

# **"Interaction to computer system based on eye and head gesture recognition using Machine Learning"**

A MAJOR PROJECT REPORT SUBMITTED TO

**RAJKIYA ENGINEERING COLLEGE BANDA**

(An Affiliated Institute of Dr. A.P.J. Abdul Kalam Technical University, Lucknow UP)



In fulfillment of the requirements for Major Project, eighth semester

**Bachelor of Engineering**

**In**

**Information Technology, REC BANDA**

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Banda - 210201

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## Declaration

I hereby declare that the project report entitled “**Interaction to computer system based on eye and head gesture recognition using Machine Learning**” submitted by us to **Rajkiya Engineering College, Banda** is the requirement for the award of the degree of the B. Tech in Information Technology is a record of bonafide project work carried out by us under the guidance of **Dr. Dhananjay Bisen Sir**. I further declare that the work reported in this project has not been submitted and will not be submitted either in part or in full for the award of any other degree in this institute.

Date:

Signature of the Candidates:

Rajkiya Engineering College Banda  
Department of Information Technology



CERTIFICATE

This is to certify that the Minor Project entitled “**Interaction to computer system based on eye and head gesture recognition using Machine Learning**” submitted by Praphull Maurya, Narendra Rajpoot, Rishabh Shukla , Atul Kumar Uttam is a record of bonafide work carried out by them, in the fulfillment with Degree of Bachelor of Technology Information Technology, Rajkiya Engineering College, Banda. This work is done during year August’19 to March’20, under our guidance.

Date:

Internal Guide Professor:

Dr. Dhananjay Bisen  
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## Acknowledgement

We would like to express our special thanks & gratitude to our guide “Dr. Dhananjay Bisen Sir” for their able guidance and support in completing my project.

We would also like to extend our gratitude to the Head of Department of Information Technology “Dr. Vibhash Yadav Sir” and our Honorable Director “Prof. S. P Shukla Sir” for providing me with all the facility that was required.

Praphull Maurya

Narendra Rajpoot

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Atul Kumar Uttam

## **Table of Contents**

<b>CONTENTS</b>	<b>PAGE</b>
<b>1. Abstract.....</b>	<b>08</b>
<b>2. Keywords.....</b>	<b>08</b>
<b>3. Introduction.....</b>	<b>09</b>
<b>3.1. HCI - Human-Computer Interaction.....</b>	<b>09</b>
<b>3.1.1. Types of Interfaces.....</b>	<b>09</b>
<b>3.2. Gesture Recognition.....</b>	<b>11</b>
<b>3.3. CNN - Convolutional Neural Network .....</b>	<b>14</b>
<b>3.4. SVM - Support Vector Machine.....</b>	<b>14</b>
<b>4. Literature Survey.....</b>	<b>15</b>
<b>5. Proposed System.....</b>	<b>20</b>
<b>5.1 HOG – Histogram of Oriented Gradient.....</b>	<b>20</b>
<b>5.1.1 Steps to create HOG .....</b>	<b>20</b>
<b>5.1.2 Drawing Function .....</b>	<b>27</b>
<b>5.2 Flow Chart.....</b>	<b>33</b>
<b>5.3. Mouse Events.....</b>	<b>34</b>
<b>5.3.1 Algorithm.....</b>	<b>35</b>
<b>5.3.2 Facial Landmark detection .....</b>	<b>36</b>
<b>5.3.3. Eye Blink Detection.....</b>	<b>37</b>
<b>5.4. Screenshots.....</b>	<b>40</b>
<b>6. Evaluation of Proposed System/Result .....</b>	<b>42</b>
<b>6.1 Performance matrix.....</b>	<b>45</b>
<b>7. Conclusion and Future Scope.....</b>	<b>46</b>
<b>8. References.....</b>	<b>47</b>

## List of Figures

CONTENTS	PAGE
5.1.1.1: Original Image.....	21
5.1.1.2: Resized Image.....	21
5.1.1.3: Kernel.....	22
5.1.1.4: Absolute value of x axis gradient.....	23
5.1.1.5: Absolute value of y axis gradient.....	23
5.1.1.6: Magnitude (Total) of the gradient.....	24
5.1.1.7: 8 x 8 cells in image.....	25
5.1.1.8: 9-bin histogram.....	25
5.1.1.9: Visualizing of HOG.....	26
5.1.2.1: Average Method (1).....	28
5.1.2.2: Average Method (2).....	28
5.1.2.3: Luminosity Method (1).....	29
5.1.2.4: Luminosity Method (2).....	30
5.1.2.5: Convex Hull.....	30
5.1.2.6: The execution of Jarvi's March.....	31
5.1.2.7: Graham Scan.....	32
5.2: Flow Chart.....	33
5.3.1: EAR (Eye Aspect Ratio) .....	34
5.3.2: Dlib Facial Landmark points.....	36
5.3.3.1: EAR (1) .....	37
5.3.3.2: Open Eye .....	38
5.3.3.3: Close Eye.....	38
5.3.3.4: For left Eye.....	39
5.3.3.5: For Right Eye.....	39
5.3.3.6: For Both Eye.....	40
5.4.1: Right Click.....	40
5.4.2: Left Click.....	41
5.4.3: Double Click.....	41

## List of Tables

<b>CONTENTS</b>	<b>PAGE</b>
<b>6.1: Test - I.....</b>	<b>42</b>
<b>6.2: Test - II.....</b>	<b>42</b>
<b>6.3: Test - III.....</b>	<b>43</b>
<b>6.4: Test - IV.....</b>	<b>43</b>
<b>6.5: Test - V.....</b>	<b>44</b>
<b>6.6: Dataset Discription.....</b>	<b>44</b>
<b>6.7: Precision, Recall and F1 score.....</b>	<b>45</b>
<b>6.8: Performance Parameters .....</b>	<b>45</b>

## **1. Abstract**

This project is centred around building up a model to control computer systems by utilizing eyes and head gestures. The face recognition system is used in combination with eyes and head gesture detection and recognition to control movements of the mouse and therefore, the computer system operates in real time. The facial detection and feature recognition are done by facial landmark detector using Dlib which uses a Histogram of Oriented Gradients based global feature detector in addition to linear classifier, a pyramid-based images, and a sliding window scheme for face detection. To recognise the feature of face we are using cascade of regressor algorithm. To capture the blinks of eyes, we have developed a unique mathematical method. The reason for this task is to develop an eyes and head motion-controlled system that can successfully utilize face parts like eyes and nose and empower the user to perform activities mapped to explicit eye blink/head motions by utilizing PC webcam. It must be consistently accurate so that users can comfortably use it like other frequent gadgets.

## **2. Keywords:**

Human-Computer Interaction, Gesture Recognition, Facial Recognition, D-Lib, OpenCV, PyAutoGUI.



### **3. Introduction:**

Over the previous years, the performance of Human-Computer Interaction (HCI) has impacted the interaction with PC and with the huge rise of computer system among general public, HCI has become essential a medium through which we humans can interact with computer systems, as PCs have become a significant part of our day to day lives. A lot of different techniques, such as hand gestures are very popularly used, but the people who with Locked-in syndrome (LIS), Quadriplegia or people who have lost their arm cannot interact with the computer system. The head gesture has the potential to communicate with an intelligent system. This project shows a vision based multimodal HCI utilizing eye blink followed by head movement that proposes an interface which can viably substitute the job of a current gadget, for example, a mouse.

#### **3.1. HCI - Human-Computer Interaction**

The research in the recent years has improved the design and computer technologies of the Human-computer interaction (HCI) that are used to develop the interface between humans and computers. Scientists working in the area of HCI observe human behaviour as how they interact with computer systems and develop technologies that can remove the complexities and enable the human beings to interact with the computer system in a newer way. We can interact with computers using various interfaces which are described as follows.

##### **3.1.1. Types of Interfaces:**

###### **Four types of Interfaces,**

- 1- Command line Interface: It is used to display a prompt, where user types a command with the help of keyboard, the computer executes that command and gives a textual output on the command prompt.
- 2- Menu Driven Interface: They have a list of multiple items where a user can choose and make selections by highlighting one or more items.
- 3- Graphical User Interface: It uses the icons, menus, windows and pointers that can be manipulated by the use of mouse. GUI are used by Desktop applications, handheld computers, internet browsers, ERP and computer kiosks.
- 4- Natural Language Interface: The NLI has a wide range from simple command systems to the voice activated text processing systems. The Commands should be spoken in “normal” languages

###### **The Architecture of HCI systems are recognized by:**

- Diversity of inputs entered and outputs given in respect to modality.
- Total number of inputs entered and outputs given to present in the HCI systems.
- The input and output should be work these diverse for interaction purpose.

On the basis of configuration and design of interface,

**HCI systems is categorized into:**

- Unimodal Human Computer interaction system.
- Multimodal Human Computer interaction system.

**Unimodal HCI system:**

Main dependency of interfaces are no. and diversity of inputs and outputs that are part of communication channels which helps user interaction with computer by the interface.

Unimodal systems are based on only 1 modality.

Base on nature of different modalities, it is divided into three types:

- Audio-Based Unimodal System
- Sensor-Based unimodal System
- Visual-Based unimodal System

**Limitations of Unimodal Human Computer Interaction System:**

- It is not a natural way of human interact with computer system.
- It is generally designed for the average type users.
- This modal fails to cater the need of a diverse type of peoples.
- It is difficult to use by illiterate, disabled, and untrained people.
- It does not provide universal interface for the people.

**Multimodal HCI System:**

- The Combination of one or more modalities, usage of multiple independent channel signals for the interaction between user and machine is called as multimodal human computer interaction systems.

- There can be two or more modes of input in multimodal interface that acts as facilitator between human and computer.
- MMHCI are easy to use for disabled and illiterate people.
- “Put That There” demonstration system is a famous example of a multimodal system.

Human-computer interaction considers the manners by which people utilize or don't utilize computational resources, frameworks, and foundations. Improvement in the usability of computer interfaces is an area of research.

### **3.2. Gesture Recognition**

Gesture recognition is a computer science topic dealing with the interpretation of human gestures via mathematical algorithms. Any motion of the body can be considered as gestures, prominent sources of gestures being the face or hand.

Feature of Gesture Recognition:

- It is more accurate.
- It is Highly stable.
- It saves time to unlock a device.

Gesture recognition can be carried out with advanced technologies such as image processing and computer vision. In relation to gesture control, the touchless UI is an emerging kind of innovation. Touchless UI (TUI) is the way toward instructing the PC through body movement and motions without contacting a mouse, a keyboard, or screen.

Gesture Recognition can be seen as a way for computer system to understand the human and its body language, thus building a bridge between humans and machines rather than primitive way of interacting such as text user interface or some GUIs that limit the user to input using keyboard and mouse than interact naturally without any touch or mechanical devices. Gesture recognition can make more redundant use of fingers or hands to point at something to work and move accordingly.

**There are two type of Gestures in computer interface:**

- Offline gestures
- Online gestures

### **Dlib:**

Dlib is a new C++ toolkit consists of machine learning algorithms and tools to create complex softwares in C++ to solve real world problems. It is used in industry as well as academia with different purpose such as building robotics, mobile phones, embedded system devices, and high performing computing environments. It is open source that allows, it use in any application with free of charge.

## **Major Features of Dlib:**

- 1- Documentation
- 2- High quality portable code
- 3- Numerical Algorithm
- 4- Graphical Model Inference Algorithms
- 5- Image Processing
- 6- Machine learning Algorithms
- 7- Networking
- 8- Graphical User Interfaces
- 9- Threading
- 10- Data Compression and Integrity Algorithms
- 11- General Utilities
- 12- Testing

## **PyAutoGUI:**

- It is a cross-platform GUI automation Python module .
- It is used to control the mouse & keyboard programmatically.
- The API of PyAutoGUI is designed to be as simple.
- It works on Windows, Linux, and macOS, and runs on Python 2, 3.

## **Features of PyAutoGUI:**

- Clicking and moving the mouse or just typing in the windows of other applications.
- Sending keystrokes to applications (for example, to fill out forms).
- Taking screenshots of a given image and find it on the screen.
- Displaying the message box for user while the automation (GUI) scripts runs on.
- Locate an application's window, and move, resize, maximize, minimize, or close it (Windows-only, currently)

## **How Does PyAutoGUI Work?**

- On macOS, PyAutoGUI uses the rubicon-objc module to access the Cocoa API.
- On Linux, PyAutoGUI uses the Xlib module to access the X11 or X Window System.
- On Windows, PyAutoGUI accesses the Windows API (also called the WinAPI or win32 API) through the built-in ctypes module.

## **OpenCV:**

- OpenCV is programmed library developed by Intel, which consist of functions mainly aimed at real-time uses such as computer vision. It is later supported by Willow Garage then Itseez.
- It is cross platform and free to use under some open-source BSD Licence.
- It supports some models from deep learning frameworks like Torch, Tensorflow, PyTorch and caffe according to defined list of supported layers.

- It promotes the Open Vision Capsules, which is compatible, portable with all other formats.
- OpenCV consists a statistical machine learning library that contains, Decision tree learning ,Gradient boosting trees, Random forest ,Support vector machine , Boosting ,Expectation-maximization algorithm, Deep neural networks , k-nearest neighbor algorithm ,Naive Bayes classifier ,Artificial neural networks

### **Application:**

- 2D and 3D feature toolkits
- Recognition and Segmentation
- Stereopsis stereo vision: depth perception from 2 cameras
- Structure from motion (SFM)
- Motion tracking
- Augmented reality
- Egomotion estimation
- Facial recognition system
- Gesture recognition
- Human computer interaction (HCI) system
- Mobile robotics
- Motion understanding
- Object identification and detection

### **Matplotlib:**

Matplotlib is an inclusive library for creating animated, static, and interactive visualizations in Python.

It includes an object-oriented API for embedding plots into applications using general-purpose GUI toolkits like wxPython, Tkinter, Qt, or GTK+.

It makes easy things very easy and hard things possible to create.

#### **1- Create**

- It creates quality plot for publication with just a few lines of code
- It uses interactive figures that can pan, zoom and update...

#### **2- Customize**

- It takes full control of line styles, axes properties, font properties.
- It can export and embed to no. of files format in interactive environments.

### **3-Extend**

- It can explore many functionality provided by third party packages.
- There is a lot of external learning source available for the Matplotlib.

### **3.3. CNN - Convolutional Neural Network**

A Convolutional Neural Network (CNN/ConvNet) is a deep learning algorithm in the class of deep neural networks, mainly used to analyse visual imagery. CNN is a classification algorithm that can take images as input and classify images, group images by similarities and accomplish object recognition within picture. For example, CNNs are used to identify faces, street signs, individuals, tumours, platypuses and other characteristics of visual data. CNNs also have applications in recommender systems, medical image analysis, and natural language processing.

### **3.4. SVM - Support Vector Machine**

A Support Vector Machine (SVM) is a discriminative classifier formally described through a separating hyperplane. In other words, given labelled training data (supervised learning), the algorithm gives an ideal hyperplane which categorizes the new examples of testing data. In two-dimensional space this hyperplane is a line isolating a plane into two sections wherein each class lay on either side.

## **4. Literature Survey:**

The survey is concentrated to address the points, focus on the research questions, understanding of the research area, clarification of the meaning of the terms and proper identification of the framework and planning of the data collection approach. The important thing is to understand the domain of research

in which head movement and eye detection is involved. During the literature survey, the attention is on the most proficient method to build up a model which can satisfy the necessities of physically disabled people and the model should be easy to understand.

Author Name	Proposed Technique	Key findings	Final Results												
Anush Ananthakumar (2018) [1]	Efficient Gesture and Face Recognition for Time Bound Application	<p><b>1</b>-Face extraction is done using the Viola-Jones facial recognition system that uses Haar like attribute along with Adaboost training.</p> <p><b>2</b>-Color segmentation is used for gesture recognition, that extract the tone of skin of detected face and also detect the position of hand.</p> <p><b>3</b>-Kanade-Lucas-Tomasi (KLT) algorithm is used to obtain the gesture by traking the hand.</p> <p><b>4</b>-This research uses the background subtraction model reduce the misclassification and extract the foreground. This type of technique highly improves the facial and gesture recognition performance in cluttered and surroundings.</p>	<p>To check the accuracy of the system with different conditions and image quality, the proposed face recognition model has been tested on many databases and the results yielded on few of which is as shown below:</p> <table><tr><th>Dataset name</th><th>Trainin g time</th><th>Accura cy</th></tr><tr><td>ORL databas e of faces</td><td>150.2 sec</td><td>98.61%</td></tr><tr><td>Caltech Faces 1999 databas e</td><td>220.5 sec</td><td>97.15%</td></tr><tr><td>Faces96 dataset</td><td>376.34 sec</td><td>97.01%</td></tr></table> <p>So, the result shows that with less training time the proposed method can achieve high accuracy.</p>	Dataset name	Trainin g time	Accura cy	ORL databas e of faces	150.2 sec	98.61%	Caltech Faces 1999 databas e	220.5 sec	97.15%	Faces96 dataset	376.34 sec	97.01%
Dataset name	Trainin g time	Accura cy													
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Caltech Faces 1999 databas e	220.5 sec	97.15%													
Faces96 dataset	376.34 sec	97.01%													
S. M.	CV Based Gesture Recognition for Object Manipulation of System.	<p><b>1</b>-Picture procurement: Image is obtained by Kinect 2.0. Kinect SDK render the obtained picture up to 30 fps.</p>	<p>The fundamental objective of paper is to build up a robust and intuitive framework utilizing gestures. These motions are then used to control and control distinctive desktop objects. This</p>												

Ariful Hoque MD. Sadun Haq Md. Hasanuzzaman[2]	<b>Technique-</b> This research proposes a method to recognize static hand signals. Perceived motions at that point can be utilized to control work area objects.	<b>2-</b> In this training, 9 unique gestures are trained. For preparing, 5 diverse individuals are utilized. This framework is assessed on an exceptional dataset from contribution of these 5 people. This framework incorporates 9 predefined motions. In the wake of running the framework, first the COP is recognized utilizing fingertip. At that point the framework holds for 2 seconds for the motion to begin. after motion begins, the framework catches the data of 30 back to back casings.	framework utilizes contour detection algorithm and graham scan algorithm to detect fingertip.9 unique gestures are be utilized to control motions. A lot more can be executed as feature vector that can recognize each of the 5 fingertips with unique excellence, yet for effortlessness just 9 has been picked.
Mohd. Baqir Khan, Kavya Mishra, Mohammed Abdul Qadeer (2017) [3]	Gesture Recognition using Open-CV <b>Technique:</b> To perform a specific task first an image is captured by the camera then applied to preprocessing to minimize noise and convert image RGB to grayscale. After that feature extraction performs for finding the shape of the palm. Hidden Marcov Model, and k-curvature are used for this.	According to this paper, we can map some specific operations or tasks with a particular gesture. For example, if the Hand is detected then main window will open.	By using GRS this idea developed an efficient human interaction with machine. this will have many applications like Remote control, Aid to physically challenged, Mouse control. GRS is implemented by using glove approach and colored marker approach.
Rohit Lal, Shital Chiddarw	Real Time HCI using Facial Gesutres.	<b>1.</b> Facial landmark points are detected and generated	The proposed model work very accurately in case of small datasets. It is also tested over



ar (2019) [5]	<p><b>Technique-</b></p> <p>This paper presents an algorithm that is useful for the physically challenged people. The algorithm developed in the paper find to be accurate with high facial detection accuracy which uses a mathematical equation to detect the eye whether open or not.</p>	<p>by using the popular python library Dlib.</p> <p><b>2.</b> Face detection is done by Haar cascade with adaboost algorithm to train classifier.</p> <p><b>3.</b> Smile detection is done by suing the viola Jones algorithm.</p> <p><b>4.</b> A scalar expression is developed to detect the of blink of eyes.</p>	<p>various functionality like surfing, playing games and doing other PC task. The model has a limitation that it is tested on RGB, in case on low lighting it is not able to detect the facial landmarks. Thus, the functionality may affect.</p>
Rushikesh T. Bankar, Dr. Suresh S. Salankar (2015) [6]	<p>Head Gesture Recognition System Using Gesture Cam</p> <p><b>Technique-</b></p> <p>This paper is mainly focused on the head movement, face tracking and detection of obstacle and using these actions to control some devices. It helps the handicapped people those who are not able to move their other body parts.</p>	<p><b>1.</b> Gesture cam is used to capture the video of head movement. A smart FGPA camera is used to reduce the computation time because FGPA cam is sufficient to process the video frame by frame.</p> <p><b>2.</b> Voila-Jones algorithm is used for the face detection and the image grabbed from the video are processed by this algorithm.</p> <p><b>3.</b> An ultrasonic sensor is used for detection the obstacles that comes in the path to warn the user. Sensor emits the sound wave that can identify the hinderance in the path.</p>	<p>A microcontroller is used to handle the wheel chair equipped with FGPA camera that takes the user inputs and perform necessary action by recognizing the head gestures. The future work suggest that there is a need of more precise detection of head in all four directions and a web cam is used for more accurate results.</p>
Hanene Elleuch, Ali Wali,	<p>Smart Tablet Monitoring By a Real-time Head Movement And Eye</p>	<p><b>1.</b> Voila-Jones algorithm is used for the face detection because it has fifteen times</p>	<p>The given model is tested on android tablet. It is found that the model has very high accuracy.</p>

<p>Adel M. Alimi (2014) [7]</p>	<p>Gestures Recognition System.</p> <p><b>Technique-</b></p> <p>This paper develops a system to monitor a tablet by using head movement and eye gaze gesture. Simple actions like opening a web browser and controlling the tablet is performed. In order to remove the system computation delay cloud computing is used. It improves the real time monitoring of the system, because tablet resources like RAM &amp; ROM is limited.</p>	<p>greater accuracy than other approaches.</p> <p><b>2.</b> Support vector machine (SVM) algorithm is used to detect and tract the eyes because it works well under different lighting conditions. Once the face is detected the algorithm will work on the ROI zone that is eyes.</p> <p><b>3.</b> Given model is tested on the 5 people with 8 different scenarios. It gives the best accuracy but the model suffers if the user wears the glasses and also if the lighting condition is low.</p>	<p>The head and eye gaze gestures can have recognized the moving objects easily. Proposed model works well under different lightning condition. Cloud computing has given boost to the computation power of the system make it possible to run the model on the small platform that have low storage capability.</p>
<p>Jilin Tu, Thomas Huang, Hai Tao [8]</p>	<p>Face as Mouse Through Visual Face Tracking</p> <p><b>Technique-</b></p> <p>This paper presents a technique for visual tracking of the human face. The proposed 3D model is able to track the various face movement like opening and closing of eyes and mouth. This model is successfully tasted on the Windows XP platform that illustrate the accuracy and robustness of the system. Various facial expressions are captured from the video</p>	<p><b>1.</b> It uses set of vertices to marks the 3D geometry of the face. Some action units are identified using facial articulations are being made.</p> <p><b>2.</b> It uses an equation for the modeling of the face. Face is captured via video frames and detection is done using the Adaboosting algorithm. In case of worst result, user is allowed to use the GUI system to fine tune the result.</p>	<p>This paper successfully proposed 3D model based visual faced tracker. Various mouse operations are performed using the three different modes. Camera mouse application gives the various idea like how user can interact with the computer system using the various facial gestures. Given algorithm is not very much optimal and robust. It needs further advancement to make it more efficient. We can gain various useful insights through this paper as various useful mathematical calculations are being done in this paper.</p>

	<p>frame. This model can help the physically disabled people to run the computer system and it can also help in the development of video games.</p>	<p><b>3.</b> Mouse control module is implemented with three modes namely, joystick mode, direct mode &amp; differential mode.</p> <p><b>4.</b> There are various other gestures like opening and closing of mouth, are used to run the system seamlessly. Proposed model is tested in windows XP environment that concludes the better efficiency of the system.</p>	
<p>Anja Jackowski, Marion Gebhard, Roland Thietje (2017) [9]</p>	<p>Head Motion and Head Gesture Based Robot Control: A Usability Study</p> <p><b>Technique-</b></p> <p>This experiment developed an assistive robot system AMiCUS for the physically disabled people suffering from tetraplegia. This robot is tested on 30 subjects in which 24 are able-bodies and 6 are tetraplegics. Overall result of this research is very useful for the mankind. AMiCUS is controlled by the head gestures and head movement of the subject. AMiCUS is successfully tested in the laboratory under different circumstances and is able to help the tetraplegics in performing their daily life</p>	<p><b>1.</b> To capture the head motions AMiCUS uses inertial measurement unit FSM-9. Various pick and place task has been done to ensure the proper functioning of robot. An emergency button is also provided for any uncontrolled condition.</p> <p><b>2.</b> There are some sets of predefined task and complex task using the cubes has been performed. After this experiment a questionnaire is done and objective and subjective evaluation is also performed.</p> <p><b>3.</b> To train the developed system lots of trials are being done in order to confirm the working of the robot. Head gestures are</p>	<p>The proposed work in this paper is very useful for the various pick and place operation in the laboratory. AMiCUS is able to control 3D dimensional rotation and translation DOFs of robot. During the experiment the robot is found to be robust as it does not perform and unintended operation.</p> <p>The analytical algorithm used for the detection of head motions need the further optimization. Another challenge is to use the machine learning algorithm for the speech recognition or eye detection. It will give the new wings to the existing research.</p>

	task at the workplace.	used to control the robot as well as gripper.	
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## 5. Proposed System:

### 5.1. HOG – Histogram of Oriented Gradients:

Histogram of Oriented Gradients is a Global feature descriptor which is often used to extract features from image data. It is widely used in computer vision and image processing tasks for object detection.

This technique counts the occurrence of gradient orientation in localized parts of an image. These include contour representations, texture features or shape descriptors.

To detect the edge features, if we only try to find the pixel is an edge or not. HOG can find the edge detection as well. This feature of HOG called the **gradient and orientation i.e;** magnitude and direction of the edges.

- In Addition, the orientations are calculated in the ‘localized’ parts. the complete image is divide into smaller portions for each region, after that gradients and orientation are calculated.
- At last, It will generate a Histogram for each of these regions in separate parts. The histograms can be created using the orientation and gradient of the pixel values, hence it is called ‘Histogram of Oriented Gradients’.

In the HOG feature descriptor, the distribution (histograms) of directions of gradients (oriented gradients) are used as features. Gradients (x and y derivatives) of an image are useful because the magnitude of gradients is large around edges and corners (regions of abrupt intensity changes) and we know that edges and corners pack in a lot more information about object shape than flat regions.

The distribution (histograms) of directions of gradients of HOG feature descriptor are used as feature. The derivative of x and y (gradients) of an image are useful because around the edges and corner the magnitude of gradients are large due to abrupt change in intensity. Edges and corners are packed in a lot more data(information) about objects shape than the flat regions.

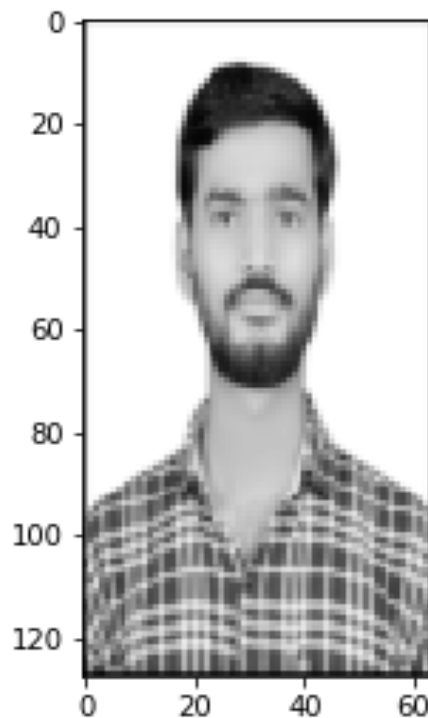
#### 5.1.1. Steps to create HOG:

##### Step 1: Pre-process the Data (64 x 128 x 3):



**Original Image (398 x 512 x 3)**

**Figure 5.1.1.1:** Original Image



**Resize Image (64 x 128 x 3)**

**Figure 5.1.1.2:** Image Resizing

Let's understand this using an example.

In this pre-processing example firstly, image is cropped and resized into a particular size.

## Step 2: Calculate the Gradients (in direction of x and y):

For calculating HOG descriptors, the first thing to calculate gradients of horizontal and vertical axis. After this, calculate the histogram of gradients.

It can be easily converted into using this kernel:

-1	0	1
----	---	---

-1
0
1

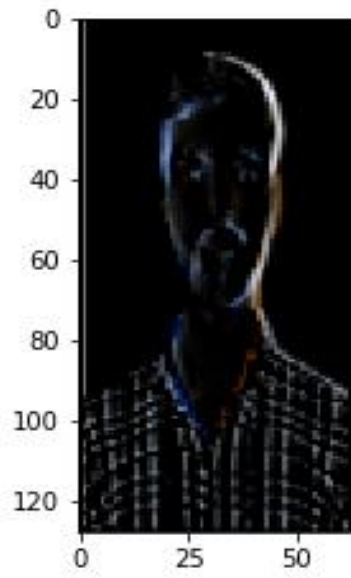
**Figure 5.1.1.3: Kernel**

These formulae are used to find magnitude and direction of gradient.

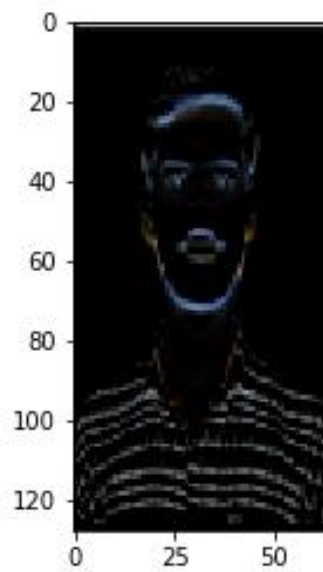
$$g = \sqrt{g_x^2 + g_y^2}$$
$$\theta = \arctan \frac{g_y}{g_x}$$

Gradient of image removes many non-essential information i.e.; constant colored background etc. and it highlights the outlines.

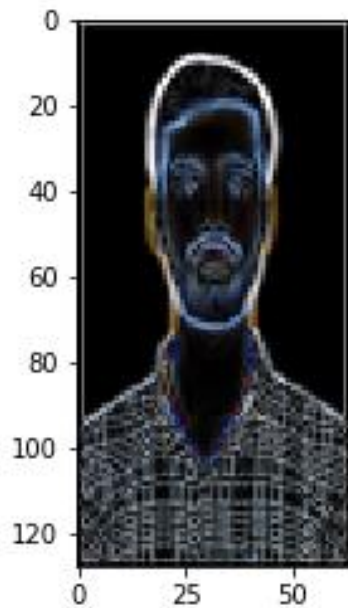
We can still look in the image and tell that it is image of person.



**Figure 5.1.1.4:** Absolute value of x axis gradient



**Figure 5.1.1.5:** Absolute value of y axis gradient



**Figure 5.1.1.6:** Magnitude (Total) of the gradient

### **Step 3: Calculating the Histogram of Gradients in 8×8 cells:**

In this step, image will be divided into 8x8 cells and Hog will be calculated for each 8x8 cells.

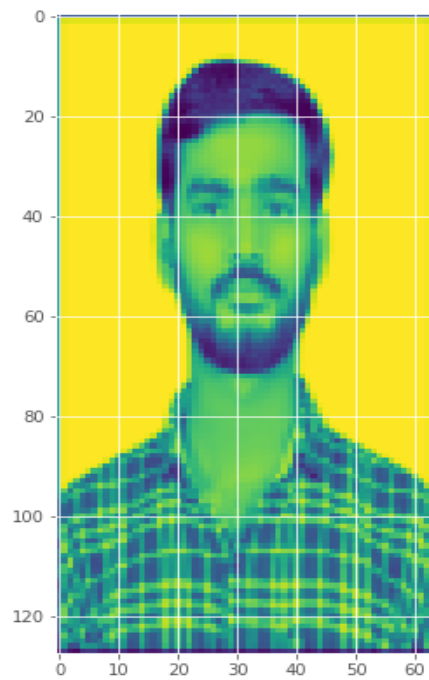
The reason behind conversion into 8x8 cells is its precise representation, an 8×8 image patch will be equal to  $8 \times 8 \times 3 = 192$  pixel. The gradient of this portion contains 2 values only (magnitude and direction) per pixel which adds up to  $8 \times 8 \times 2 = 128$  numbers.

Patch makes it more robust to the noise and make its representation less sensitive to noise.

The histogram should contain a vector consist of 9 bins and the angels are 0,20,40,60.... 160.

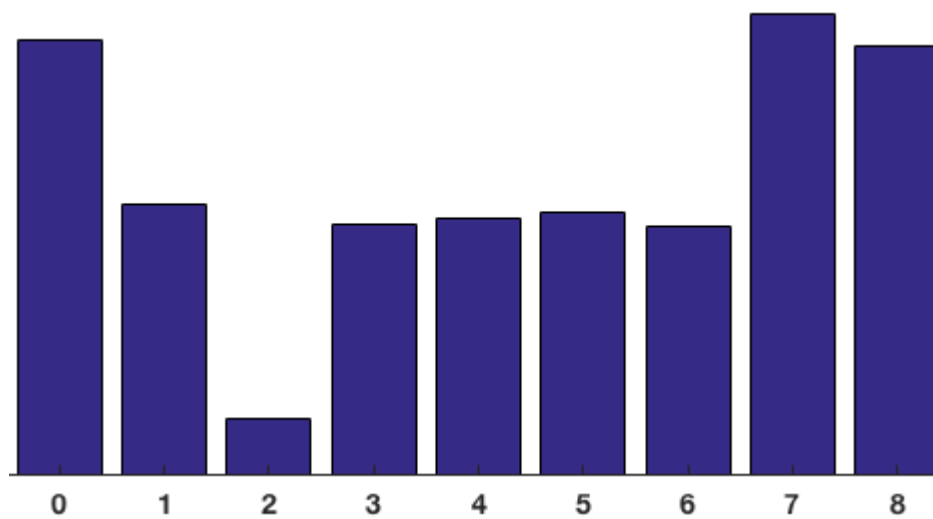
Image of One 8×8 patch and its gradients look.





**Figure 5.1.1.7:** 8 x 8 cells in image

The 9-bin histogram of 8x8 cells are in below figure.



**Figure 5.1.1.8:** 9-bin histogram

In the given representation, the y-axis is 0 degrees. it can be seen the histogram has a lot of weight near 0 and 180 degrees, that is, In the patch the gradients are pointing either up or down.

#### Step 4: Calculating the HOG feature vectors

lets combine four 8×8 cells to create a 16×16 block. as we already know that each 8×8 cell has a 9×1 matrix for a histogram. So, we would have four 9×1 matrix or a single 36×1 matrix. To normalize this type of matrix, lets divide each of these values by the square root of the sum of squares of the values. Mathematically, for a given vector V:

$$V = [a_1, a_2, a_3, \dots, a_{36}]$$

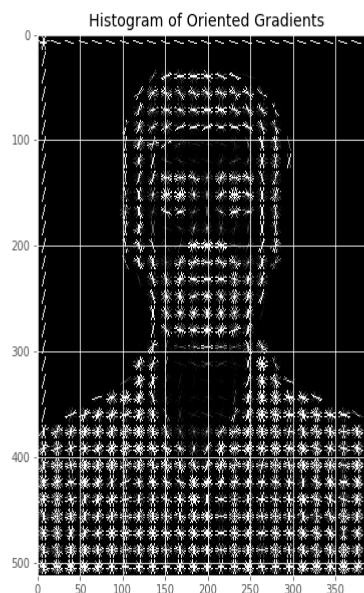
We will calculate the root of the sum of squares:

$$k = \sqrt{(a_1)^2 + (a_2)^2 + (a_3)^2 + \dots + (a_{36})^2}$$

And lets divide every value in the vector V with this value k:

$$\text{Normalised Vector} = \left( \frac{a_1}{k}, \frac{a_2}{k}, \frac{a_3}{k}, \dots, \frac{a_{36}}{k} \right)$$

#### Visualizing Histogram of Oriented Gradients



**Figure 5.1.1.9:** Visualization of HOG

The HOG descriptor of an image patch that can be visualized by plotting the  $9 \times 1$  normalized histogram in the  $8 \times 8$  cells. See image on the side. You can notice that dominant direction of the histogram captures the same shape of the person, especially around the torso and legs.

So, this is how a vector of feature descriptor is created for the images used for the training and the testing of in the model.

The training of dataset used to train the model is an xml file that lists the images in the training dataset and also contains the positions of the face boxes. To create XML files, we can use the `imglab` tool. It is a simple graphical tool used for labelling the objects in images with boxes.

Once, We will done with the generation of feature vector for a given image. An SVM is trained to detect whether this feature vector is of a face or not. A simple 1/0 binary classification will suffice.

## Predicting the face:

We are using shape predictor function of Dlib to find the important details:

“This object is a tool that takes in an image region containing some object and outputs a set of point locations that define the pose of the object. The classic example of this is human face pose prediction, where you take an image of a human face as input and are expected to identify the locations of important facial landmarks such as the corners of the mouth and eyes, tip of the nose, and so forth.”

The shape predictor functions are using an ensemble of regression trees can be used to regress the location of facial landmarks from a sparse subset of intensity values extracted from an input image.

### 5.1.2 Drawing Function:

Drawing methods work with frameworks/pictures of subjective profundity. The limits of the shapes can be rendered only for 8-bit images. All the methods accept the parameter as color that uses an RGB value (and these color value may be obtained with `CV_RGB` or the constructor of scalar) for brightness of grayscale images and for color images for color images, color ordering in Blue, Green, Red. In open CV library functions `imshow()`, `imread()` and `imwrite()` expect these color values as parameters. All scalar function has following sign:

`Scalar(blue.component, green.component, red.component[, alpha.component])`

If the figure that drawing function want to draw is partially outside or completely outside, the drawing method or function need to handle the coordinates of pixel given with sub-pixel accuracy. The real pixel coordinates calculated as:

$$\text{Point}(x, y) \rightarrow \text{Point2f}(x * 2^{-\text{shift}}, y * 2^{-\text{shift}}).$$

This feature is mainly effective when rendering anti-aliased shapes.

## RGB to Grayscale Conversion:

- 1- luminosity method /Weighted method
- 2- Average Method

### 1- Average method

This method is one of the simplest methods to convert an RGB image to grayscale image. We just need to take the average of the value of three colors.

For Example:

We have an RGB image with three color value  $r$  for red,  $g$  for green and  $b$  for blue. Then we just need to calculate the sum of all three value and divided by three.

It's done in following way:

$$\text{grayscale image} = (R * G * B)/3$$

Let we have a color image as given below we calculate the average of each pixel of given image and replace each pixel with average to get grayscale image:



**Figure 5.1.2.1:** Average Method (1)

After replacing each pixel value we'll get following grayscale image:



**Figure 5.1.2.2:** Average Method (2)

But in average method we detect that the brightness of image is not good enough. This problem is caused by the average value of three color. Three colors red, green and blue have three different value of their wavelength and have their own different contribution in the image. So, we need to take average in respect of their contribution instead of taking equal contribution. In average method we take contribution same as following

*33% of Red, 33% of Green and 33% of Blue*

## **2- Luminosity method /Weighted method:**

We have seen that the problem in average method due to their different wavelength. This method gives the solution of previous method problem. We know that the wavelength of red colour is higher in all three colours, and the wavelength of green colour is lesser than red colour and green colour also gives soothing effect of our eyes.

Due to soothing effect and lesser wavelength we need to increase the contribution of green colour and due to higher wavelength, we need to decrease the contribution of red colour and blue colour. According to above consideration the new formula for grayscale image is;

$$\text{grayscale image} = (0.3 * R) + (0.59 * G) + (0.11 * B))$$

According to above equation color all three colors Red, Green and Blue have contributed respectively 30%, 59% and 11%.

On applying above equation, we get more cleared grayscale image of an RGB image.

Let we have following coloured image:



**Figure 5.1.2.3:** Luminosity method (1)

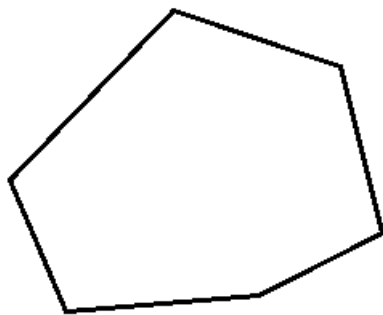
After applying luminosity method or weighted method we get following grayscale images:



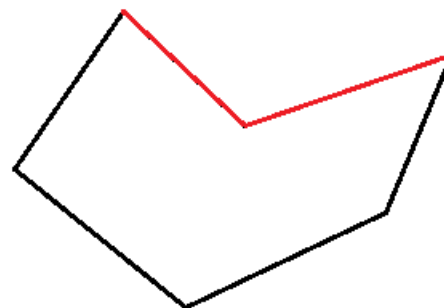
**Figure 5.1.2.4:** Luminosity method (2)

### **Convex hull:**

The convex hull is a set of points of smallest polygon, this polygon enclosed all points those are present in set with minimum use of points. Convex word means that polygon has zero corners twisted inwards.



Convex Hull polygon



Non-Convex Hull polygon

**Figure 5.1.2.5:** Convex Hull

The red edge shows that the shape is concave instead of convex, concave is the opposite shape of convex.

### **Finding the convex hull:**

### Jarvis's Algorithm:

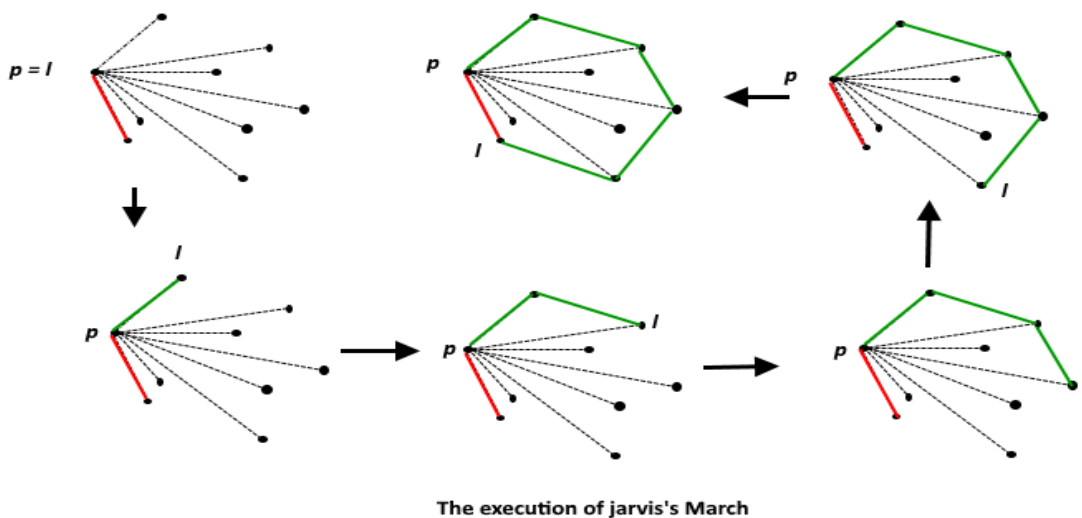
This is the simple approach to find convex points. First, we select left most point (or a point that has minimum x coordinate value). After selecting left most point, select a right most point (or a point that has highest value on x coordinate). Connect these two points and divide sets of points into two parts, lower parts and above parts.

Next, select a point that has highest perpendicular distance from divider line (a line draw between left most and right most point).

This algorithm takes  $O(nh)$  time in worst case, where h is equal to the number of vertices in convex hull.

### Algorithm:

- Find two points first 'left most' and second 'right most'.
- Divide points into two parts above and below the line joining left most and right most points.
- In the bottom half, select another left most point and add the point with lowest angle to the y-axis from the current point.
- Repeat scanning in same way in the above half.



**Figure 5.1.2.6:** The execution of Jarvi's March

### Graham Scan:

This algorithm, selecting a point, that have minimum value on y-axis and also lie surly on convex hull. If multiple point has lowest y coordinate, then we select a point that has highest x coordinate.

After that we sort all the points according to their angle at which they lie. This angle also known as polar angle. If we have two points with same angle, then we select one with minimum distance from starting point.

We use stack data structure to store these points on memory. During the traversing all sorted points, if we found convex shape then we push that point to stack and if we found concave shape we pop point on top of the stack.

This method has worst case complexity  $O(n \log n)$  time.

### Algorithm:

1. find a point  $P_0$ , that has minimum value on Y-axis.
2. Calculate polar angle of each points.
3. Sort all points with respect to their polar angle.
4. Initialize a stack,  $S$
5. Push three starting points in stack
6. Push( $S, P_0$ )
7. Push( $S, P_1$ )
8. Push( $S, P_2$ )
9. For  $i$  in range  $(3, n)$ :
10. While ( $\text{angle}(\text{topnext}(S), \text{top}(S) \text{ and } P_i) == \text{right turn}$ )
11. Pop( $S$ )
12. Push( $S, P_i$ )
13. Return  $S$

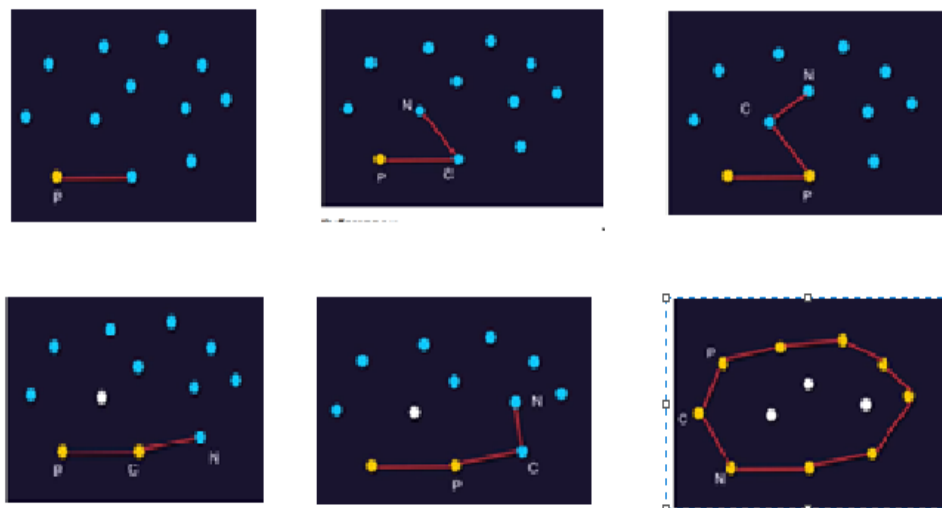
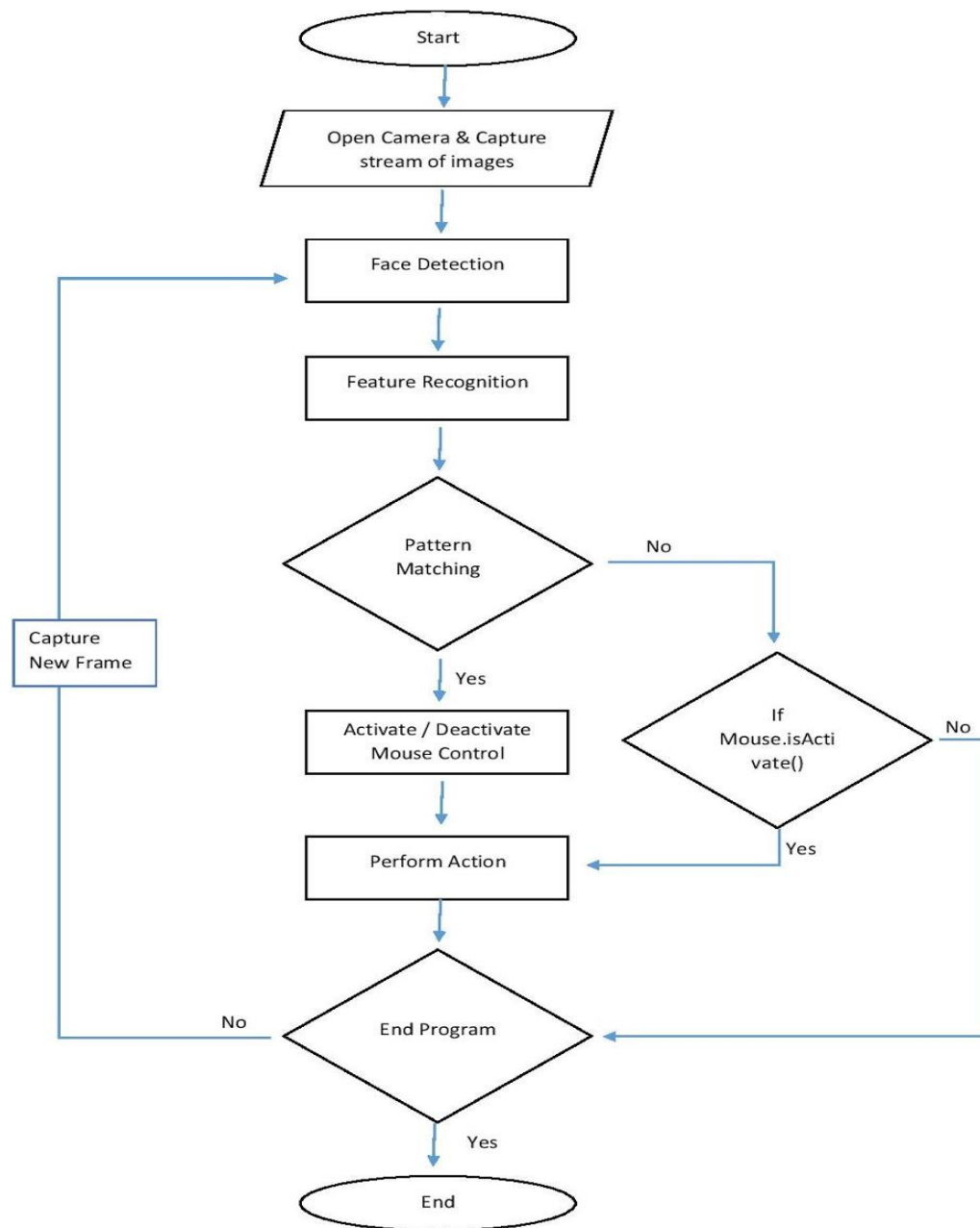


Figure 5.1.2.7: Graham Scan



## 5.2. Flow Chart:



**Figure 5.2:** Flow Chart

(Above Flow Chart shows the sequence of routines that are running inside the system)

Above Flow Chart has following steps:-

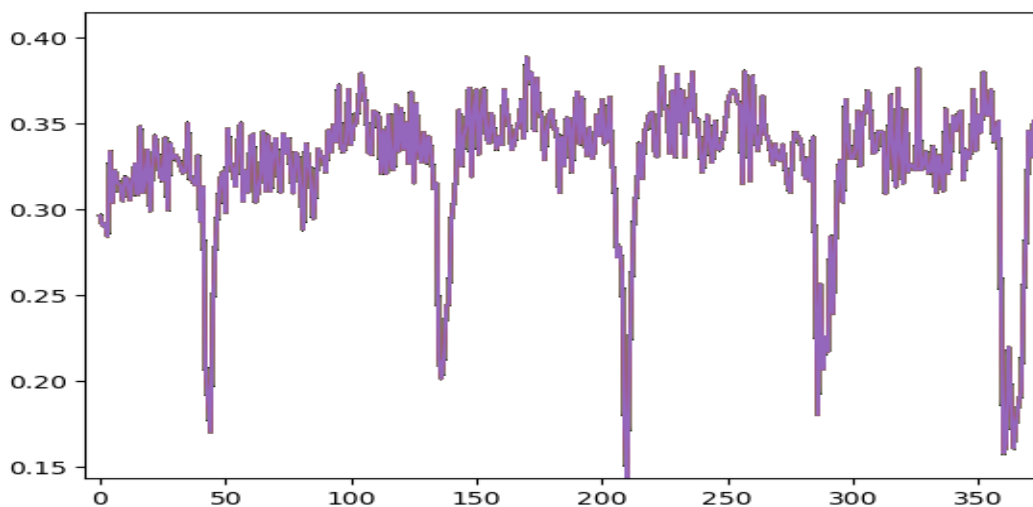
1. Start program

2. Turning on the webcam and webcam continuously captures frames of image.
3. The system performs an action to detect face and recognize its features like eyes, nose.
4. The system finds the pattern and match the pattern.
5. If pattern has been matched, then system take an action of activation or deactivation of mouse.
6. Perform Action:
  - a) Mouse control by moving of head.
  - b) Right click and left click on eye blink.

### 5.3. Mouse Events:

Mouse events like (double click, left click and right click) would be perform according to blink count. We point nose tip to move mouse cursor if nose tip move left from its centre position then mouse cursor move to left and tip move to right then mouse cursor move to right same as for up and down. We capture each frame from webcam and detect facial landmark like (eye, nose).

This system will count blinks of eye but we detect that normally a person blinks their eyes in specific time duration. So, we need avoid those normal blinks or single blink in a fix time duration. To avoid this problem, we capture following graph between EAR (Eye Area Ratio) and time.



**Figure 5.3.1:** EAR (Eye Aspect Ratio)

We absorb above graph and find that a normal person performs single blinks in 2-2.5 seconds. So, we take 2.5 second as specific time to avoid routine single blinks made by user. To perform any action like Double Click, Left Click, Right Click user need to blink his eyes more than one time in time duration of 2.5 second. This system start time counting as the user perform single blink and after 2.5 second system check how many times eye blink by user in each 2.5 second. If user blink his eyes only one time in 2.5 second, system will avoid this one blink.

**Double click -:**

If blink counts in 2.5 second is two, then system will perform double click action.

We define following function to perform double click:

```
def doubleClick():  
    mPoint = pyautogui.position();  
    pyautogui.doubleClick(mPoint.x,mPoint.y)  
    return
```

**Right click -:**

if blink count in 2.5 second is three, then system will perform right click action.

Following function is defined to perform Right Click:

```
def rightClick():  
    mPoint = pyautogui.position();  
    pyautogui.rightClick(mPoint.x,mPoint.y)  
    return
```

**Left click -:**

if blink count in 2.5 second is four, then system will perform left click action and following function is used to perform left click:

```
def leftClick():  
    mPoint = pyautogui.position();  
    pyautogui.leftClick(mPoint.x,mPoint.y)  
    return
```

**5.3.1 Algorithm**

1. Initialize video streams as vs;

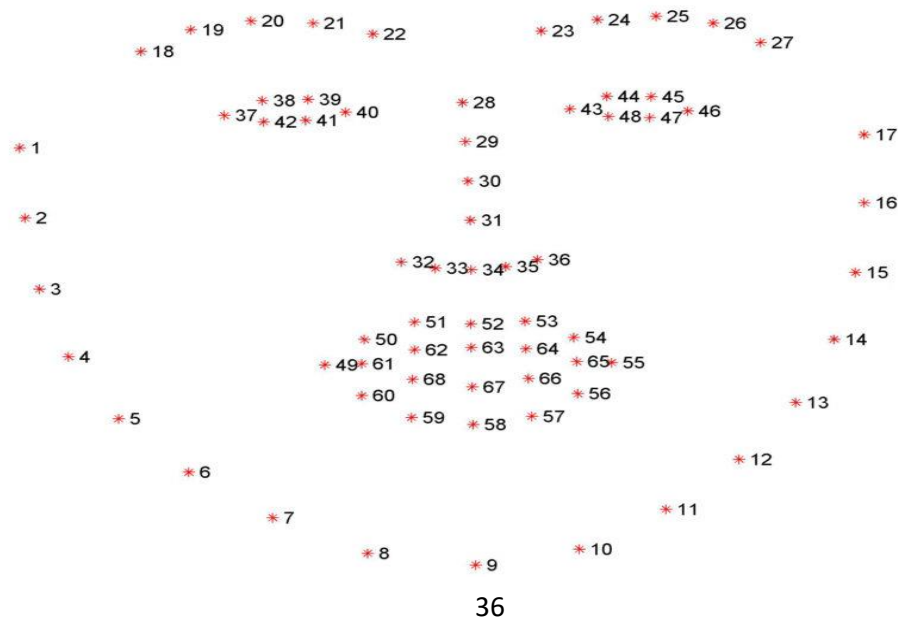
2. load face predictor;
3. BLINK\_COUNT: = 0;
4. TIME\_COUNTER: = 0;
5. while(true)
  - a. if fame is not available in vs:
    - i. break;
  - b. frame is captured frame from video\_stream vs;
  - c. convert frame RGB to grey scale;
  - d. Detect Face in frame;
  - e. Detect Eye after face detection;
  - f. Calculate EAR (Eye Area Ratio) for each eye;
  - g. If EAR < EAR\_THRESHOLD:
    - i. start\_time\_counter ();
    - ii. BLINK\_COUNT++;
  - h. if TIME\_COUNTER > THRESHOLD\_TIME\_COUNTER:
    - i. stop\_time\_counter ();
    - ii. TIME\_COUNTER: =0;
    - iii. BLINK\_COUNT: = 0;
    - iv. IF BLINK\_COUNT == 2:
 

Perform\_double\_click ();
    - v. ELSE IF BLINK\_COUNT == 3:
 

Perform\_left\_click ();
    - vi. ELSE IF BLINK\_COUNT == 4:
 

Perform\_right\_click ();

### 5.3.2 Facial Landmark detection and eye blink detection -:



**Figure 5.3.2:** Dlib Facial Landmark points

In the face gesture recognition, detection of facial landmarks plays an important role in real-time. there has been various research done on robust landmark detection algorithm [12]. The two-step process of facial landmark is the localization of face in the image and detection of various main facial features. In this paper, face detection is done by Histogram of Oriented Gradients based global feature-based Cascade Classifiers and the landmarks generated using the dlib library. The model is pre-trained on an iBUG 300-W [13], [14], [15] dataset which was annotated with a location of 68 facial (eyes, eyebrows, nose, mouth, and jawline) landmark coordinates as shown in Fig. 5.3.2.

### 5.3.3. Eye Blink detection -:

Eye blink detected with useful facial landmark detection. Many libraries use to detect facial landmark. But this system uses DLIB pre-trained library with 68 index which help to find facial landmarks.

For eye blink detection we need to focus on index 37 to 40 for right eye and 43 to 46 for left eye.

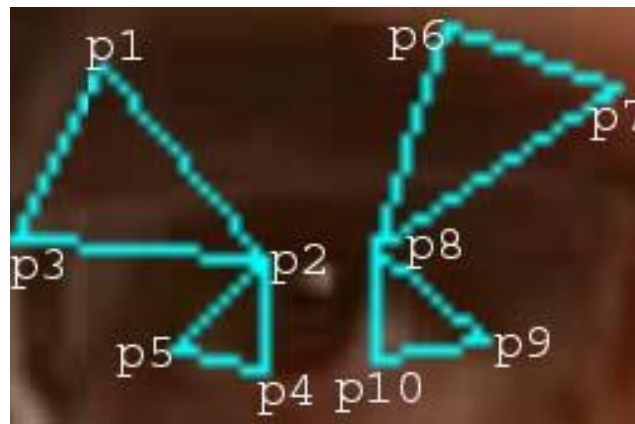
#### A. Parameter for eye blink detection:

In this section, we are going to define a parameter ( $\beta$ ) to find whether eye is close or open. We will also find the relation between this parameter and with area enclosed.

Here we are considering  $\beta$  to be large for open eye and it will be small for closed eye.

We are taking points from (18,22) ,{20} ,(37,42) for left eye and (23,27) ,{25} , (43,48) for right eye as shown in figure facial landmark.

The whole area of single eye is divided into four parts.



**Figure 5.3.3.1:** EAR (1)

From various observation we are summarizing some fact below.

- I. When we open our eyes, the value of  $\beta$  should also increases and sum of area enclosed by  $\triangle (p2 p4 p5)$  and  $\triangle (p8 p9 p10)$  is also increases.

$$\beta \propto (AreaOf(\Delta p_2 p_4 p_5) + AreaOf(\Delta p_8 p_9 p_{10}))$$



**Figure 5.3.3.2: Open Eye**



**Figure 5.3.3.3: Closed Eye**

- II. When we closed our eyes, hence the value of  $\beta$  should decrease, but sum of area enclosed by  $\Delta(p_1 p_2 p_3)$  and  $\Delta(p_8 p_9 p_{10})$  increases, i.e.;

$$\beta \propto \frac{1}{AreaOf(\Delta p_1 p_2 p_3) + AreaOf(\Delta p_6 p_7 p_8)}$$

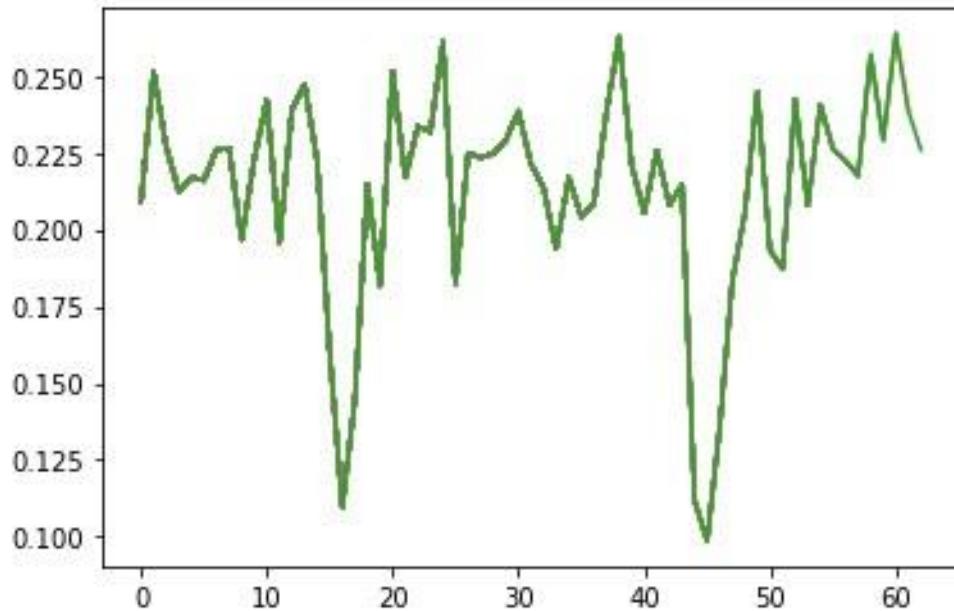
From the above two observation it can be concluded as.

$$\beta = \frac{AreaOf(\Delta p_2 p_4 p_5) + AreaOf(\Delta p_8 p_9 p_{10})}{AreaOf(\Delta p_1 p_2 p_3) + AreaOf(\Delta p_6 p_7 p_8)}$$

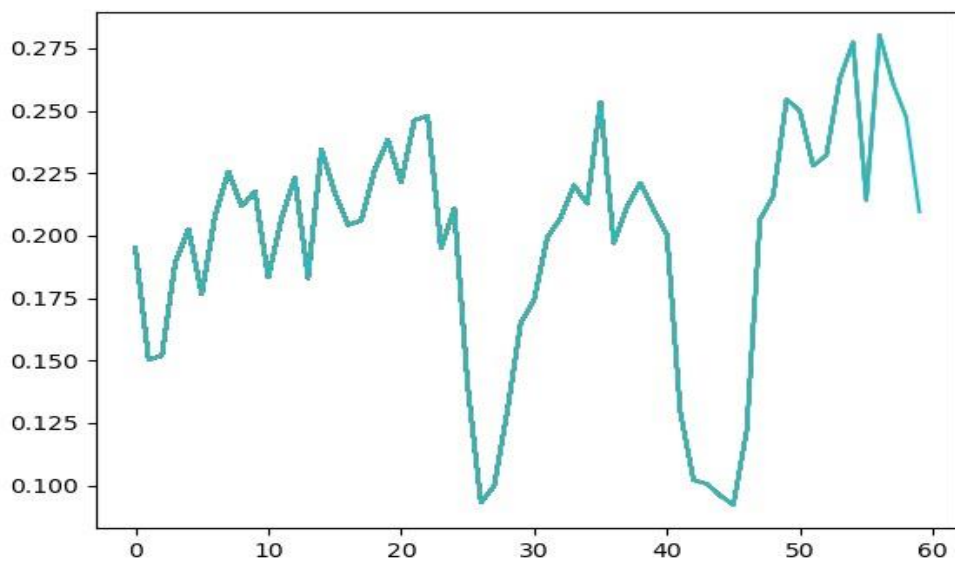
**B. Value of  $\beta$  to eye blinking pattern.**

As we now value of  $\beta$  decreases when eye is closed and increase when the eye opened.

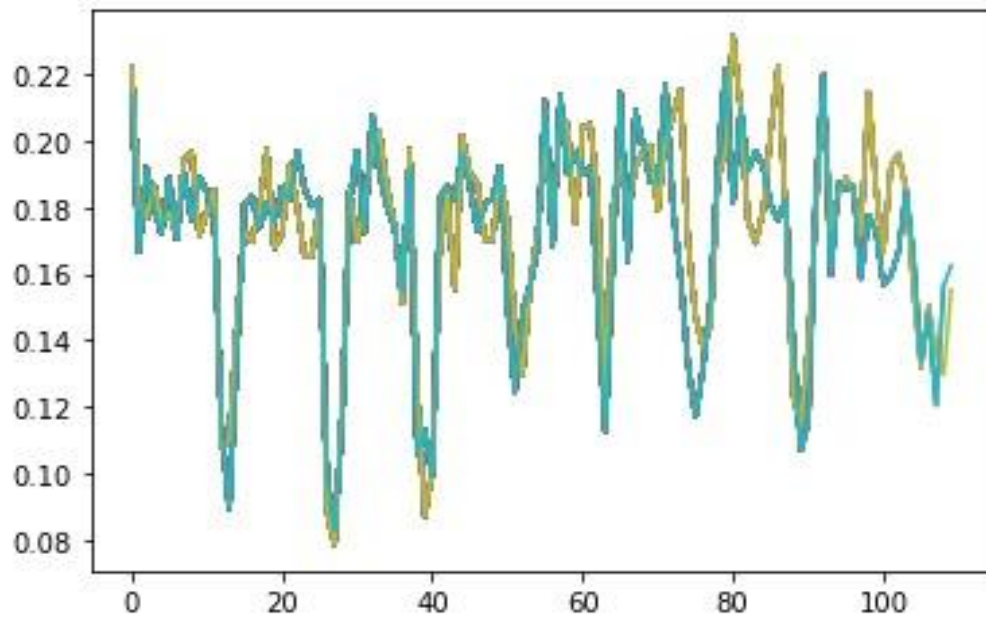
So by plotting the graph between value of  $\beta$  with time, we can find the threshold value of  $\beta$  to count eye blink.



**Figure 5.3.3.4:** For left eye



**Figure 5.3.3.5:** For right eye



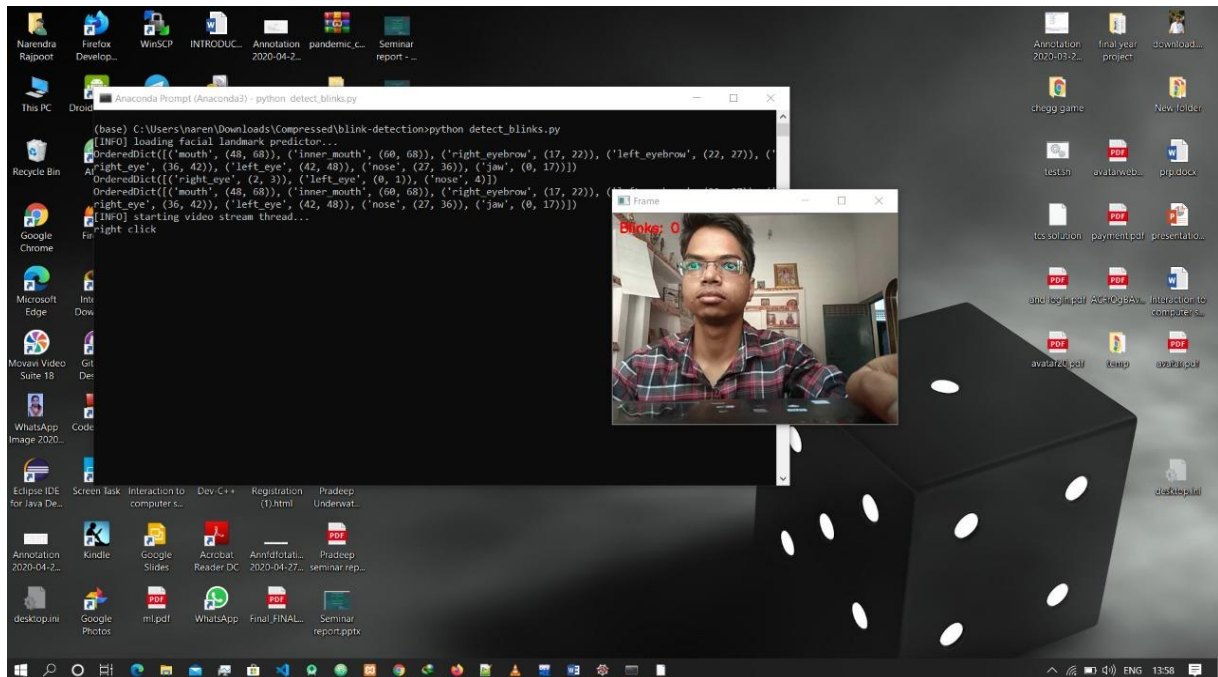
**Figure 5.3.3.6:** Both eye blink

From the above graph we can conclude that, the threshold value of  $\beta$  should be 0.12

So, the blink will be counted if  $\beta \leq 0.12$

## 5.4. Screenshots:

### 1: Right Click



**Figure 5.4.1:** Right Click



## 2: Left Click

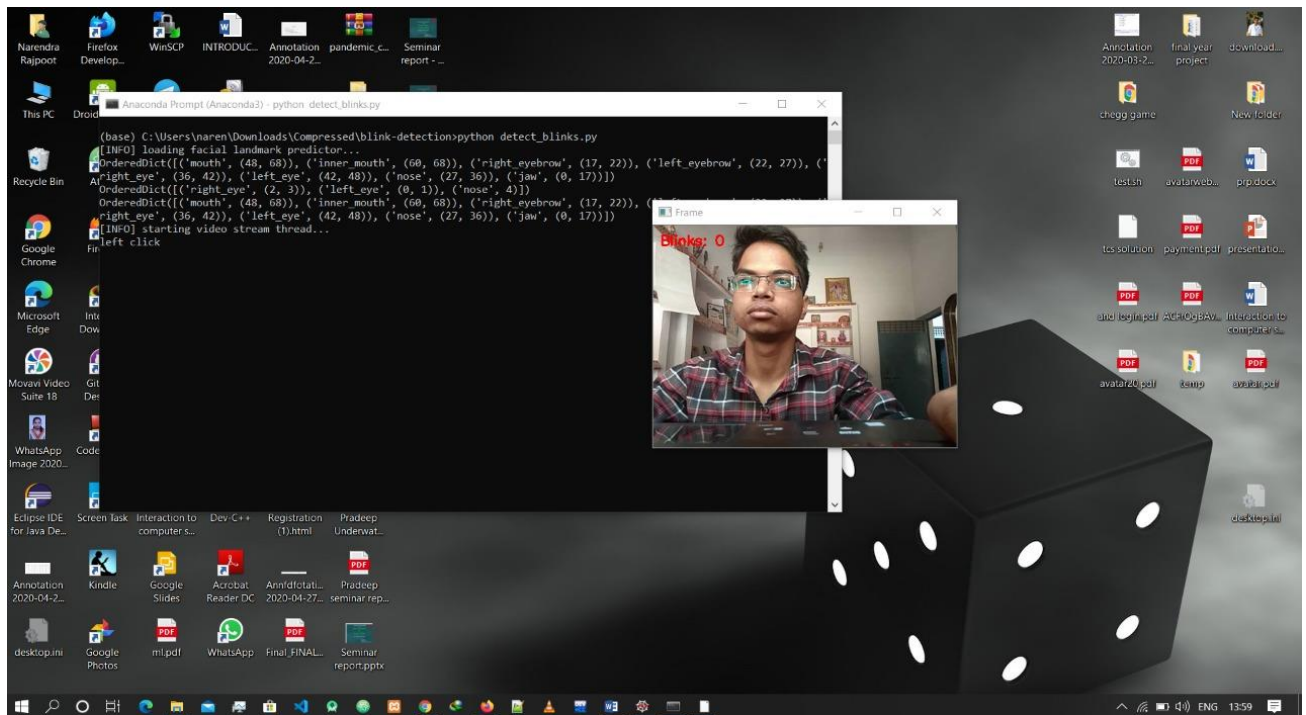


Figure 5.4.3: Left Click

## 3 – Double Click

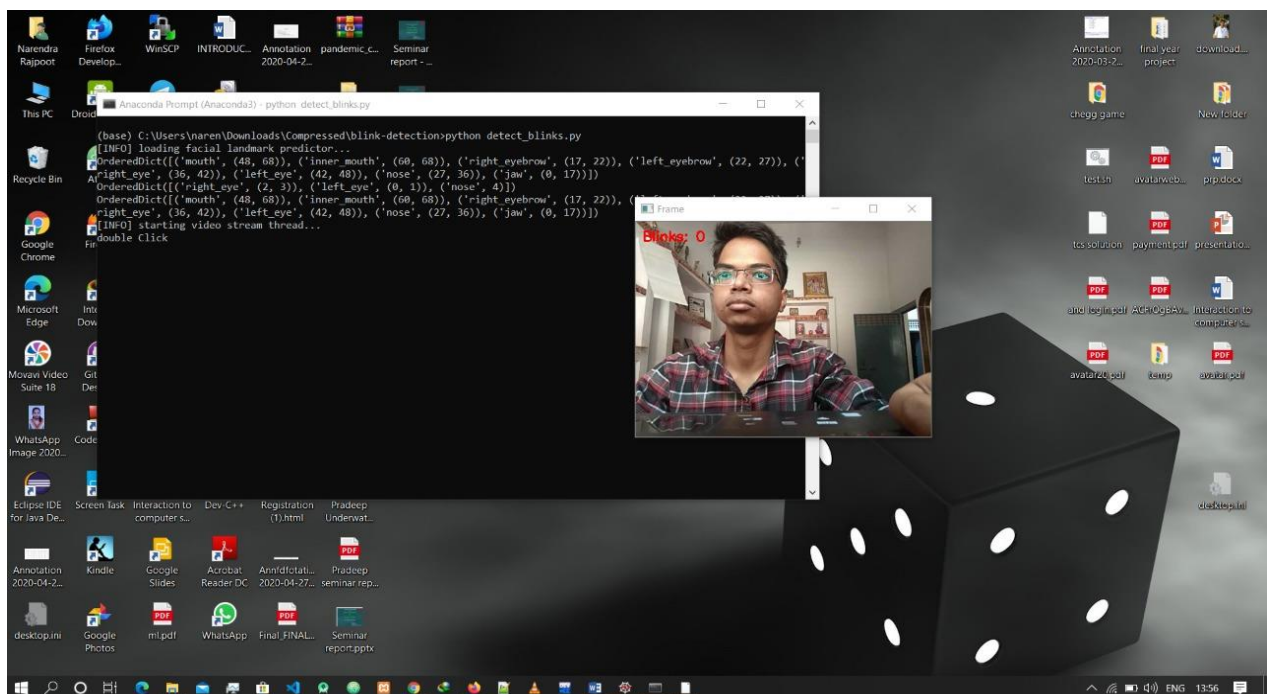


Figure 5.4.3: Double Click

## 6. Evaluation of Proposed System/Result:

This model is tested on Laptop having following configuration:

1. Operating System : Windows 10 x64,
2. CPU : i5 core, 2.30GHz,
3. Webcam : 2MP

And we tested this system in various light intensity like high, moderate and low light. Also, we add glass as measurement. We tested this system four times in same light intensity and we conclude the following four tables. In each condition we check

**TABLE – I**

Test - I

Light Intensity	Having Glasses	Eye Detected	Blink Detected
High	Yes	Yes	Yes
	No	Yes	Yes
Moderate	Yes	Yes	No
	No	Yes	Yes
Low	Yes	No	No
	No	No	No

**Table 6.1: Test - I**

**TABLE – II**

Test - II

Light Intensity	Having Glasses	Eye Detected	Blink Detected
High	Yes	Yes	Yes
	No	Yes	Yes
Moderate	Yes	No	No
	No	Yes	No
Low	Yes	No	No
	No	Yes	No

**Table 6.2: Test - II**

**TABLE – III**

Test - III

Light Intensity	Having Glasses	Eye Detected	Blink Detected
High	Yes	Yes	Yes
	No	Yes	Yes
Moderate	Yes	No	No
	No	Yes	No
Low	Yes	No	No
	No	Yes	No

**Table 6.3: Test - III****TABLE – IV**

Test - IV

Light Intensity	Having Glasses	Eye Detected	Blink Detected
High	Yes	Yes	Yes
	No	Yes	Yes
Moderate	Yes	Yes	No
	No	Yes	Yes
Low	Yes	No	No
	No	Yes	No

**Table 6.4: Test – IV**

**TABLE – V**

Test - V

Light Intensity	Having Glasses	Eye Detected	Blink Detected
High	Yes	Yes	Yes
	No	Yes	Yes
Moderate	Yes	No	No
	No	Yes	No
Low	Yes	No	No
	No	Yes	No

**Table 6.5: Test – V**

According to the above data we conclude that our system gives better performance in High light intensity or in sun light than moderate light intensity or low light intensity and when the light intensity is moderate then system performance is better than performance in low light intensity and worse than performance in high light intensity or sun light. This system is not appropriate in low light intensity it will work fine in proper light intensity or in day light.

We tested performance of this system by taking distance (between user and webcam (d)) as a measurement parameter and get following result.

**TABLE – VI**

The dataset we have used to check the metrics of model is described below.

Person	Spectacles	Number of blinks			Lighting
		<i>Left</i>	<i>Right</i>	<i>Both</i>	
A	No	20	20	A	No
B	No	20	20	B	No
C	No	20	20	C	No
D	No	20	20	D	No
E	No	20	20	E	No

**Table 6.6: Dataset Description**

**TABLE - VII Precision, Recall and F1 score for blink detection**

Person	Precision (P)			Recall (R)			Average Precision	Average Recall	Average F1 Score
	<i>Left</i>	<i>Right</i>	<i>Both</i>	<i>Left</i>	<i>Right</i>	<i>Both</i>			
A	94.73	100.00	100.00	94.73	95.00	100.00	98.24	96.57	97.40
B	100.00	100.00	100.00	95.00	95.00	100.00	100.00	96.67	98.31
C	100.00	94.73	100.00	100.00	100.00	95.00	98.24	98.33	98.28
D	88.88	94.73	94.73	88.88	89.47	89.47	92.78	89.27	90.99
E	100.00	100.00	100.00	95.00	100.00	100.00	100.00	98.33	99.16

**Table 6.7: Precision, Recall and F1 score****TABLE - VIII Performance Parameters for blink detection**

Person	True Positive			False Positive			False Negative		
	<i>Left</i>	<i>Right</i>	<i>Both</i>	<i>Left</i>	<i>Right</i>	<i>Both</i>	<i>Left</i>	<i>Right</i>	<i>Both</i>
A	18	19	20	1	0	0	1	1	0
B	19	19	20	0	0	0	1	1	0
C	20	19	19	0	1	0	0	0	1
D	16	17	17	2	1	1	2	2	2
E	19	20	20	0	0	0	1	0	0
F	18	19	20	1	0	0	1	1	0

**Table 6.8: Performance Parameters**

## 6.1 Performance Metrics:

The performance metrics of Eye blink detection is F1 Score i.e; harmonic mean of Precision and Recall.

$$F1 = \frac{2 \times P \times R}{P + R} \quad (8)$$

Where P = Precision

$$(P = \frac{TP}{TP + FP} \times 100)$$

and,

R = Recall

$$(R = \frac{TP}{TP + FN} \times 100)$$

True Positive (TP): Model correctly predicts that eye has blinked. False Positive (FP): Model incorrectly predicts that eye has blinked.

False Negative (FN): Model incorrectly predicts that eye hasn't blinked.

The overall result is very good except for a case i.e; in very low light.

## **7. Conclusion and Future Scope:**

In this project, we proposed a model that interact to computer system based on eye and head gesture recognition using Machine Learning. This project is based on a model with recognition accuracy greater than the real-time models. Proposed model is able to recognize blink of eyes and gestures of the head. We are using eye area ratio in order to achieve the maximum accuracy and will perform the left, right and double click of mouse operations on respective left, right and both blink of eyes. The principle objective of this project is to build up a powerful and intuitive model utilizing eye flicker and head gesture. These motions are then used to control the system. This system uses HOG algorithm for feature descriptor and SVM algorithm for training the model.

In this project we are using HOG as a feature descriptor and Ensemble of Regression Trees for face alignment, HOG is an old technique to extract feature, Using CNN as feature extractor can be more efficient than HOG, how it works in real time is still on paper. We can implement some other feature descriptor and face alignment algorithm. In this project we are not using any activator to activate the movement of cursor. In future we can implement this part to in the project.

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