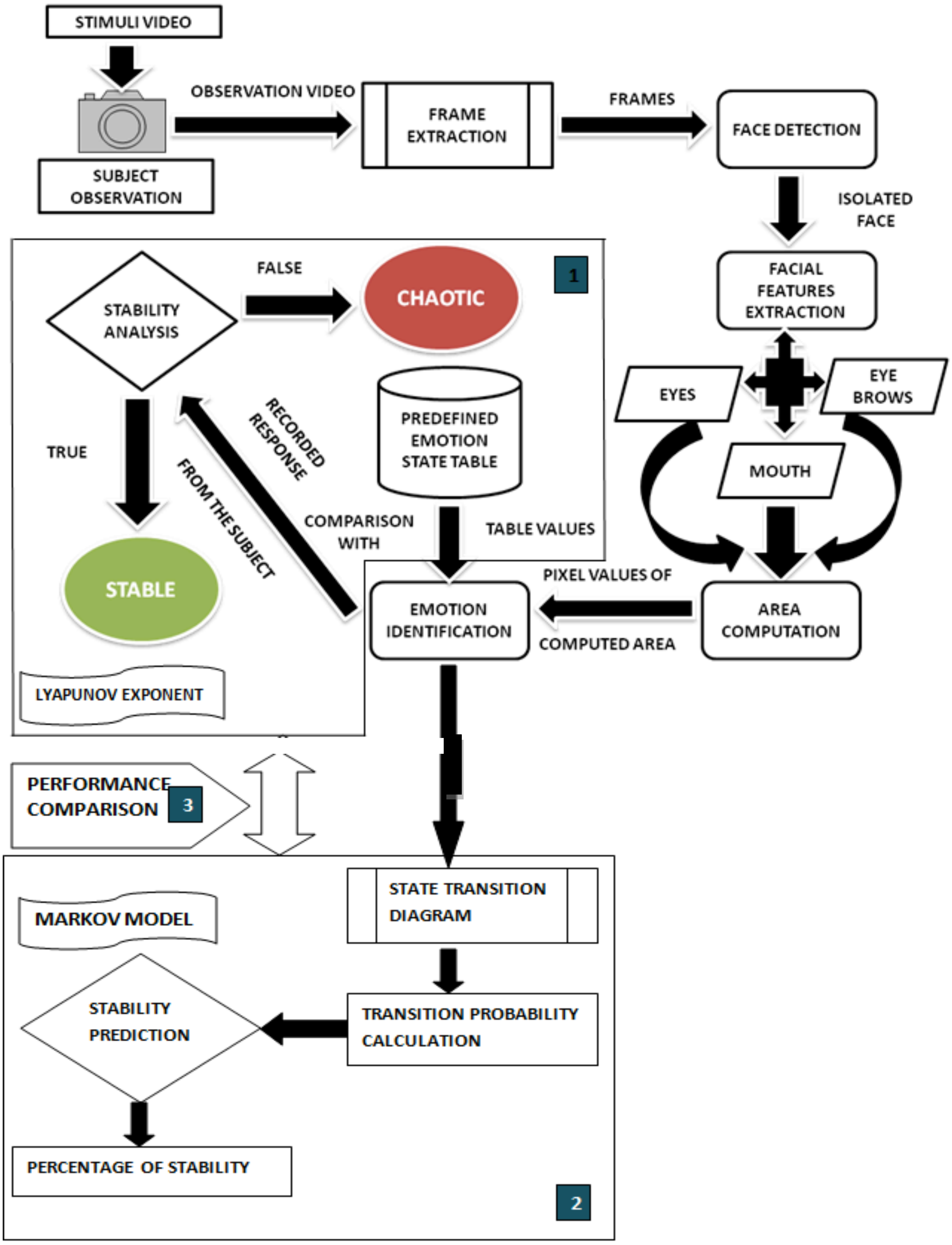


Figure 4.1 Architecture Diagram

The architecture diagram is first divided into three sections along with the basic beginning processes. The process first begins with the stimuli video, which is shown to the subject and then the frames are extracted from the subject observation video. The facial features are then extracted and areas computed. This is followed by the emotion identification module from where the divisions start.The first section is the stability analysis of the subject based on pre-defined table and Lyapunov exponent analysis which gives the result of whether the subject is stable or chaotic in nature.The second section is stability analysis using Markov model which uses transition probabilities to calculate the percentage of stability of the subject.The last section is the performance comparison between these two methods.

4.3 MODULE DIAGRAM:

The module diagram is given below:

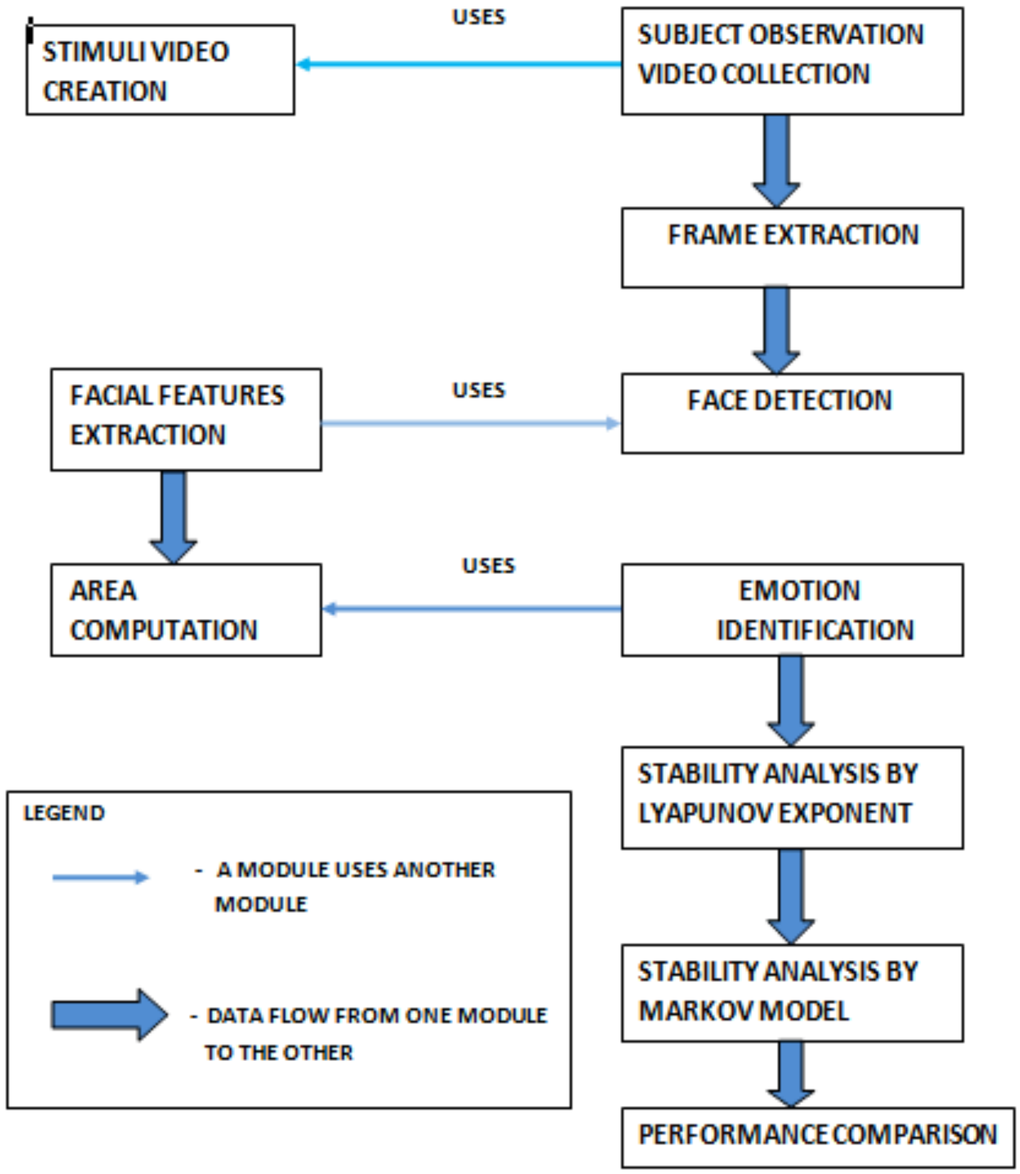


Figure 4.2 Module Diagram

The modules are explained below:

• **Stimuli Video creation:**

It combines various emotion triggering videos, each of which evokes a particular emotion, into a single video, thereby creating the required stimuli video.

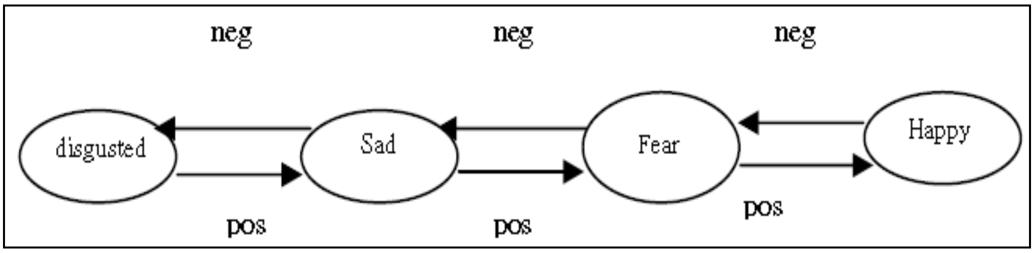


Figure 4.3 Emotion Triggering Sequence

While implementing, A particular order of emotional arousal is initially deployed which did not give expected arousal of emotions. We hence, reordered based on a survey from the subjects and deployed a new order which was much more efficient and triggered all the emotions properly.

- **Subject observation video collection:**

The subject is made to observe the stimuli video and their corresponding emotions are recorded into a single video and fed to the system as input.

After collecting observation videos from a few subjects, It was found that, there were some discrepancies which have been discussed in section 8.2.

- **Frame Extraction:**

The observation video is segmented into multiple frames and the required frames for face detection are extracted. Initially, one frame per emotion was extracted. Later, It was observed that subjects did not universally respond at the same instance to the stimuli video. Hence 5 frames per emotion was taken, thereby giving a wider window of opportunity for capturing the instance of emotion. It also simplified the analysis.

- **Face detection and isolation:**

It identifies the face from the selected frames and isolates the face to a separate image file by using image cropping function.

It uses YCbCr color model and plots a red line-box around a face detected based on the skin color. Two or more faces might be detected when a similar pattern is observed in the frame but this problem is resolved by processing the face closest to the camera.

- **Facial features extraction:**

From the cropped image file containing the faces and the pixel locations of facial features (Eye brows, eyes and mouth) are tracked.It uses Smiling Detection algorithm. It postulates that each of the facial feature is symmetrically located at a proportionate distance from the forehead. This simplified the task of tracking the facial features.

- **Area computation:**

Using the pixel locations, bounding boxes are drawn around the facial features and their areas are computed. It uses edge detection algorithm and converts a colored image into a black and white image, where edges of each facial feature be clearly identified. Edges are displayed in white.

For computing the area of each eye, it locates the first pixel from the top, which is upper eye lid and the first pixel from the bottom, which is the lower eye lid. Then it computes the distance between these two pixels, which gives the width of the eye. This is the Eye Opening (EO).

For computing the area of the mouth, it finds the length/width and height between the upper and lower lip and finds its product which gives the area of the mouth. This is the Mouth Opening (MO).

For computing the position of the eyebrow, the region where the eyebrow pixels are located is identified. Discreetly the values 1 and 0 were given for upper and lower regions respectively, where the eyebrows are found.

•**Emotion Identification:**

The areas of facial features obtained from the image are compared with the reference table and the corresponding emotions are identified. After surveying around 30 subjects, I framed the reference table, by normalizing the individual values.

• **Stability analysis by Lyapunov exponent:**

The area values of the facial features are substituted in the Lyapunov equation dx(t+1)/dx(t) and chaos is predicted using the result theoretically. Practically, I computed the stability by matching individual subject's value with the given reference table.The values computed from the Eye Opening,Mouth Opening and Eyebrow Constriction are substituted in the differential equation of the Lyapunov exponent and the graph is plotted using the values obtained after the calculation.By observing the plot in the graph,depending on either the positive or negative value,a classification is made regarding the stability of the subject.

• **Stability analysis by Markov Model:**

Transition probabilities are defined for each transition from one emotional state to another.Using the likeliness of the transitions,the percentage of probability is calculated,giving an account of the detailed stability report of the subject.

• **Performance Comparison:**

The performance of the two methods are compared based on time and the best one among them is found and displayed.

4.4 UML DIAGRAM:

4.4.1 STATE-CHART DIAGRAM

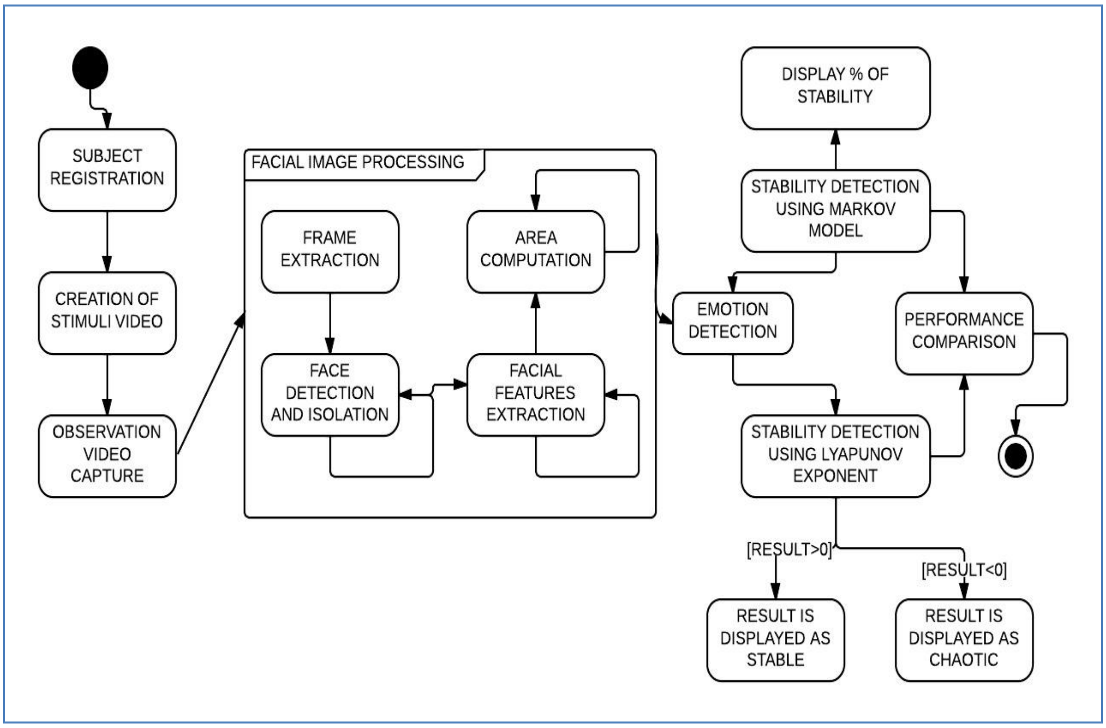


Figure 4.4 State-chart Diagram

4.4.2 USE-CASE DIAGRAM

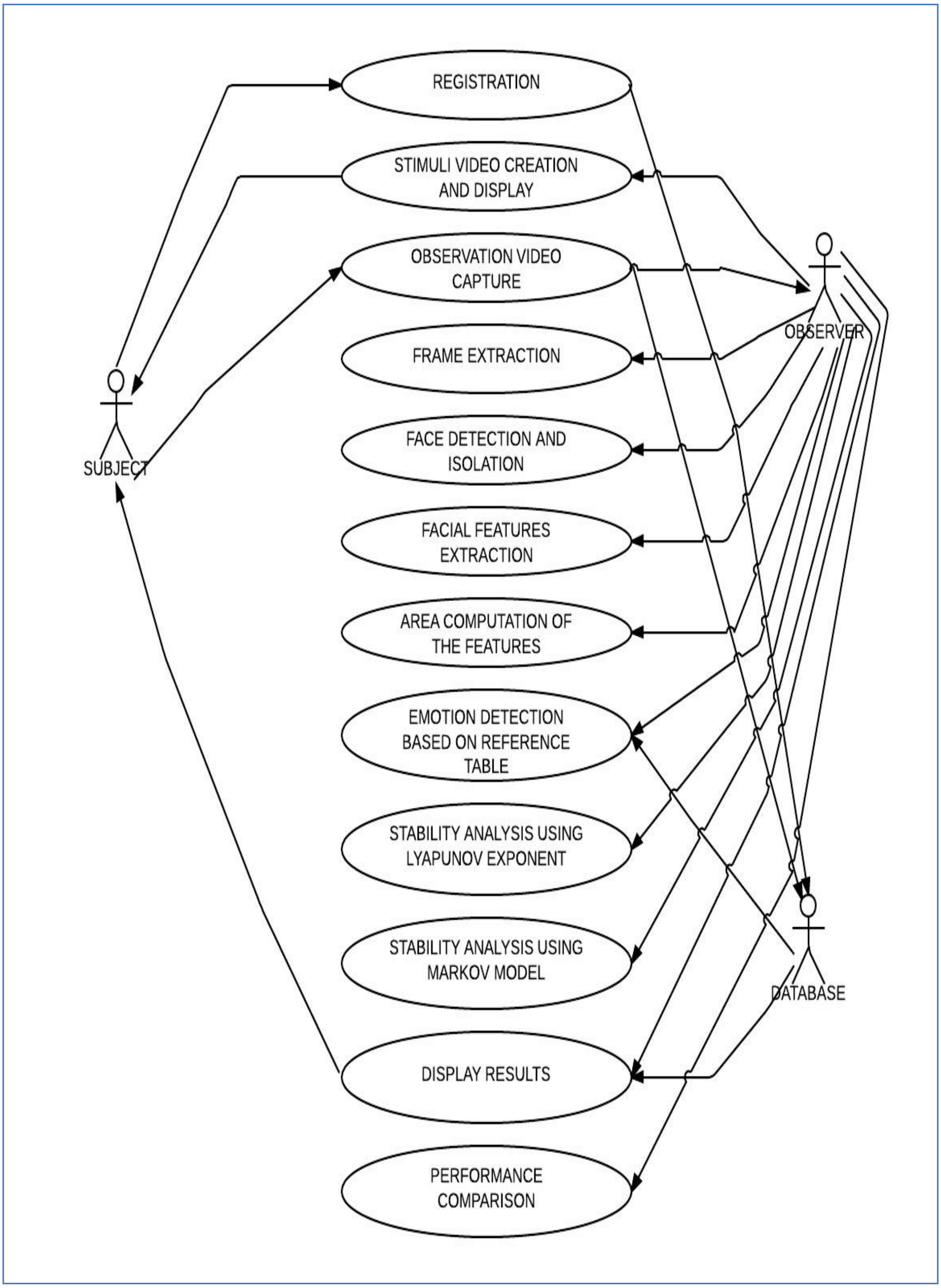


Figure 4.5 Use-case Diagram

4.4.3 SEQUENCE DIAGRAM

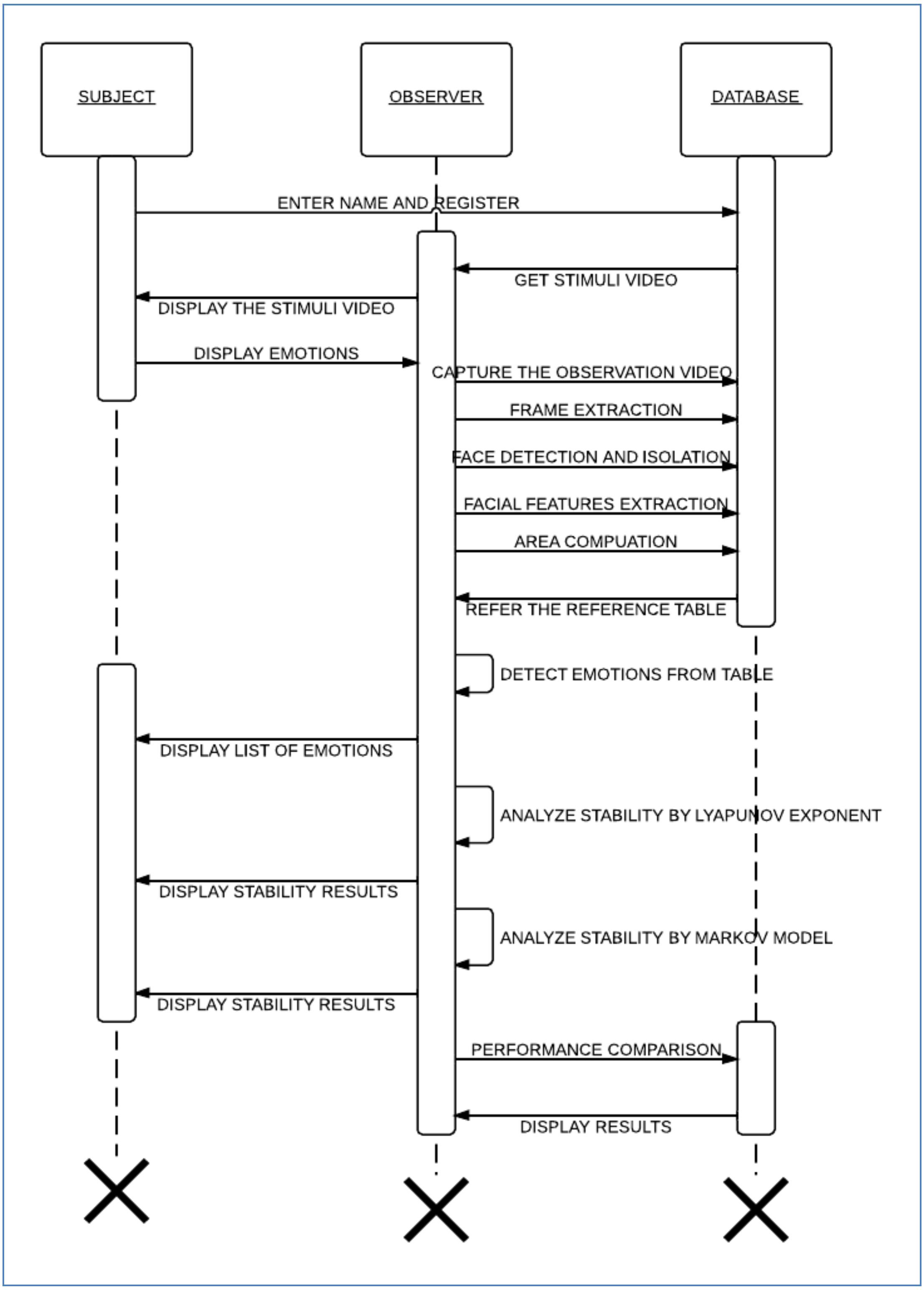


Figure 4.6 Sequence Diagram

4.4.4 ACTIVITY DIAGRAM

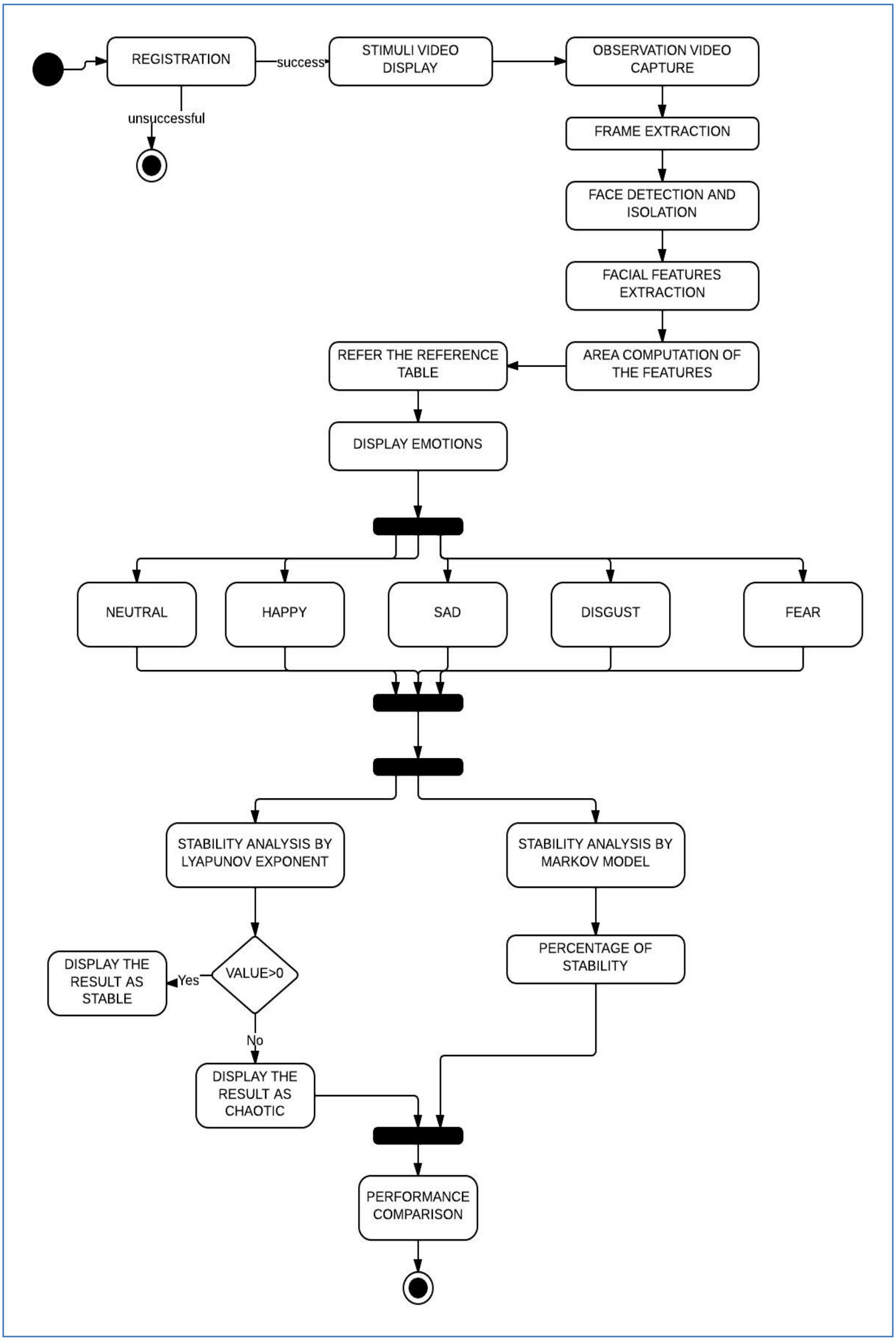


Figure 4.7 Activity Diagram

4.4.5 CLASS DIAGRAM

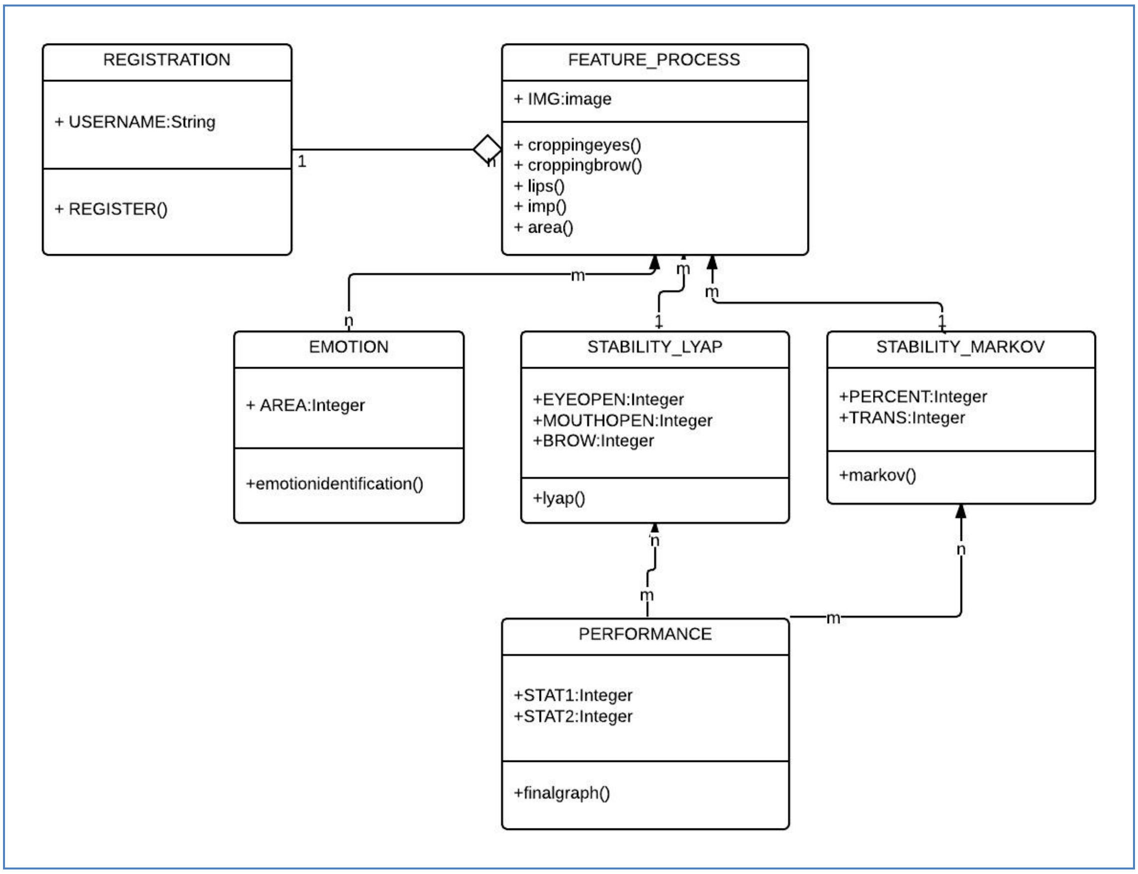


Figure 4.8 Class Diagram

4.4.6 DEPLOYMENT DIAGRAM

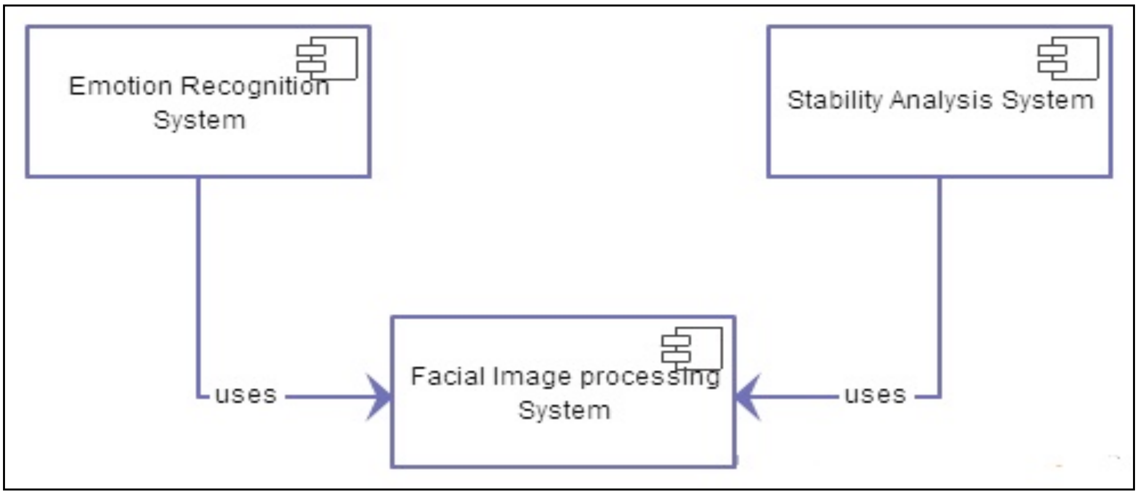


Figure 4.9 Deployment Diagram

4.5 DATA-FLOW DIAGRAM

4.5.1 CONTEXT DIAGRAM

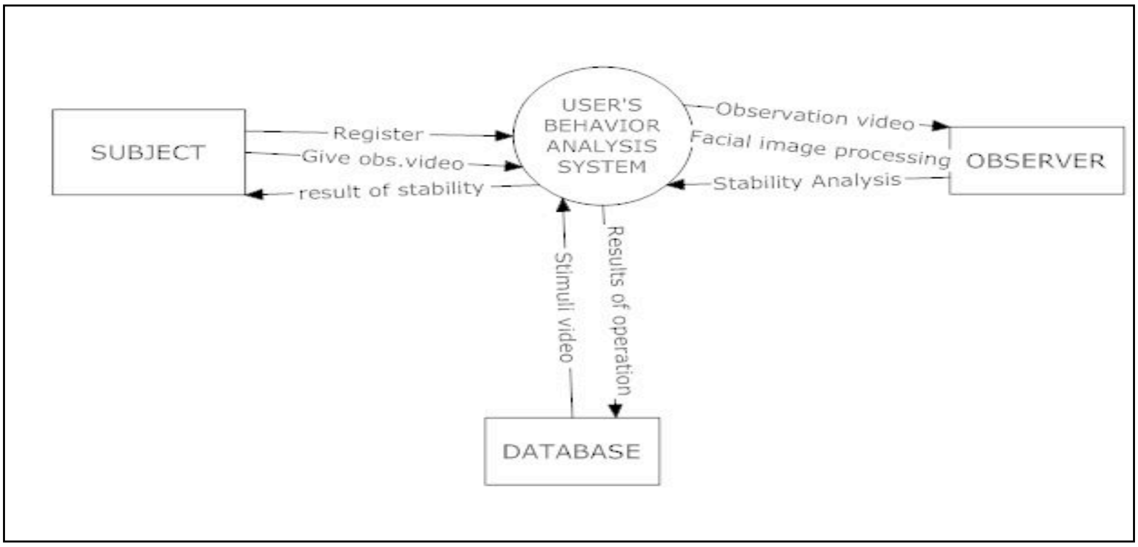


Figure 4.10 Context Diagram

4.5.2 LEVEL 0 DFD

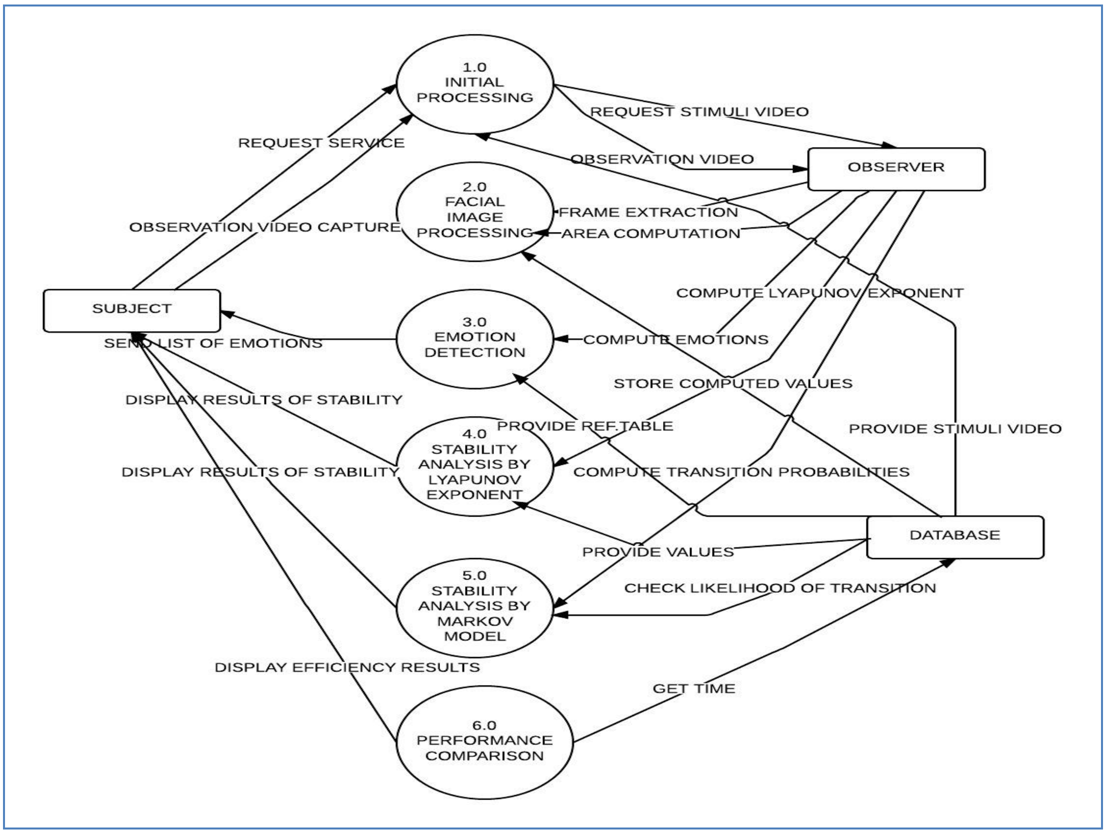


Figure 4.11 Level 0 DFD

4.5.3 LEVEL 1 DFD

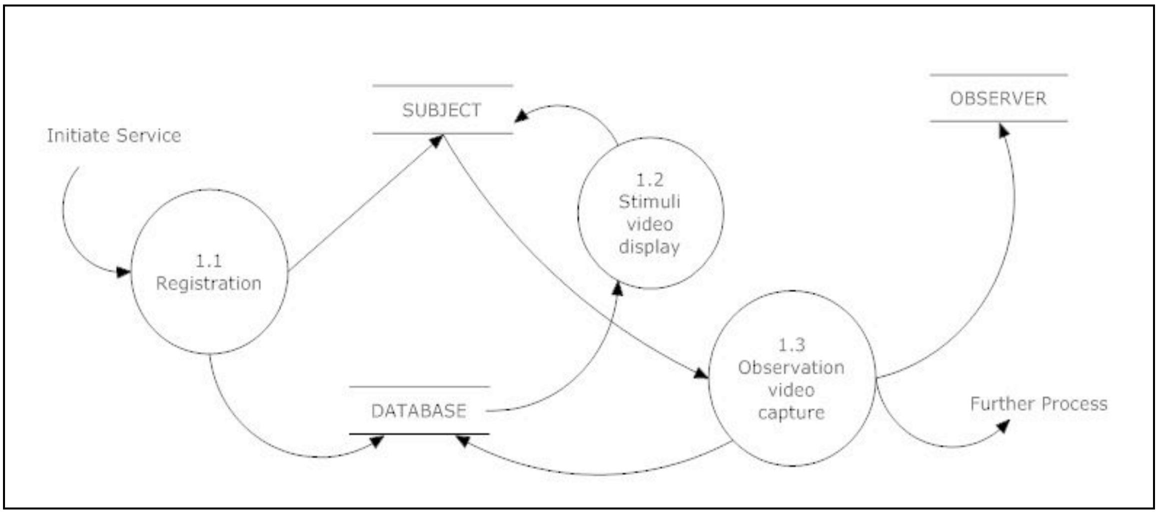


Figure 4.12 Initial Processing DFD

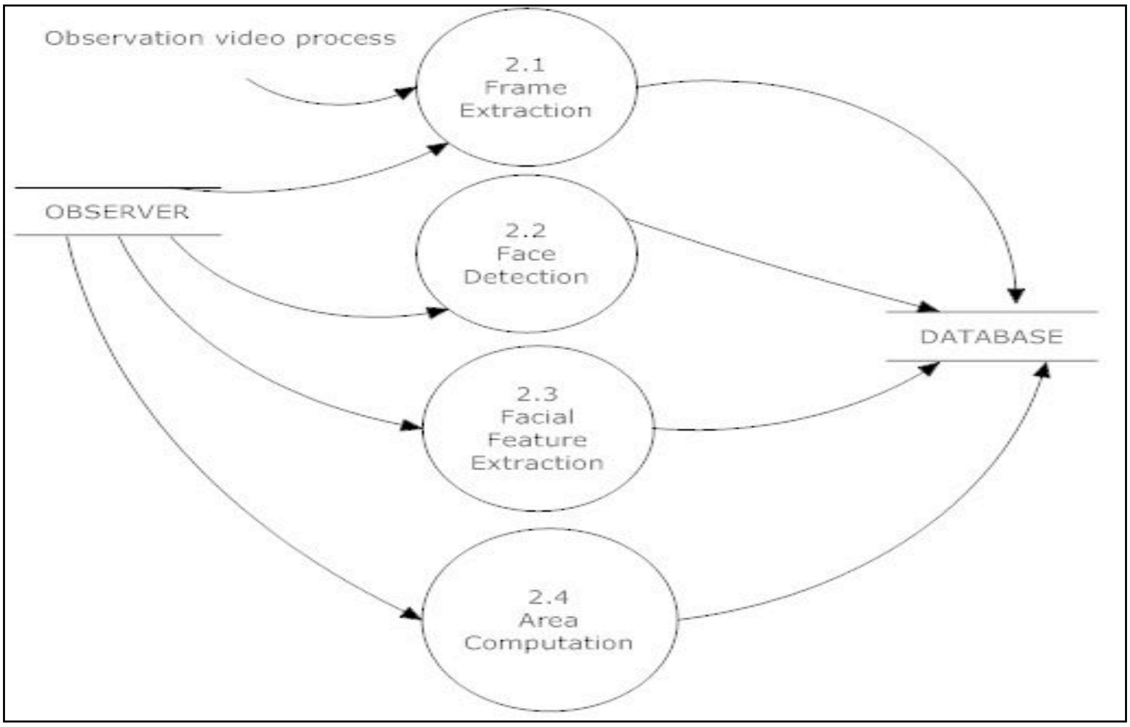


Figure 4.13 Facial Image Processing DFD

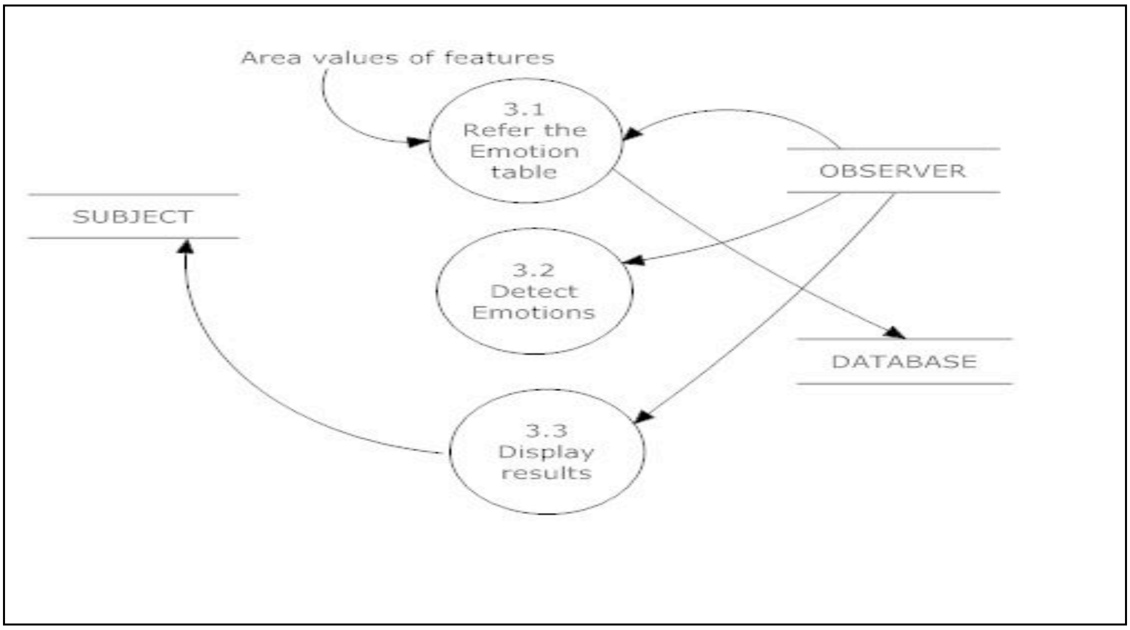


Figure 4.14 Emotion Detection DFD

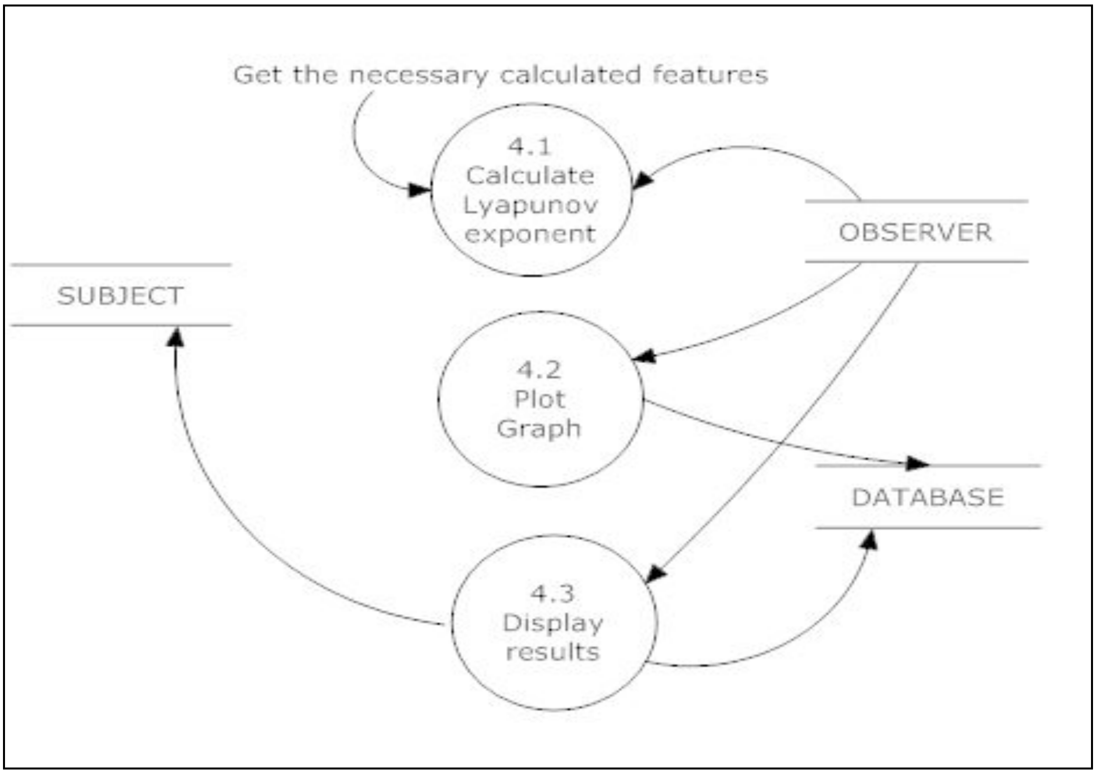


Figure 4.15 Stability Analysis by Lyapunov Exponent DFD

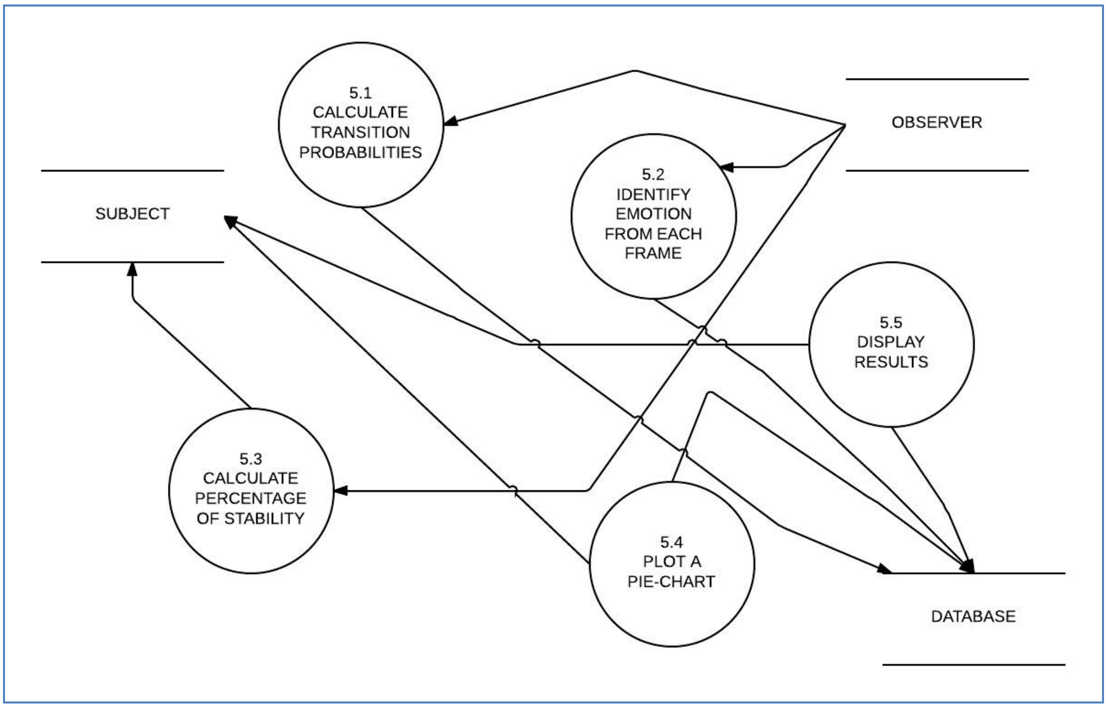


Figure 4.16 Stability Analysis by Markov Model DFD

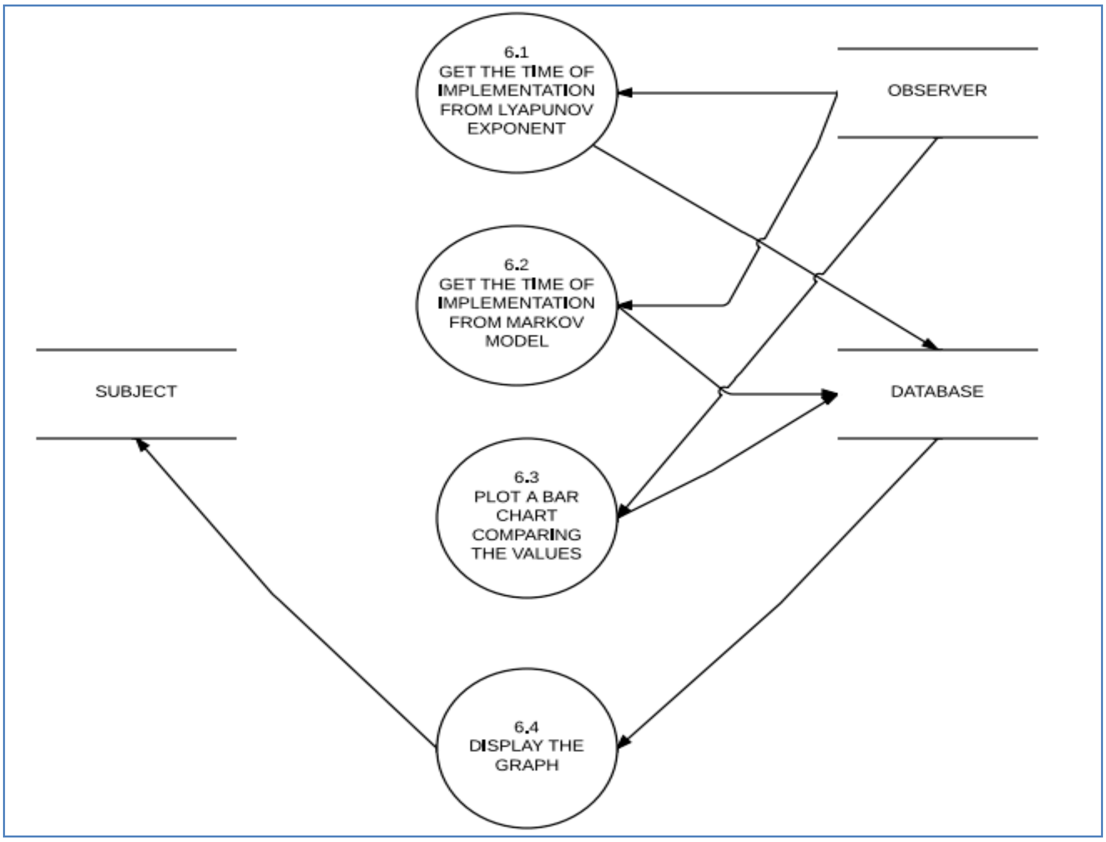


Figure 4.17 Performance Comparison DFD

5. IMPLEMENTATION

5.1 DEVELOPMENT PROCESS:

The application is first started by the creation of the stimuli video. This video is a collection of emotion triggering clips appended together to make the subject react in different manners. The observation video, which is the video that records these reactions, is done next. The video is then analyzed and frames are extracted. The faces of the subject are extracted from each frame and facial features are isolated. The area computation for each of the facial feature follows. Based on the areas, emotions are identified and finally, stability is analysed. The implementation is fairly simple. The subject to be tested is asked to sit and observe the stimuli video. The reactions of the subject to the video are recorded onto a camera. This video is then analysed using the application which gives the output of whether the subject is psychologically stable or chaotic.

The system can be tested by analysing the video of a subject who is known to be chaotic or stable using a fMRI or any other similar tests and comparing the results.[1]

5.2 STABILITY ANALYSIS USING LYAPUNOV EXPONENT:

The stability of a subject is inferred from the result of the Lyapanov equation. When implementing using the application, I also use a score based technique, where the subject's stability is rated on a scale of 1 to 60, where 60 is considered to be highly stable. Theoretically, when using the Lyaponov equation, the area values of each facial feature is substituted into it and the results are tabulated. The time difference values are then calculated and tabulated. A graph is then charted using these time difference values for each emotion. If the graph remains on the positive side of the x-axis for all values, the person is considered to be chaotic. This is inferred as the subject exhibits that particular emotion in spite of the triggering of others. [2]

5.3 FACE DETECTION:

In order to detect the emotion of the subject, the face and the facial features have to be identified. The face is first isolated using the face detection technique. It involves the skin color detection and isolation. It combines motion detection by spatio-temporal filtering with an appearance-based face model in the form of a neural net. Multiple person tracking was performed using time-symmetric matching and Kalman filtering. The use of colour as a cue for detection and tracking is described. Colour provides a computationally efficient yet effective method which is robust under rotations in depth and partial occlusions. It can be combined with motion and appearance-based face detection. Human skin forms a relatively tight cluster in colour space even when different races are considered.

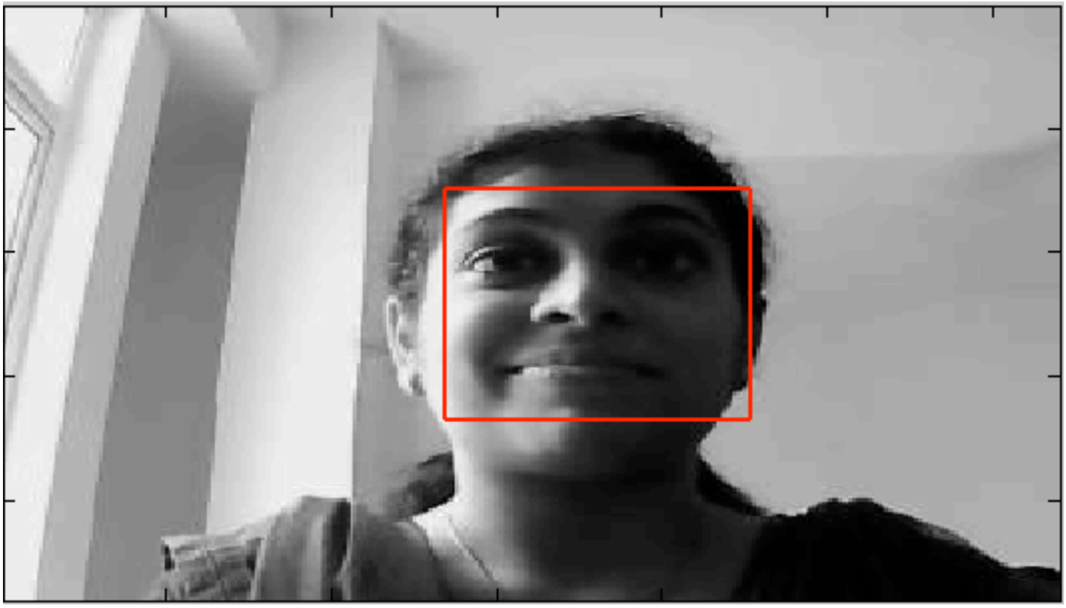


Figure 5.1 Face Detection

5.4 EMOTION TRIGGERING:

In order to arouse mixed emotions, there is a need to submit time-staggered audio visual stimulus causing arousal of different emotions. In other words, persistence of more than one emotion can be maintained by exiting subjects with one base emotion, superimposed with other relatively short-duration emotions. For instance, a base emotion of happiness, when perturbed by a burst of disgust and fear in time-succession, represents a coexistence of multiple emotions for a certain time frame. After the mixed emotions are synthesized, three important facial attributes, such as Mouth opening (MO), Eye opening (EO), and Eyebrows constriction (EBC) are determined from the facial expression of the subject. This needs segmentation of eye, mouth and eyebrow regions and their localization. The exact range of these three adjectives depends on individuals personality, culture and upbringing, and country/state where he/she belongs to. In order to keep the measurements error-free,the measurements were normalized by dividing the actual measurement of MO, EO and EBC by its largest experimental value for the given subject.[2]

5.5 FACIAL FEATURES EXTRACTION:

It is well-known that in HSV system, human skin maintains a standard range in Hue, Saturation and Value, thereby providing a simple means to segment skin region from the faces. After the skin region is segmented, next segmentation of eye, eyebrows and lip region are done. Lip region in a colored image can be easily segmented because of its distinctive color profile that segregates it from the skin color. Segmentation of the eye-region is performed in two phases. Firstly, the third dark-most sub-region in the monochrome version of a given facial image is obtained, and then the sub-region is grown, so as to identify the region containing dark eyeballs. Similarly segmentation of the eyebrow region is performed by determining the second dark-most region from top of the face, starting from the hair region. A localization algorithm is also undertaken to localize the segmented regions in the image. After segmentation, and localization the eye opening (EO), mouth opening (MO), and eyebrow constriction (EBC) is determined from the counting of pixels of interest. Based on the size range of the features, the emotion can be identified as given in the table below:[1]

Table 5.1 Emotions Based On Facial Feature Areas

Emotion Transition	Eye Opening and Eyebrow Constriction	Mouth Opening
Neutral->Disgust	Increases	Increases
Neutral->Fear	Increases	Decreases
Neutral->Happy	Decreases	Increases
Neutral->Sad	Equal	Equal

5.5 STABILITY ANALYSIS USING MARKOV MODEL:

After the stability is analyzed using the Lyapunov exponent analysis,an effort is made to analyze the stability using the prediction technique named as Markov Model.Markov model functions by using the transition probabilities for each transition.A transition is the movement from one emotional state to another in a given period of time.Such a transition is marked by a certain probability depending on the likeliness of the transition. The calculation of probabilities is done on the basis of the formula

$$P_1 = \frac{P_1}{P_1 + P_2 + \ldots.. + P_n}$$

Where

P_1= Required probability

P_1+P_2+....+P_n=Total probability

The stimuli video has the information regarding the type of emotion to be exhibited in the given time.Using this as a clue,the observation video is split into frames and the emotion in each frame is found.Using the transition in the stimuli video as reference,the observation video is checked and using the ransition probabilities,the percentage of correctness to the reference is observed and displayed as the percentage of stability of the person.In addition,a transition diagram is drawn to show the states traversed.For easy observation,the percentage of stability is displayed by means of pie-chart.

5.6 PERFORMANCE COMPARISON:

At the end, the performance of the two methods-Stability analysis by Lyapunov exponent and Markov model is analyzed and compared on the basis of time criteria.Among the two methods,Markov model is found to show a lower time evaluation since Lyapunov method contains the calculation of the differential equation to find out the solution.Further more,On evaluating the methods on the basis of efficiency,Markov model shows the clear interpretation of stability on the grounds of percentage whereas Lyapunov exponent gives only two results-stable or unstable.In conclusion,Markov model serves as a more efficient method of the analysis of stability.

6. EXPERIMENTATION METHODS

6.1 LYAPUNOV EXPONENT ANALYSIS:

Lyapunov exponent is normally calculated for difficult weight setting of the discrete dynamics. When Lyapunov exponent is found to be positive, the dynamics is said to have strong chaotic behavior. Harter et al. considered different parameter sets of the discrete dynamics, and plotted the Lyapunov exponents against various weights scaling in the range 0 to 1. Their graphical demonstration envisages that for most weight scaling, the Lyapunov exponent is positive indicating the positive behavior of the dynamics.

The state diagram for the lyapunov equation is given as

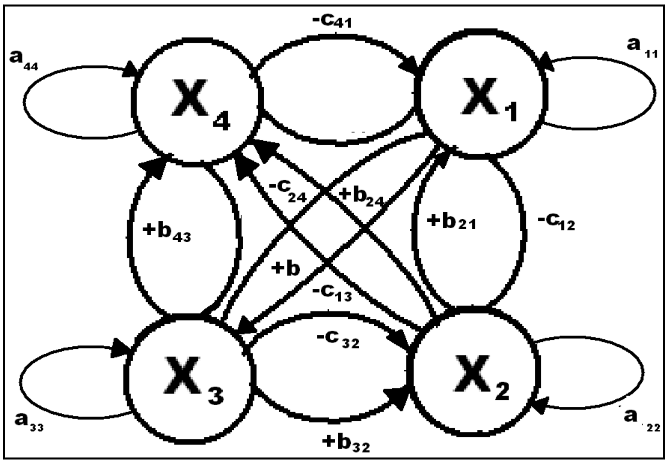


Figure 6.1 State Diagram for Lyapunov Equation

The Lyapunov equation is given as follows:

$$\frac{dX_i}{dt} = a_{ii}X_i(1-\frac{X_i}{K}) + \sum_{\exists j} b_{ji}X_i(1-\exp(-\beta_{ji}X_j)) - \sum_{\exists k} c_{ki}X_i(1-\exp(-\lambda_{ik}X_k)) \tag{1}$$

The 1st term in the R.H.S. of the above equation corresponds to self-growth of emotional state Xi. Here, aii denotes the inertial co-efficient that regulates the self-growth of Xi. The factor (1- Xi/K) is a controlling term that selects the sign of intrinsic growth rate aii. For instance when Xi< k, the first term in the right hand side is positive, when Xi =k the 1st term becomes zero, and when Xi> K, it becomes negative. In other words, Xi is allowed to increase up to a level of K, and a fall-off in the growth rate in Xi starts once it exceeds K. The 2nd term represents the co-operation between emotion Xj and Xi for some j. It is indeed important to note that the 2nd term takes into account the co-operation of Xi with a growing Xj. The third term on the other hand represents competition of Xi with growing Xk for some K. The parameters: βji and λik control the growth of Xj and Xk respectively.[1]

6.2 THEORETICAL TESTING:

The difference equation values for various time frames are obtained and plotted against time. If the line remains above 0,the subject is said to be stable, satisfying the conditions for stability,

$$dx/dt>0; \tag{2}$$

Example 1:

From the experimental testing, the values of $a_{ii}.b_{ji},c_{ki},\beta_{ji},\lambda_{ik}$ and X_i values. Substituting the values in the Lyapunov equation, either positive values or negative values are got as results.

For instance, we know that,

$$dx/dt =a_{11}X_1(1-X_2/k); \tag{3}$$

$$k=1000,X_1(0)=30 ,X_1(1)=32,X_2(2)=1222,X_{21}(1)=1,\ \lambda_{21}=0.0045 \tag{4}$$

$$=>X_{21}(1)=X_1(0)+a_{11}X_1(0)+a_{11}X_1(0)(1-X_2(0)/k); \tag{5}$$

$$=>30=32(1+a_{11}(1-32/1000); \tag{6}$$

$$=>a_{11}=-0.064 \tag{7}$$

$$=>dx_1/dt=a_{11}X_1(1-X_1/k)-c_{12}X_1(1-\exp(-\lambda_{21}X_2(2)); \tag{8}$$

$$=>X_1(2)/X_1(1)=1+a_{11}(1-X_1(1)/1000)-c_{12}(1-\exp(-\lambda_{21}X_2(2)); \tag{9}$$

Substituting the values for the variables,

$$C_{12}=-0.062 \tag{10}$$

Using the values of a_{11} and c_{12} in the primary equation,we get,

$$X_1(2)/X_1(1)=1.0001 \tag{11}$$

Similarly,when the equation is applied for various scenarios of dx_i/dt,we get,

$$X_1(3)/X_1(2)=0.9939 \tag{12}$$

$$X_1(4)/X_1(3)=0.93792 \tag{13}$$

$$X_1(5)/X_1(4)=0.9377 \tag{14}$$

$X_1(6)/X_1(5)=1.000$ (15)

$X_1(7)/X_1(6)=0.9939$ (16)

$X_1(8)/X_1(7)=0.9381$ (17)

$X_1(9)/X_1(8)=0.9381$ (18)

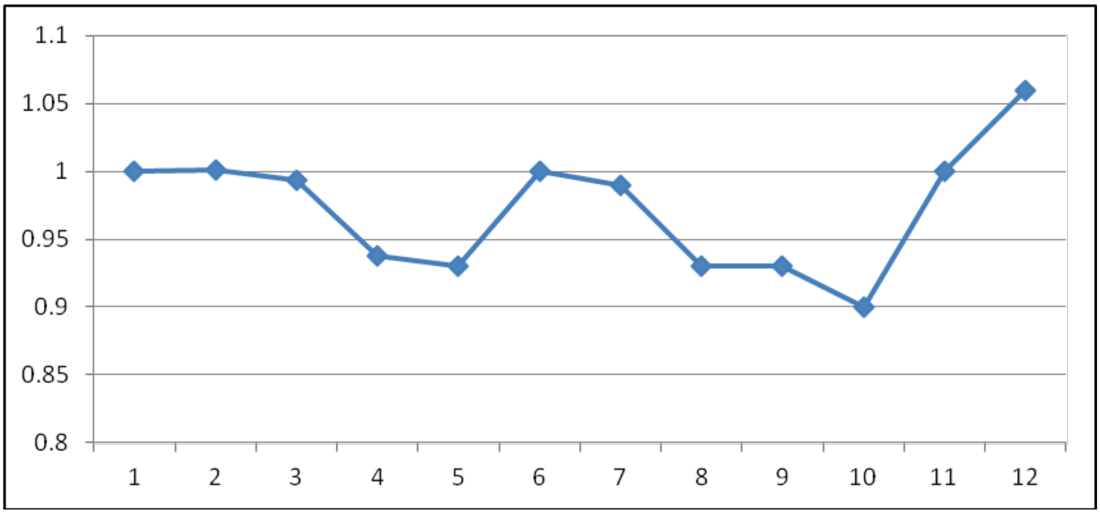
$X_1(10)/X_1(9)=0.90$ (19)

$X_1(11)/X_1(10)=1.0001$ (20)

$X_1(12)/X_1(11)=1$ (21)

When a graph is plotted with these values with dx/dt on the Y-axis and frame difference on the X-axis,A graph is obtained like this.

dx/dt



Frame difference

Figure 6.2 Graph of stability

Since dx/dt remains above 0 completely,the subject is assumed to be stable by condition of stability.Similarly,the graph is obtained for a chaotic person as below,which confirms to the stability condition of lyapunov exponent analysis:

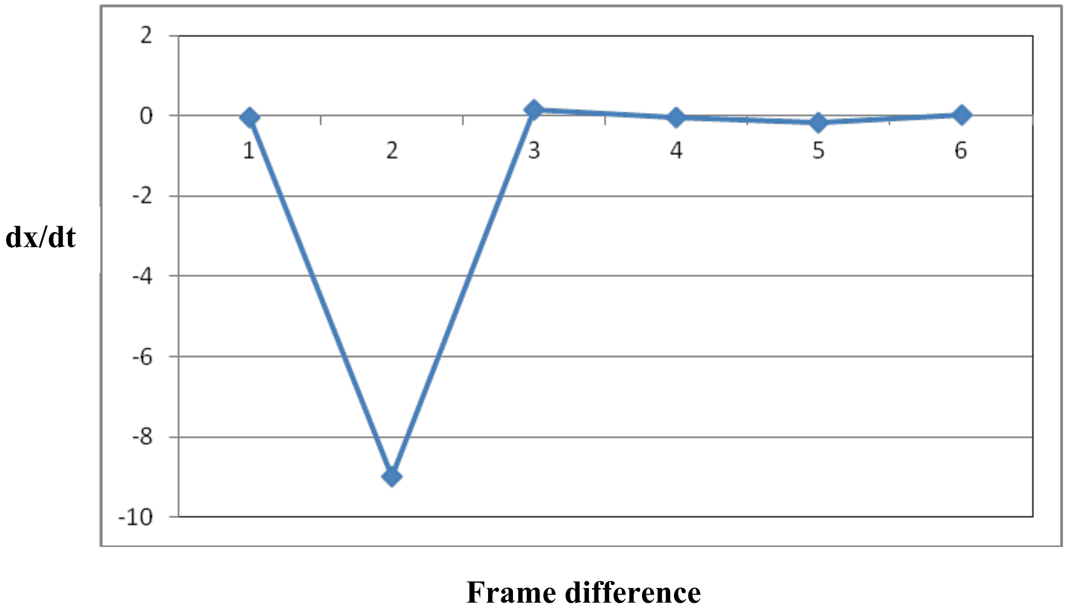


Figure 6.3 Graph of chaos

6.3 THEORETICAL TESTING USING MARKOV MODEL

A Markov model is a stochastic model which assumes a Markov property.Markov property is defined by two characteristics –Memoryless property.where the present state is dependent on the previous states in a non-deterministic way or it can be said as the process depends only upon the present state and not upon the past state and Stationary property which defines time as homogeneous.

Similar to the Lyapunov exponent, Markov model is said to model the dynamic behavior of the emotions but by using the conditional transition probabilities. The transition probabilities are defined for each transition from one emotional state to another in a defined period of time. The transitions are numbered based on the likeliness of transition of the states. For example, when a transition from a state S1 to state S2 has a higher likeliness of transition, the probability is labelled above 0.5 and the rest of the lower probability transitions are divided equally making the total cost of probability to be 1.An example of a transition diagram using the transition probabilities are shown in the figure below:

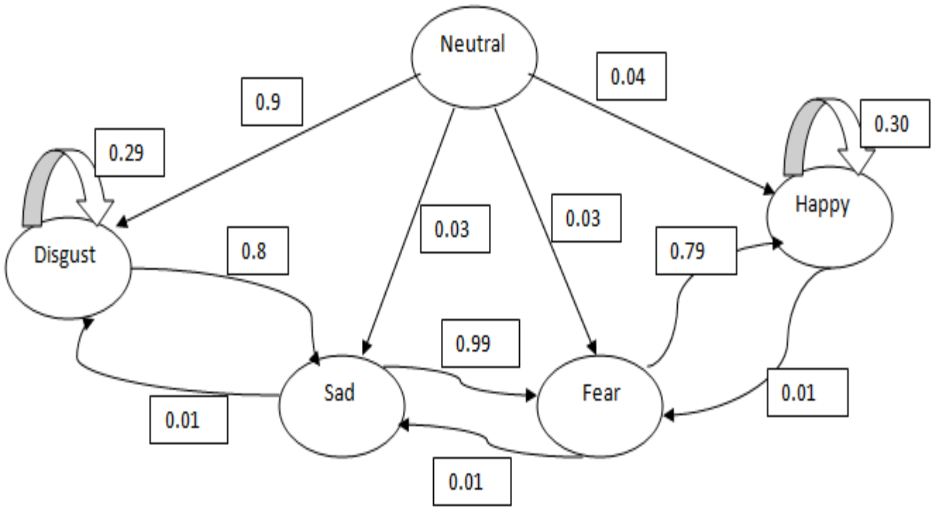


Figure 6.4 Transition Diagram with Probabilities

By calculating the total probability from a set of transitions,the score of the person can be calculated .Thus,the percentage of the stability can be calculated easily using the score.The transition diagram is drawn using the emotion exhibited in the frame.The emotion shown in each frame is calculated by using the reference value of the Mouth opening,Eye opening and the Eyebrow constriction obtained in the initial implementation.Stability is assessed depending on the percentage.A pie-chart is drawn to represent the likeliness of stability,graphically.

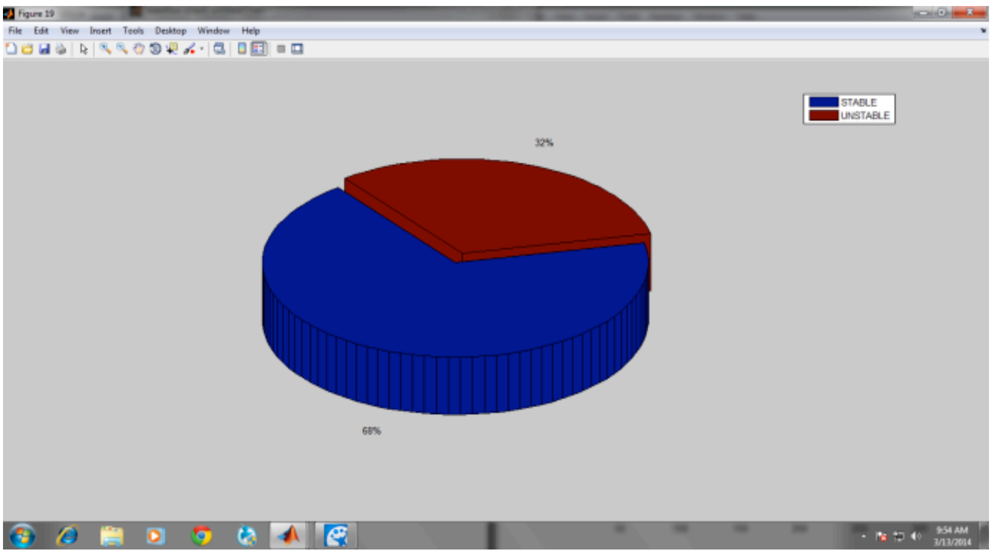


Figure 6.5 Pie-chart showing the Percentage of Stability

6.4 PERFORMANCE METRICS

6.4.1 SUCCESS RATE

The Success Rate is defined as the ratio of number of successful cases to the number of cases taken for testing.

$$\text{Success rate} = \frac{\text{number of successful cases}}{\text{total number of test cases}}$$

The success rate of this project is **0.75.**

6.4.2 EXECUTION TIME

The Execution time is defined as the time taken for executing the application and procuring the results. The execution time of this project is 3 to 5 minutes. Improved functions have been used to increase the computational efficiency and thus reducing computational overhead.

6.5 SIZE ESTIMATION

A certain type of measurement is needed to indicated the size of the project.The metric used in this project is the LOC metrics because of its ease of size measurement.The tool used to measure the LOC is "LOC metrics". The results are given as follows:

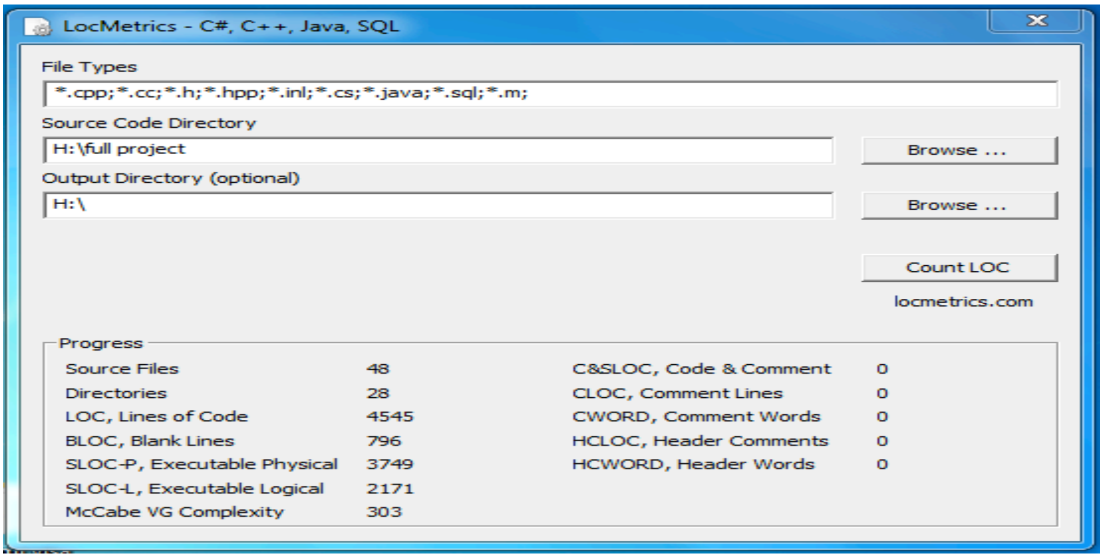


Figure 6.6 LOC Metric Evaluation

The project has nearly 4545 LOC with a McCabe's complexity of 303.

7. CONCLUSION

7.1 CONCLUSION:

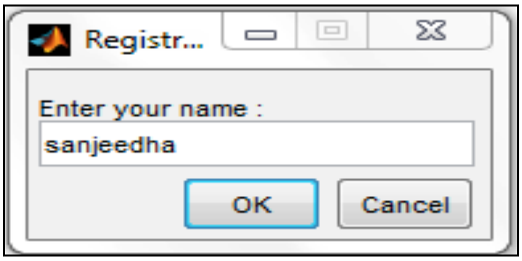
The application effectively identifies the stability of a subject based on the multi-emotional dynamics they exhibit. The system is useful to identify psychological disorders of people who have recently suffered epilepsy or trauma. This, however, is only a diagnostic tool and should not be used as a substitute for traditional tools such as EEG and fMRI.[1]

7.2 FUTURE ENHANCEMENTS:

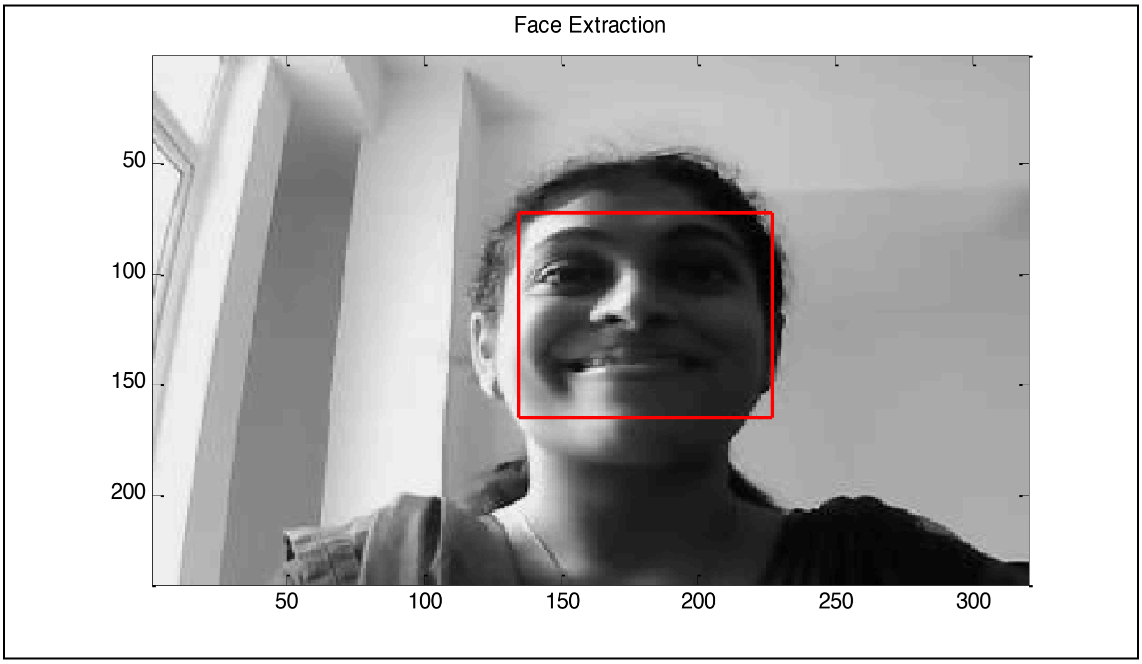
In the future, the application can be extended onto a mobile platform where the front camera of the mobile phone can be used to record the reactions of the subject whilst it displays the stimuli video on its screen. The processing can be done remotely using a server based system. This way the results can be obtained remotely without the need of heavy equipment to be carried around. It can also be made openly available as a commercial application to mobile application stores to benefit a greater population.

APPENDIX-1

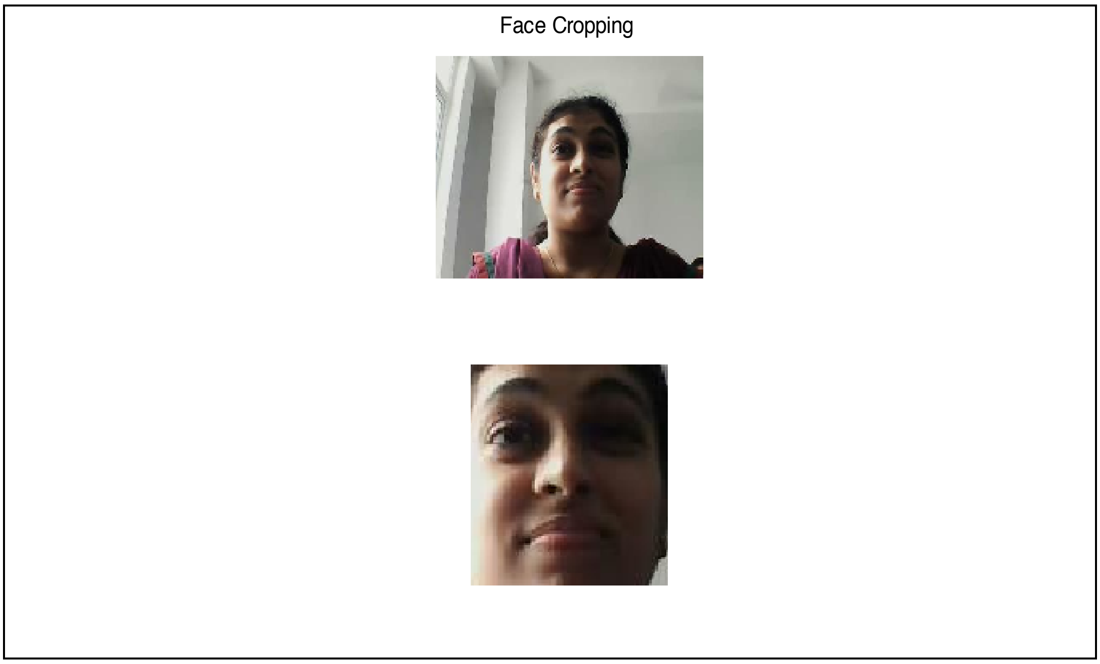
SCREENSHOTS



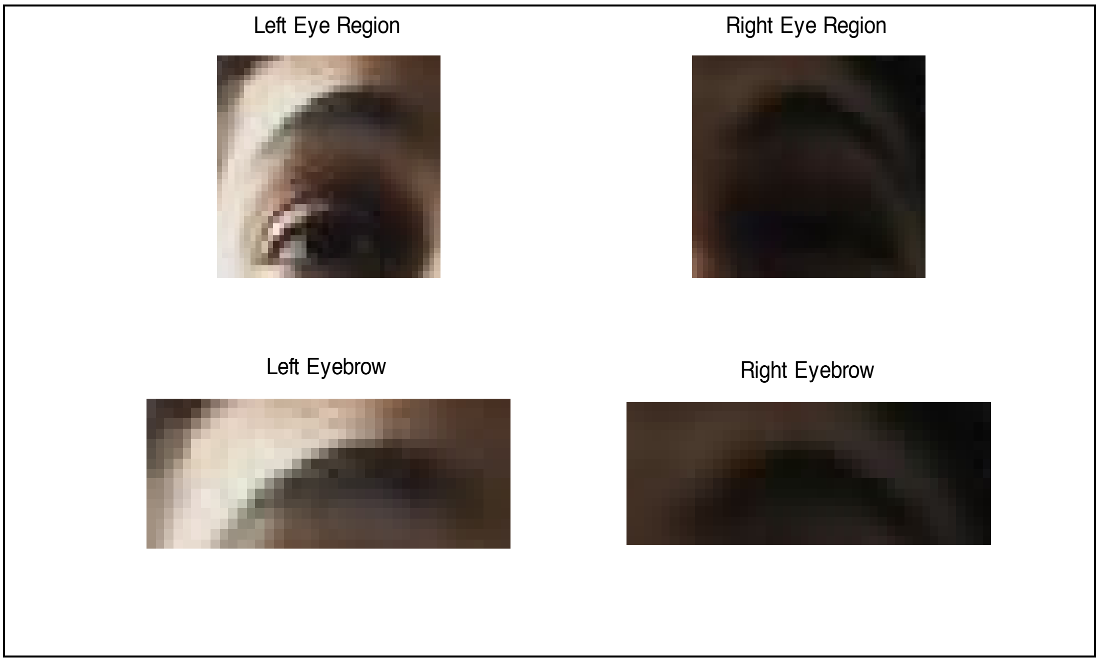
Screen 1-Registration Prompt



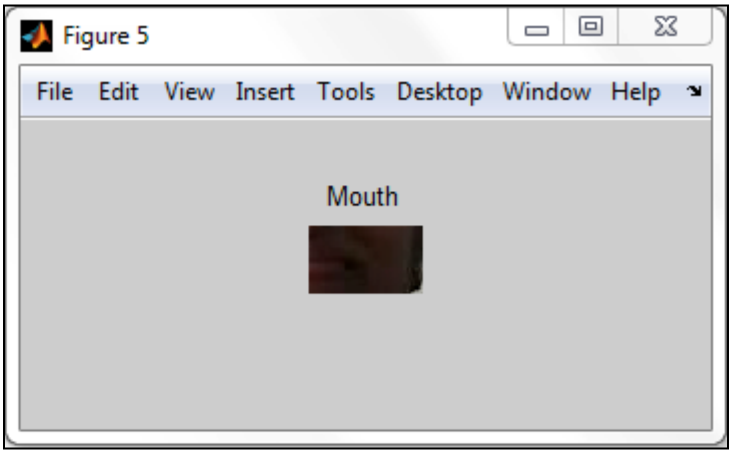
Screen 2-Face Detection



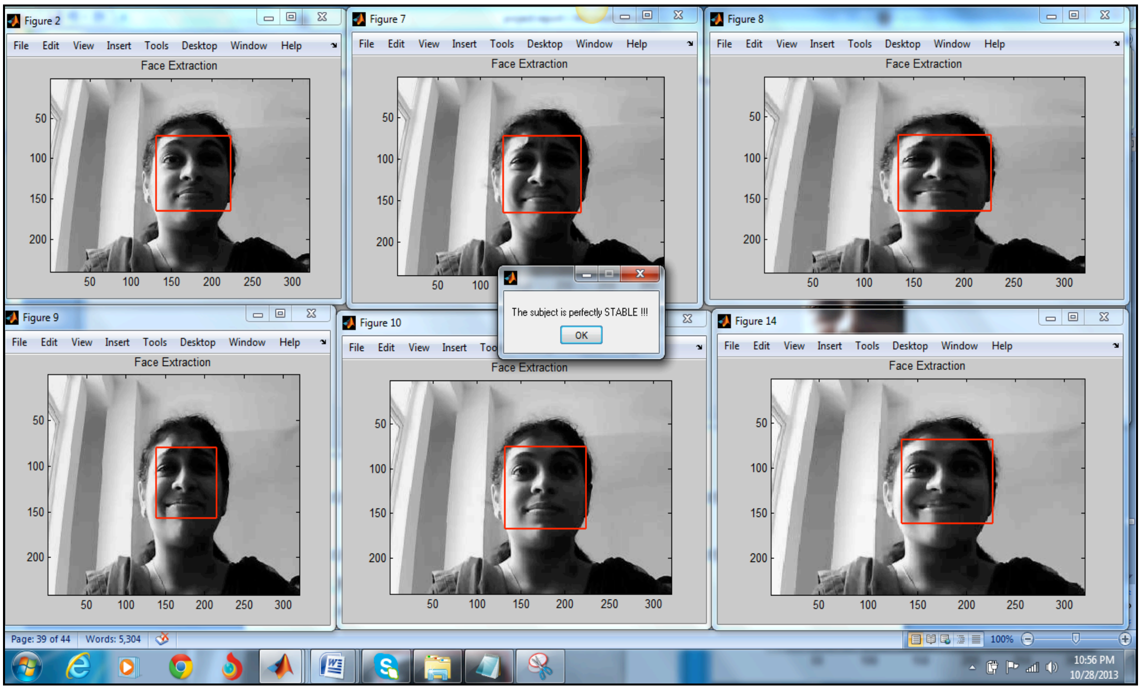
Screen 3-Cropped Face



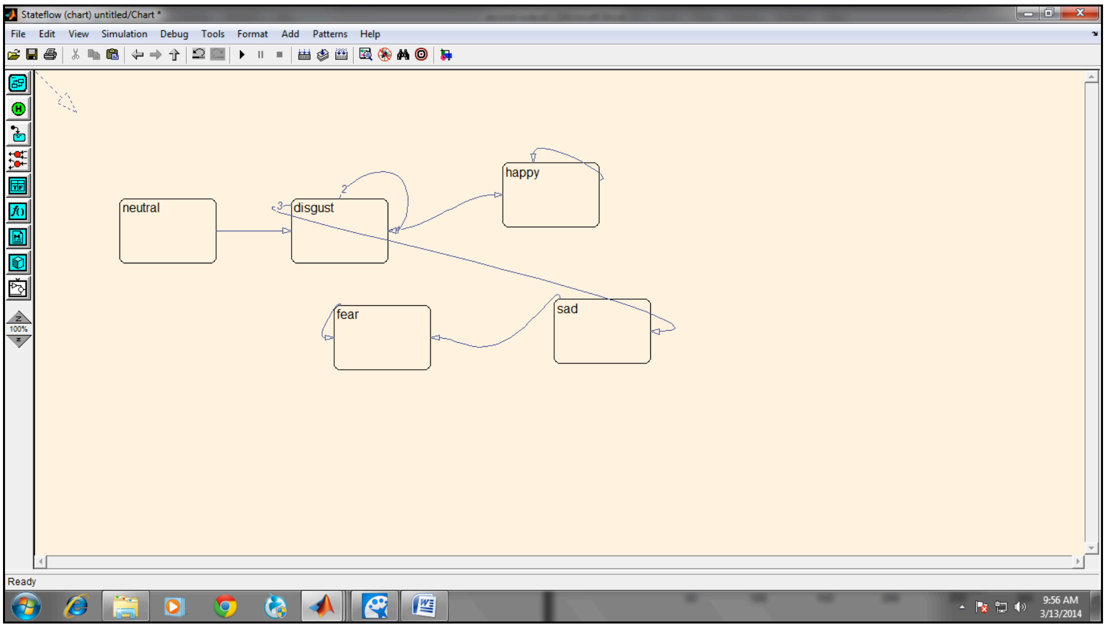
Screen 4-Facial Features Extraction



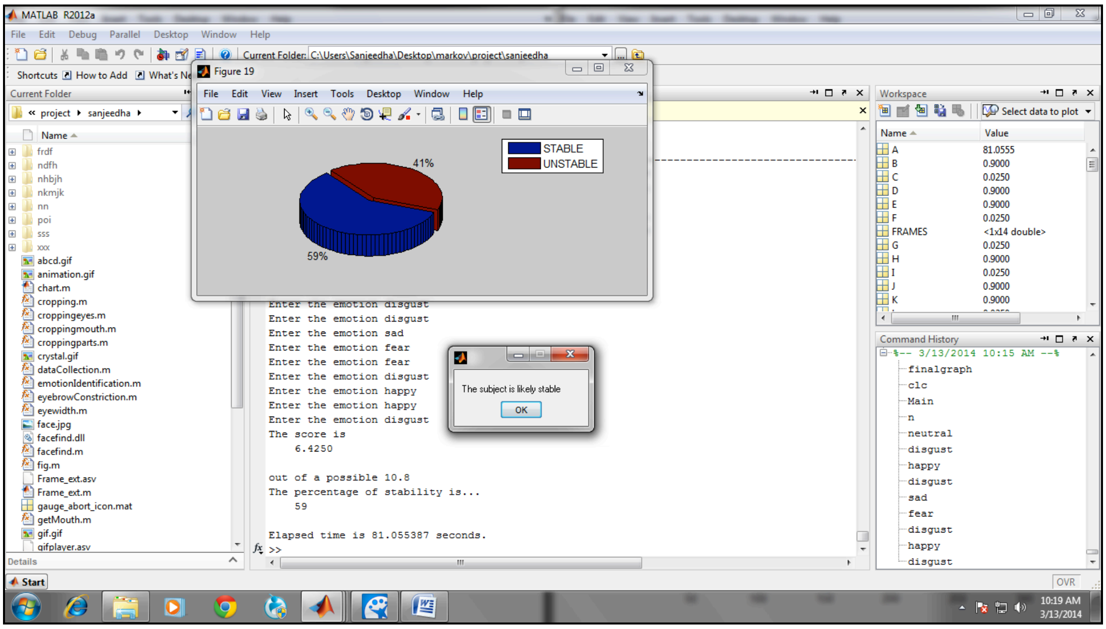
Screen 5-Extracted Mouth



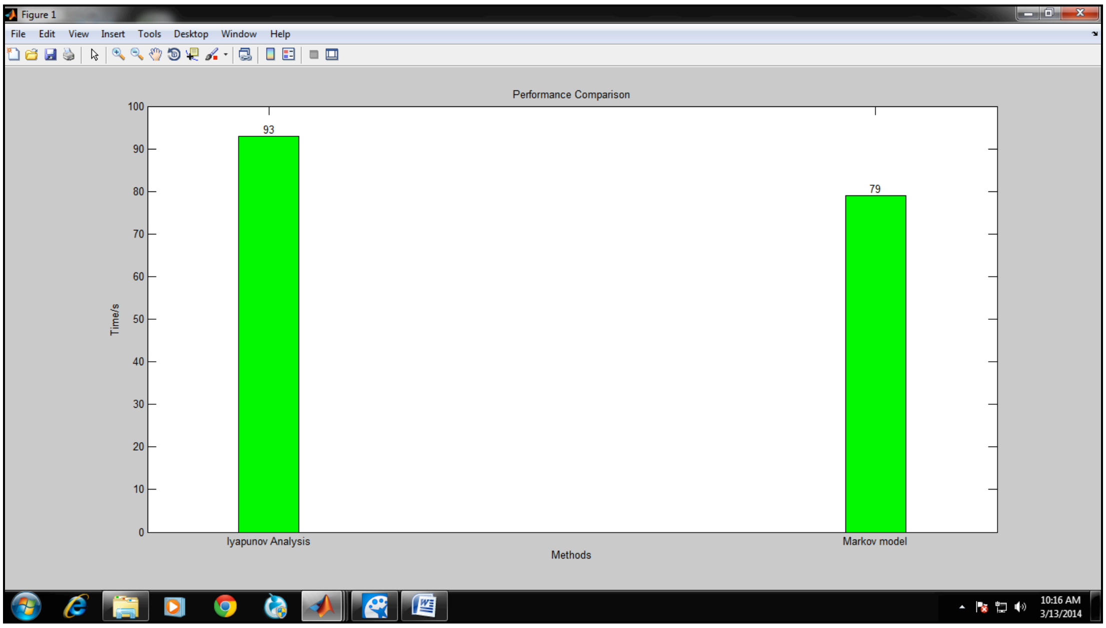
Screen 6-Stability Analysis using Lyapunov Exponent



Screen 7-. Transition Diagram of emotional states



Screen 8-. Stability Analysis using Markov Model



Screen 9-. Performance Comparison

CONSOLE OUTPUT:

LYAPUNOV EXPONENT ANALYSIS

$$

MENTAL STABILITY ANALYSIS

$$

131.5888

224.2991

72.0000

165.0000

units =pixels

fig_pos = 2

units = pixels

fig_place = 3

Eyebrow Tracking :

number of white pixels above benchmark

19

number of white pixels below benchmark

5

Eyebrow Constriction level is HIGH

36 40

36 42

Positions of Eye lid covers :

Start Value

3

End Value

35

Eye width is

32

units =pixels

figg = 5

Mouth Tracking :

Length :

47

Breadth :

11

Mouth area is

517

The value of EO is

32

The value of EBC is

1

The value of MO is

517

*****************Neutral 1****************

32 1 517

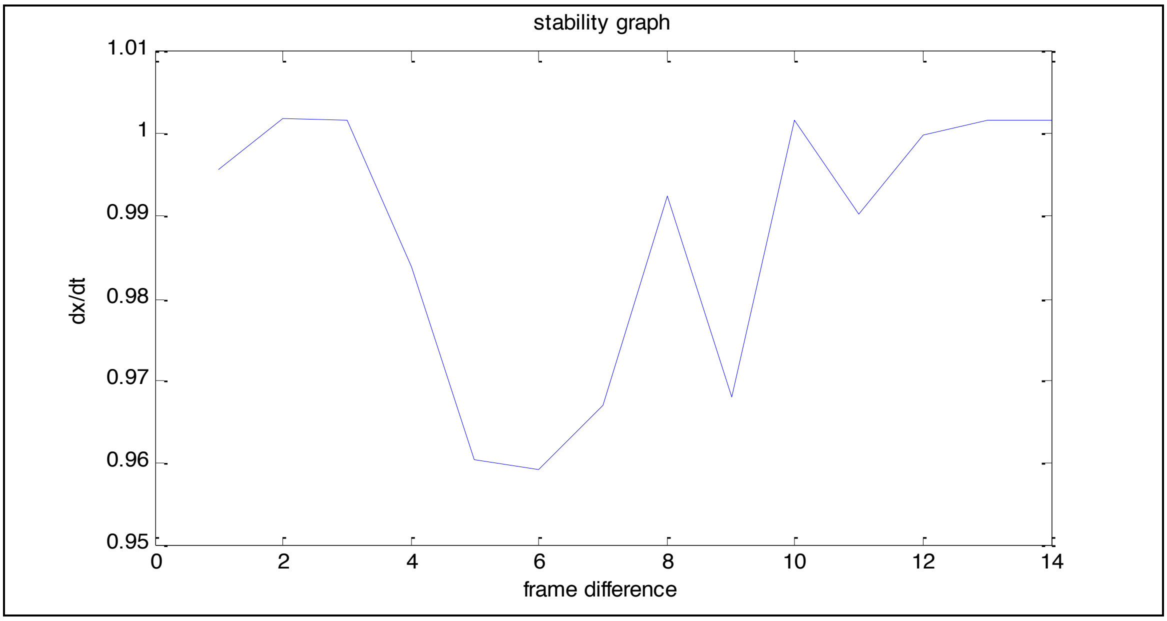
*****************Neutral 1****************

****

The subject is perfectly STABLE !!!

****

Elapsed time is 204.408423 seconds.



Screen 10-Generated Graph for Stability

MARKOV MODEL

Enter the emotion: neutral

Enter the emotion: disgust

Enter the emotion: happy

Enter the emotion :disgust

Enter the emotion :neutral

Enter the emotion :fear

Enter the emotion :fear

Enter the emotion :sad

Enter the emotion: neutral

Enter the emotion :happy

Enter the emotion :happy

Enter the emotion :happy

The score is

    5.5500

out of a possible 10.8

The percentage of stability is...

    51

Elapsed time is 164.297568 seconds.

TEST CASES

- **OUT-OF-BOUNDS ERROR:**

If the face in the observation video is not clearly centered and visible, it leads to the out-of-bounds error while extracting the frames from the video in MATLAB. This impedes the further analysis of the frames.

Figure 7.2 Out-Of-Bounds Error

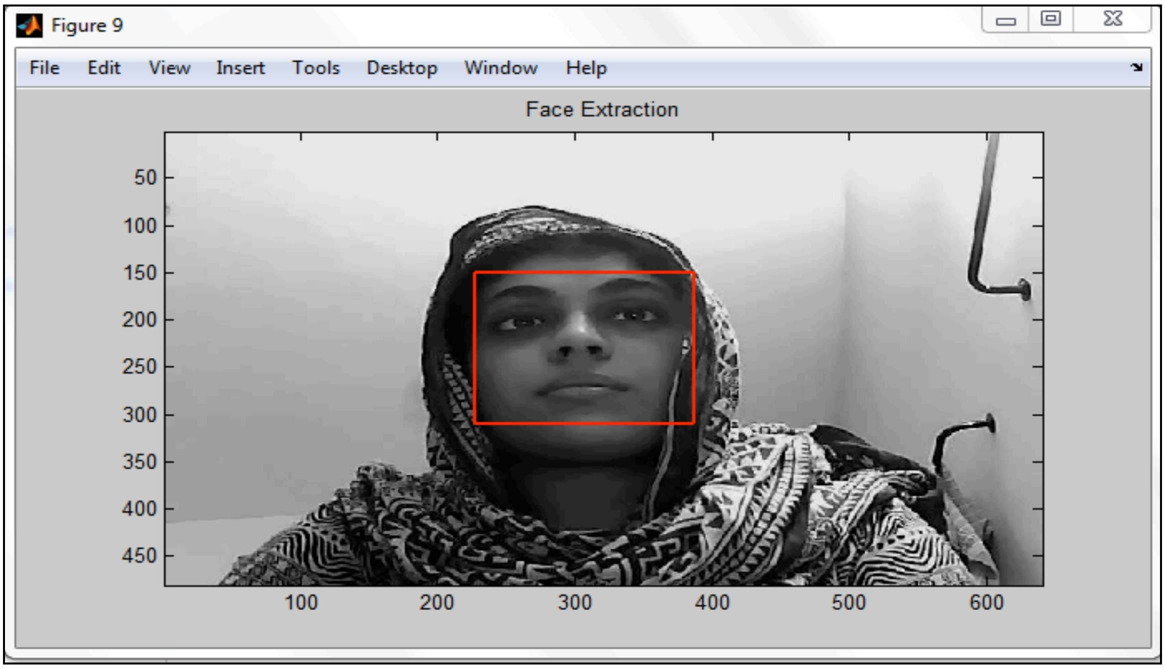


Figure 7.3 Face Detection With Head Cover

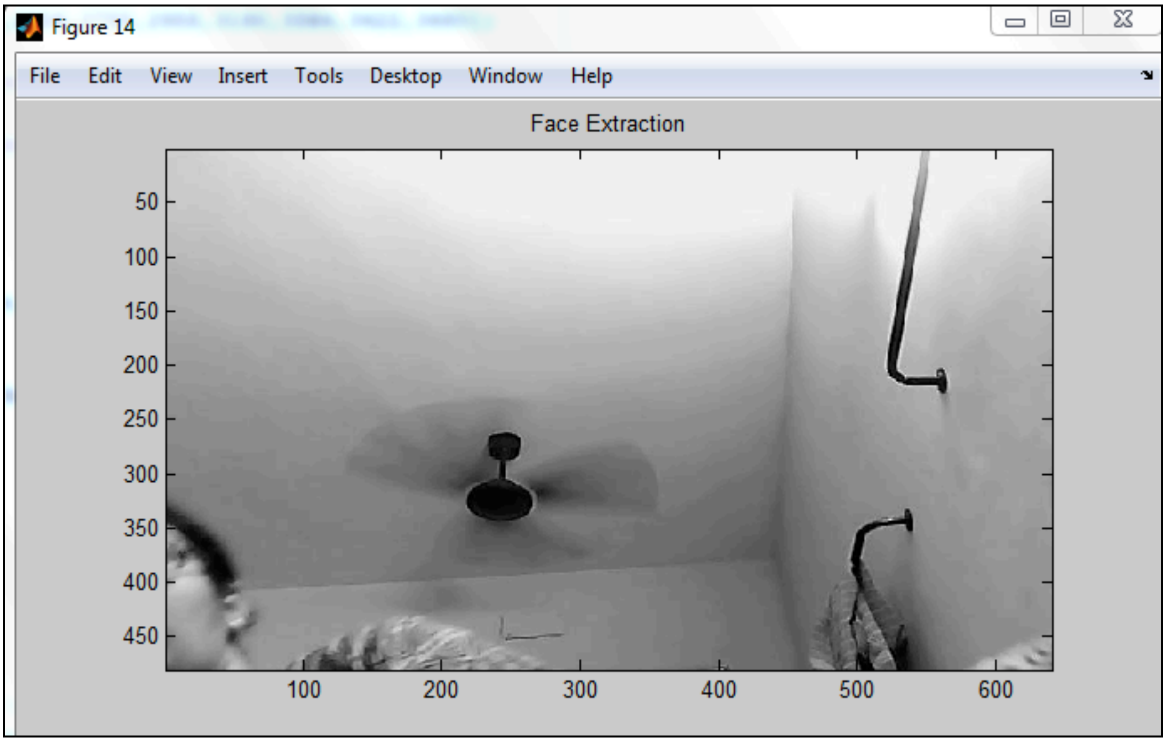


Figure 7.4 Face Out Of Frame

- **FACIAL OBSTRUCTIONS ALTERING EYE AREA:**

When the subject has objects obstructing the view of their eyes such as spectacles, it leads to an altered computation of the eye area. This might in turn result in a falsified stability.[1]

Figure 7.5 Subject Wearing Spectacles

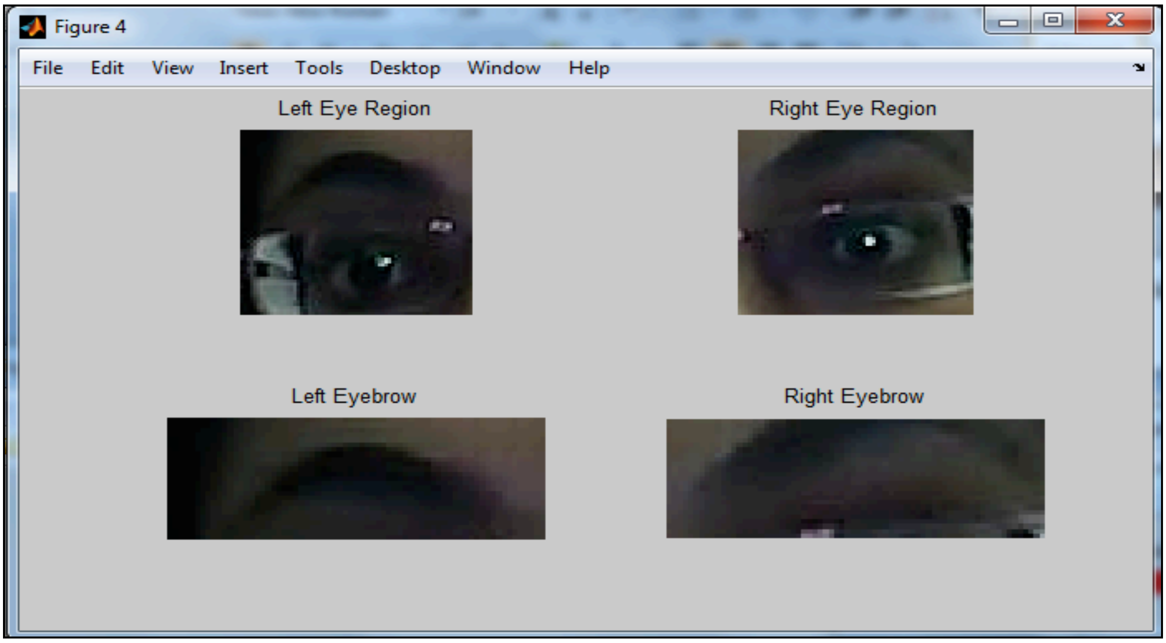


Figure 7.6 Eyes Extracted With Spectacles

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