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A Project Report
on
**Virtual Mouse with hand gestures Tracking using
Image Processing**

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For
The award of the degree of

Bachelor of Technology in
Computer Science and Engineering

(2017 – 2021)

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CERTIFICATE

This is to certify that this Project-1 report on “Virtual Mouse with hand gestures Tracking using Image Processing”, submitted by Yerra Yashua Krupason (17311A05M2), Buddavarapu Teja Swaroop (17311A05M5) and Pathkoti Dinesh Kumar (17311A05M3) in the year 2020 in partial fulfillment of the academic requirements of Jawaharlal Nehru Technological University for the award of the degree of Bachelor of Technology in Computer Science and Engineering, is a bonafide work that has been carried out by them as part of their **Project-1 during Fourth Year First Semester**, under our guidance. This report has not been submitted to any other institute or university for the award of any degree.

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1st semester, COMPUTER SCIENCE AND ENGINEERING solemnly declare that the Project-1
work, titled “Mouse with hand gestures Tracking using Image Processing” is submitted to
SREENIDHI INSTITUTE OF SCIENCE AND TECHNOLOGY ¹ for partial fulfillment for the
award of degree of Bachelor of technology in COMPUTER SCIENCE AND ENGINEERING. It
is declared to the best of our knowledge that the work reported does not form part of any dissertation
submitted to any other University or Institute for award of any degree.

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I would like to express my gratitude to all the people behind the screen who helped me to transform an idea into a real application.

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Abstract

With the development of technology and knowledge of establishing a connection and process of interaction between human and computer system is evolving since the invention of computer technology. So a specific interactive module like a virtual mouse that makes use of Object Tracking and Gestures that will help us to interact which might be an alternative way for the traditional touch screen technology and the physical mouse. In this project an Object Tracking application that interacts with the system to provide mouse functionalities is created which uses user hand with color bands or tapes. As the mouse is one of the important inventions in computer world, which has improved human machine interactivity. In present scenario, wireless and Bluetooth embedded mouse technology is developed but it is not that ideal to use as this technology is not completely hands free. So, in the proposed model these limitations are removed and interaction is made user friendly as well as cost is also reduced. This model is actually a virtual mouse system using hand gestures with the help of computer vision. Python and OpenCV library is used for real time and computer vision to implement the system. The camera output is displayed on the screen of the monitor. This system allows the user to use the mouse cursor using their hand with color tapes or bands, the webcam tracks and captures the images and these images are analysed to perform mouse operations like left-click, right-click, and double click using different hand gestures.

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1. Introduction

1.1 Motivation

The mouse is one of the important inventions in computer world which improved human machine interactivity. In present scenario, wireless and Bluetooth embedded mouse technology is developed but it is not that ideal to use as this technology is not completely hands free. In Bluetooth technology the mouse developed requires power such as battery power or connecting devices like dongle.

By adding these extra components to the mouse the cost increases and it is also not user friendly to use. So, in the proposed model these limitations are removed and interaction is made user friendly as well as cost is also reduced. This model is actually a virtual mouse system using hand gestures with the help of computer vision.

1.2 Definition

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The primary aim of this project is to improve human and computer interaction by developing an effective and alternative way of controlling the cursor and its various functions such as left click, right click, scroll up, scroll down and selection.

With the help of this model a user can easily interact with the system/computer without the use of an external device. It also allows the user to interact with system from a considerable distance. And because of this improvement the essential hardware required for the computer/laptop is also reduced.

This model makes use of the webcam to capture the video feed, which is used for image processing, and now a days webcam is an essential device/hardware for a laptop/computer and therefore it is not considered as an extra hardware.

1.3 Objective

The objective of this project is to improve the usability and experience of the users by providing a better machine and human interaction. The Image/Video feed from the webcam is used to track and detect gestures and mapping those unique gestures to different mouse events.

Retrieve the image data from the webcam and convert it to a usable format and use it as input. The image must be filtered to identify different colors. Make contours and find the mean positions of those contours. Track those mean positions to recognize the gestures. Map those gestures to different mouse actions and use them.

2. LITERATURE SURVEY

2.1 Existing System

In the existing system[1], a two colored model is used, which uses two distinguished colors and hand gestures to identify and perform respective mouse movements and events. This system performs only basic functionality of mouse i.e, mouse cursor movement, drag or selects items and right clicks. This system in [1] uses RBG color coding in which it uses the exact color calibration color code by which we need to use same calibrated colors to get good accuracy.

In [2], the algorithm they used gave less accuracy in performing the actions and the continues movement of fingers also results in strain in fingers. The Methods used by Authors in [3] gave less accuracy in detecting the colors. In [4], authors developed eye ball tracking mouse control, but the limitation of this paper [4] is eye blinking can occur randomly so performance of the model decreases. The Authors of [5] used pupil movement detection using open source computer vision where the eye movement is converted into voltage and time graph. But for this method in [5] a normal webcam cannot be used. And accuracy in performing the mouse actions by methods of [2-3] gave only 75-80% accuracy

In [1] the background extraction, subtraction etc are done to the image and features are extracted in order to work with functionalities. To perform mouse events and movements an external code is used by which the time complexity is more which indirectly takes time for the system to know the feature the user is expecting and search and perform by the system in [1]. As the mouse events are limited in [1], in order to perform other functionalities we need other devises and these are the limitations of the system.

2.1.1 Comparing various methods

S.no	Method Used	Algorithms used and Drawbacks	Accuracy
1	Virtual Mouse Using Object Tracking	Hvm,Svm algorithms are used.Time taken to detect is nearly 20 sec	70-75%
2	Gesture Recognition Based Virtual Mouse	Convex Hull algorithm is used.Accuracy is 75-85% Continuous finger movement results in stress in fingures	75-85%
3	7 Design and Development of Hand Gesture Based Virtual Mouse	Computer Vision is used. Less accuracy and system recognition of colours is poor.	75-80%
4	13 Virtual Mouse Control by Webcam for the Disabled	Eye ball Tracking using matlab. Eye blinking may occur random	80-90%
5	Cursor Control Using Eye Ball Movement	Pupil movement detected using open source computer vision. The eye movement converted into voltage and time graph, normal webcam can't be used.	80-85%

Table 2.1 Existing System

2.3 Proposed System

The model/system that we proposed is a cursor control model using image processing, which takes hand gestures with the color tapes and bands as input that are captured from the webcam of the system, is feed as an input which is converted into HSV color format. Then by detecting the centers of the color contours and thereby detecting the gestures, it performs mouse events and mouse movements accordingly. In this we used three standard colors which represents the three fingers of a hand and detect the gestures of the hand. We can calibrate the three colors based on the values of hue, saturation and value accordingly so that the exact color coding is not required i.e, exact colors are not used each time.

In this project a library in Python (PyAutoGui) and OpenCV library from cv2 is used to implement this model for Hand gesture tracking and performing the mouse movements accordingly. ² This system is easy to use and it is also easy to remember the gestures that are provided to perform different operations. And once the Model is deployed on the system, we can use this version of the mouse all the time and on all apps.

3. SYSTEM ANALYSIS

3.1 Functional Requirements Specifications

After analysing the project objective, we have come up with following modules:

- **Color Calibration:**

With the help of Computer vision (Opencv2), we recognised three standard colors and converted them into HSV format using cv2.convert() function and calibrated the colors. Users can dynamically adjust hue, saturation, value of the colors.

- **Centroid Detection:**

From the output of the color calibration module, we calculate a mean point which represents contour of each color. With these centroid points we detect the type of gesture position made by user.

- **Multiple Gesture Recognition:**

By the position and movement made by the user various gestures are recognised, if any gesture is not recognised by the system model then it considers it as free movement of the mouse cursor with help of only one color.

- **Mouse Events and Movement:**

Based on the gestures recognised by the model equivalent mouse events are performed with the help of ‘Pyautogui’, a python library.

3.2 Software Requirements

- 64-bit Operating System: Windows 7 or Higher
- Jupyter Notebook/ Google Colab
- Python version >3.0
- PyAutoGUI
- OpenCV

3.3 Hardware Requirements

- A Good Webcam
- RAM preferably >8GB for faster processing
- GPU
- Memory space >500GB

3.4 Environmental Specifications

- A well lit room with mostly light and pale colors.
- No other objects should be present in front of the webcam (particularly red, yellow blue colored objects) except colors on the user's hand.

4. SYSTEM DESIGN

4.1 Architecture

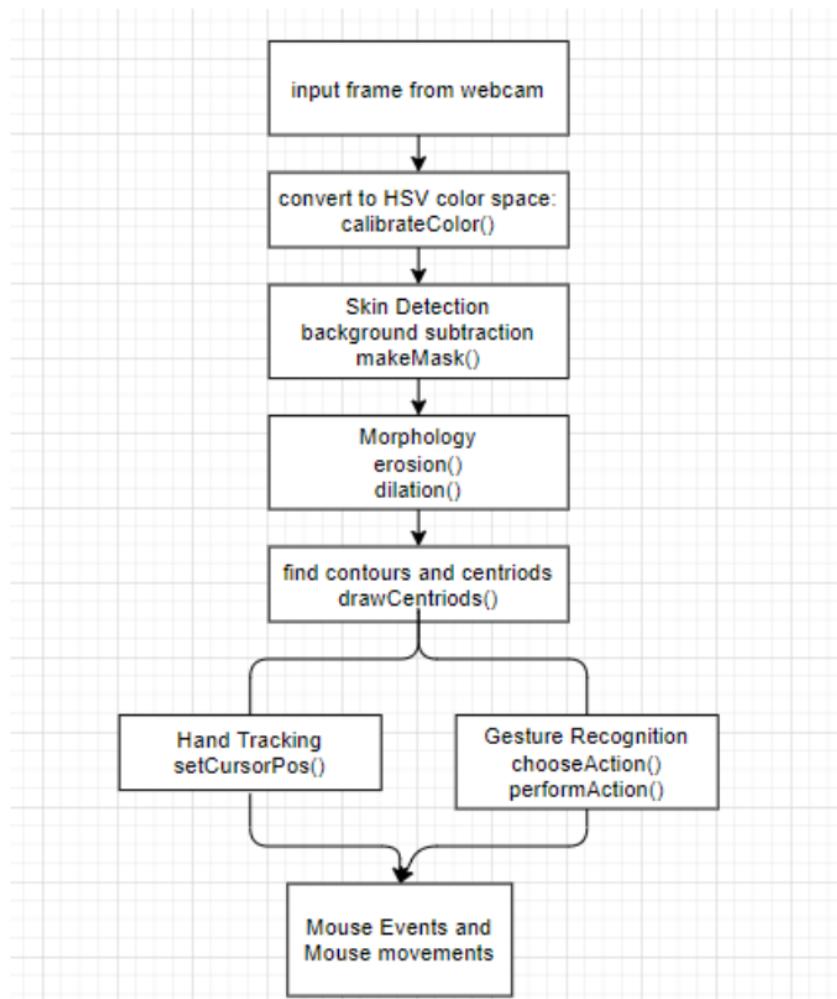


Fig 4.1 : Architecture Diagram

The architecture consists of taking input from webcam and converting into HSV color coding and then performing some operations to remove noise by using background subtraction and applying morphology. Then the contour is extracted and equivalent mouse events are performed.

4.2 UML Diagrams

4.2.1 Use Case Diagram

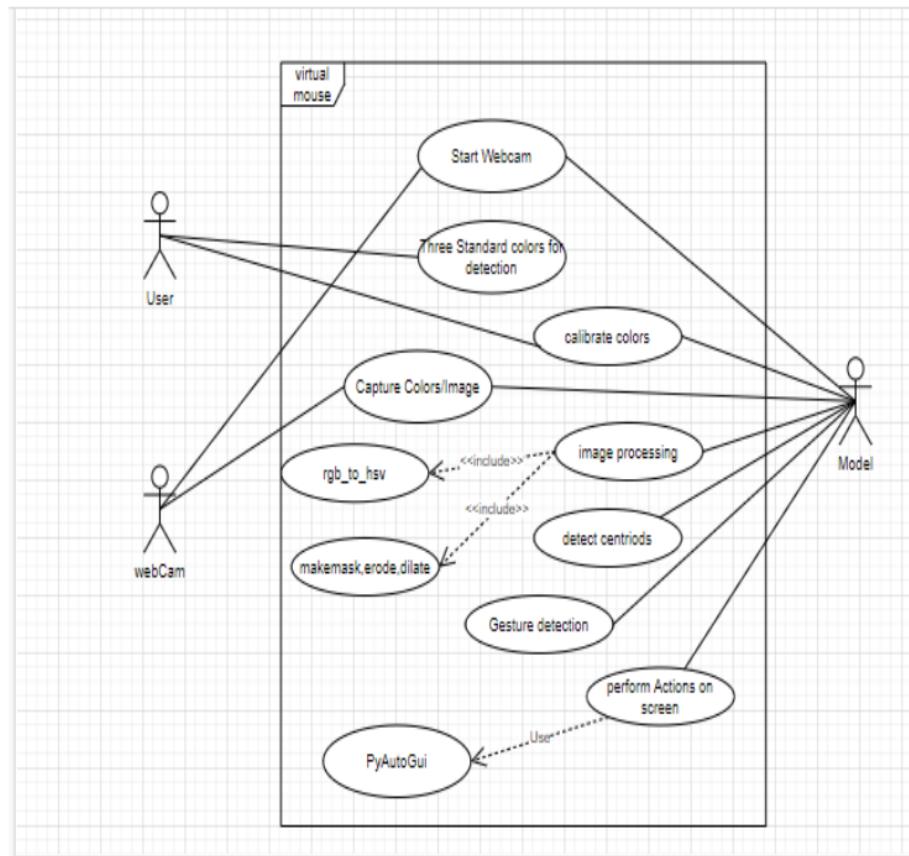


Fig 4.2.1 : Use Case Diagram

In this use case diagram user, webcam and model are the actors of the system. Various operations and functions of each actor is mentioned with their dependency and other relations are shown clearly in the diagram.

4.2.2 Class Diagram

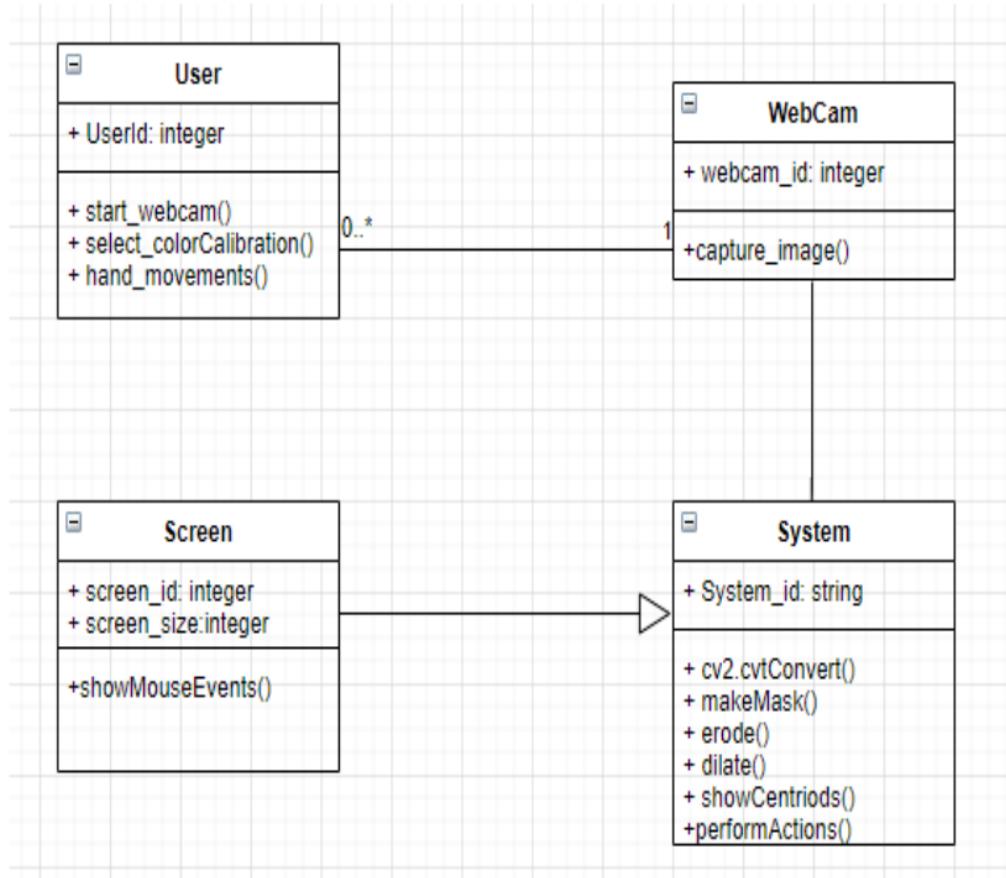


Fig 4.2.2 : Class Diagram

In this class diagram the user, webcam, screen and system are the classes used to represent this virtual mouse. The relationship between them is shown clearly and the functions and methods of each class is explained. Each class has its own attributes to describe the class which holds the variables and model or version description.

4.2.3 Sequence Diagram

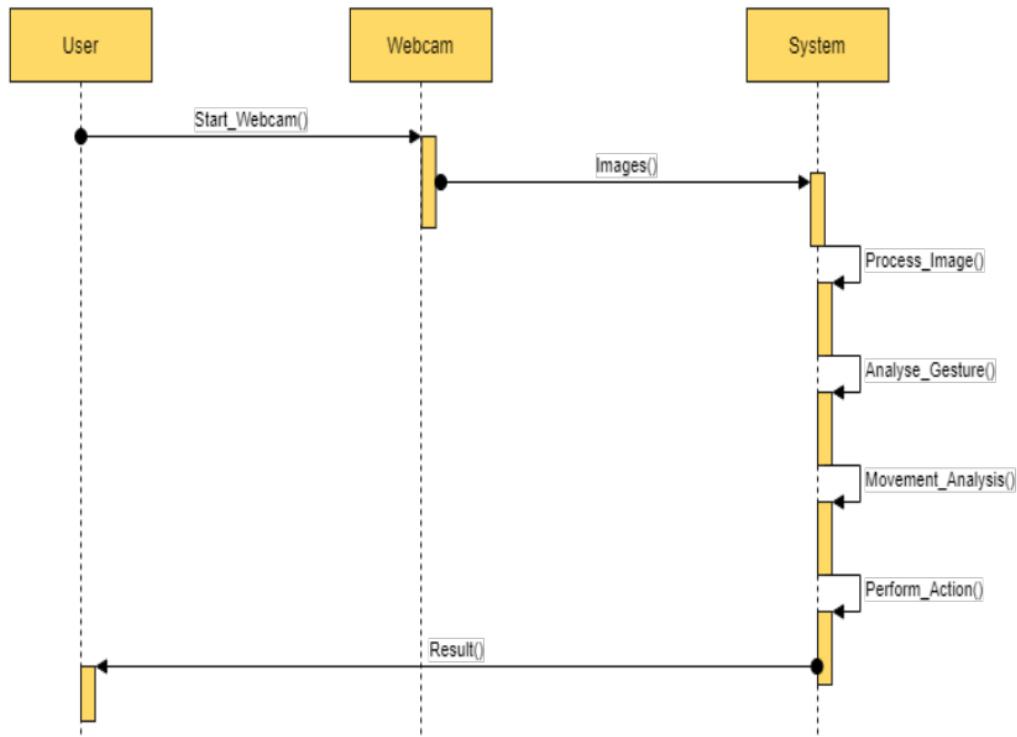


Fig 4.2.3 : Sequence Diagram

In this sequence diagram user, webcam and the system are the three parts where flow of control from one part to another is shown and works done at each stage by that particular system is described. The time and control is shown in the diagram and arrows represent the change in control.

4.2.4 Activity Diagram

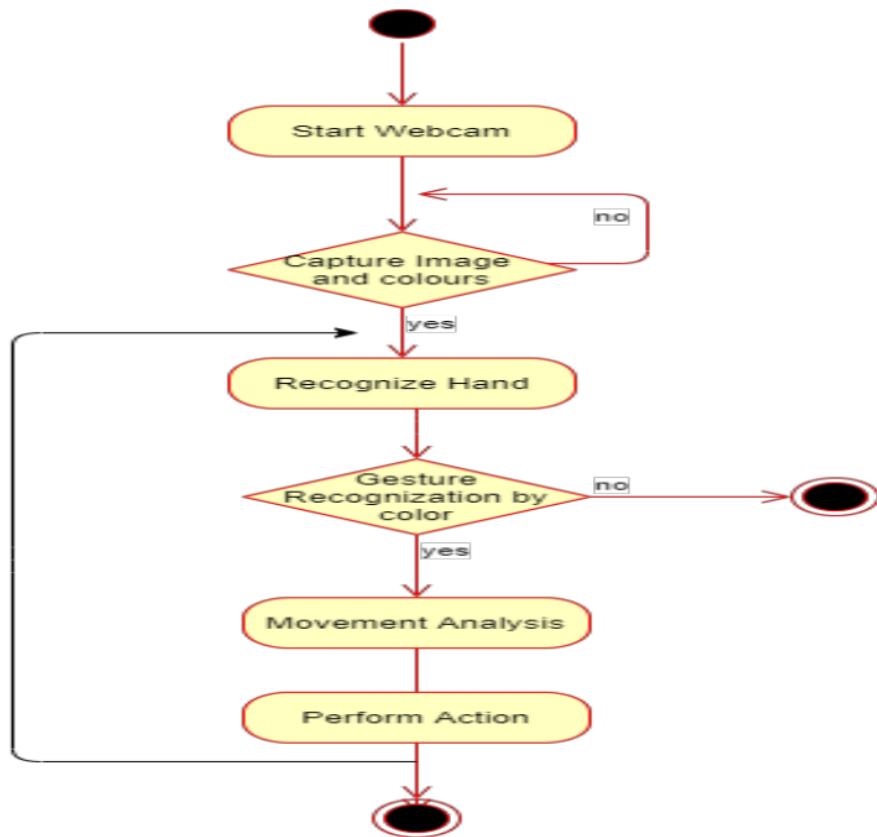


Fig 4.2.4 : Activity Diagram

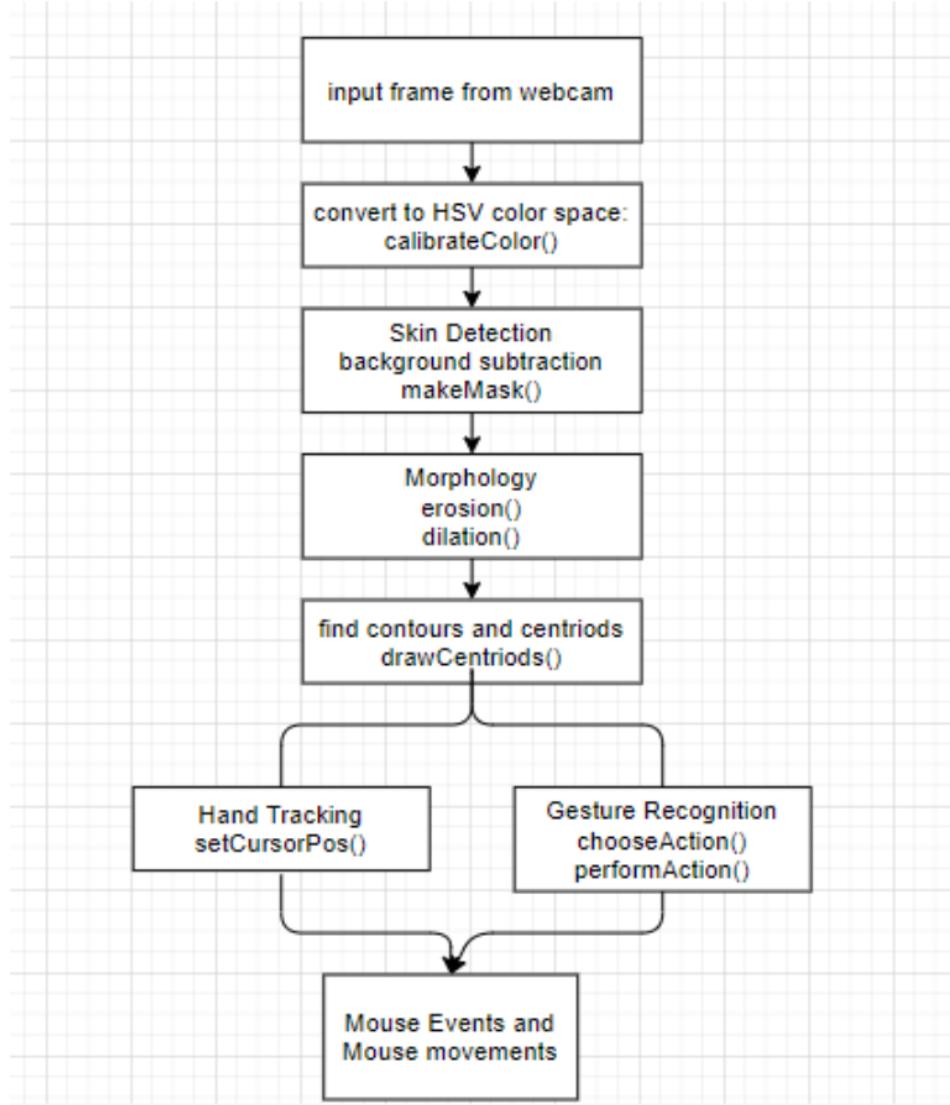
In this diagram the actions and the activities performed by the model is described and it starts from start and flows with the activities done by the model with the decisions and flow for both the options. The flow of model ends at the end of the activity diagram when the user end using the model or the model is interpreted.

4.3 Old vs New Architecture



In this system uses RGB color coding and it is converted into grey scale color coding image which requires lot of time and results in performance of the system. The same color coding need to be used each time so that when we change the calibration of color the system may not work properly.

4.3.2 New System



In this system the RGB color coding is not used and no need to convert the system to grey scale color coding, by which the performance of the system is increased. Dynamic color calibration is done so that there is no need for using same color coding image and thus increasing the accuracy and performance.

5. Implementation

5.1 Methodology

5.1.1 Concept

HSV color format is a color model which is considered to be in a cylindrical shape. It will map the RGB colors space to three Dimensional value space (hue, saturation, and value). Here each color is defined by three values hue, saturation and value. ⁹

Hue is considered as a value defining the angle of a particular color if RGB color space ⁹ is considered as a color circle. Red color has a hue value of 0 degrees, Similarly green color has a hue value of 120 degrees and blue's hue value is considered as 240 degrees. Saturation specifies the intensity of the color or the amount of color used. Saturation value of 100% for a color specifies that the color is in its purest form possible, On contrast color with 0% saturation results in greyscale. Value tells about the brightness of the particular color. Any color with 0% of value is in pure black form whereas any color with 100% value has no black in it.

5.1.2 Implementation of Model

In this model we recorded the image from webcam and converted it from RGB to HSV color format. Then user required to calibrate the three colors i.e, red, yellow, blue in the image which consists of user hand with three colors on fingers individually. In this model we used calibrateColor() function to calibrate the three colors individually by the function. The user can manually calibrate the colors by adjusting the Hue, saturation, value ranges or they can choose default values.

From these calibrated individual images the three fingertips where the color band lies are extracted from user hand, in the video captured by webcam, using the cv2.inRange() function i.e. contours are detected. Noise is removed by applying morphism which contains two steps erosion and dilation. The output images are free from noise and are termed as 'mask', and from these images the centroids are calculated.

As a webcam is not ideal, so the noise of the background is also captured in the image and also the vibrations of the user may also get captured. Due to these vibrations of the user hand the centroids keep varying about a mean position which reduces the efficiency of the model. In order to increase the efficiency and differentiate the actual movements from vibrations, we used an enhanced formula to handle the noise caused by vibrations.

The function chooseAction is used to calculate the three centroids, which is used to decide the functions to be performed by the mouse based on the positions of the three centroids. Based on the action returned by chooseAction() function, we use performAction() function to perform the equivalent mouse events and movements using PyAutoGUI library which can be implemented in python environment. The actions that need to be performed by the system are:

- free cursor movement
- scroll up
- scroll down
- left click
- right click
- drag/select

5.1.3 Algorithm of Model

```
Function distance(center1,center2)
{
    Distance ← square root(center1*center1 + center2*center2)
    return Distance
}
```

```
Function makeAMask(hsv_image, ranges_of_color)
{
    Mask ← opencv2.inrange(hsv,color_range)

    // Morphosis
    Eroded ← erode(mask,kernel)
    Dilated ← dilate(eroded,kernel)

    return Dilated
}
```

```
Function setCursorPosition(centriod,previous_pos)
{
    If the cursor movement is voluntary then
        Position = centriod + (learning rate)*(previous_pos - centriod)

    If the cursor movement is because of vibration of hand or involuntary then
        Position = centriod + (learning rate)*(previous_pos - centriod)
```

```

        return Position
    }

Function CalibrateColor(color,range)
{
    Opencv2.createHsvTrackBar
    While true
        Frame ← CaputeFrame().read()
        Frame ← Flip_frame(Frame)
        Hsv ← convertColor(Frame,RGB_TO_HSV)
        makeAMask(hsv,color_range)

    return range
}

Function chooseAction(yellow_position, red_center, blue_center)
{
    If distance of yellow ,red and blue centers is less then
        Action ← drag

    Else if distance of red and blue is less then
        Action ← left_click

    Else if distance of red and blue is less then
        Action ← right_click

    Else if distance of yellow and red is more and difference of red and blue is more then
        Action ← scroll_down

```

```
Else if difference between red and blue is more then
    Action ← scroll_up
Else
    Action ← free_movement

return Action
}
```

5.1.4 Noise rate formula

To deal with the noise caused by unwanted vibrations we use following method- first we compare the new position of the centroid with the previous position. If the difference between them is less than 5 pixels, we considered that it occurred due to noise.

If the difference between them is more then it is done by user voluntarily, so the cursor position is changed accordingly by this function.

- To set cursor position, if the cursor movement is voluntary then
$$\text{Position} = \text{centriod} + (\text{learning rate}) * (\text{previous_pos} - \text{centriod})$$
- if the cursor movement is because of vibration of hand or involuntary then
$$\text{Position} = \text{centriod} + (\text{learning rate}) * (\text{previous_pos} - \text{centriod})$$

5.1.5 Comparison of various rates-

S.No.	Mouse Event	Pixel Difference	Description	Learning Rate	Sensitivity
1	Cursor Movement	< 5	Voluntary Hand Movement	0.7	Ideal
2	Cursor Movement	< 5	Voluntary Hand Movement	0.8	Ideal
3	Cursor Movement	< 5	Voluntary Hand Movement	0.9	High Sensitivity
4	Cursor Movement	< 5	Voluntary Hand Movement	1.0	High Sensitivity
5	Cursor Movement	< 5	Voluntary Hand Movement	0.6	Low Sensitivity
6	Cursor Movement	>5	Vibrations/Noise	0.1	Ideal
7	Cursor Movement	>5	Vibrations/Noise	0.0	High Sensitivity
8	Cursor Movement	>5	Vibrations/Noise	0.2	Low Sensitivity
9	Cursor Movement	>5	Vibrations/Noise	0.3	Low Sensitivity

Table 5.2 Learning rate for Cursor Movement

5.2 Results/Screenshots

5.2.1 Calibration of colors

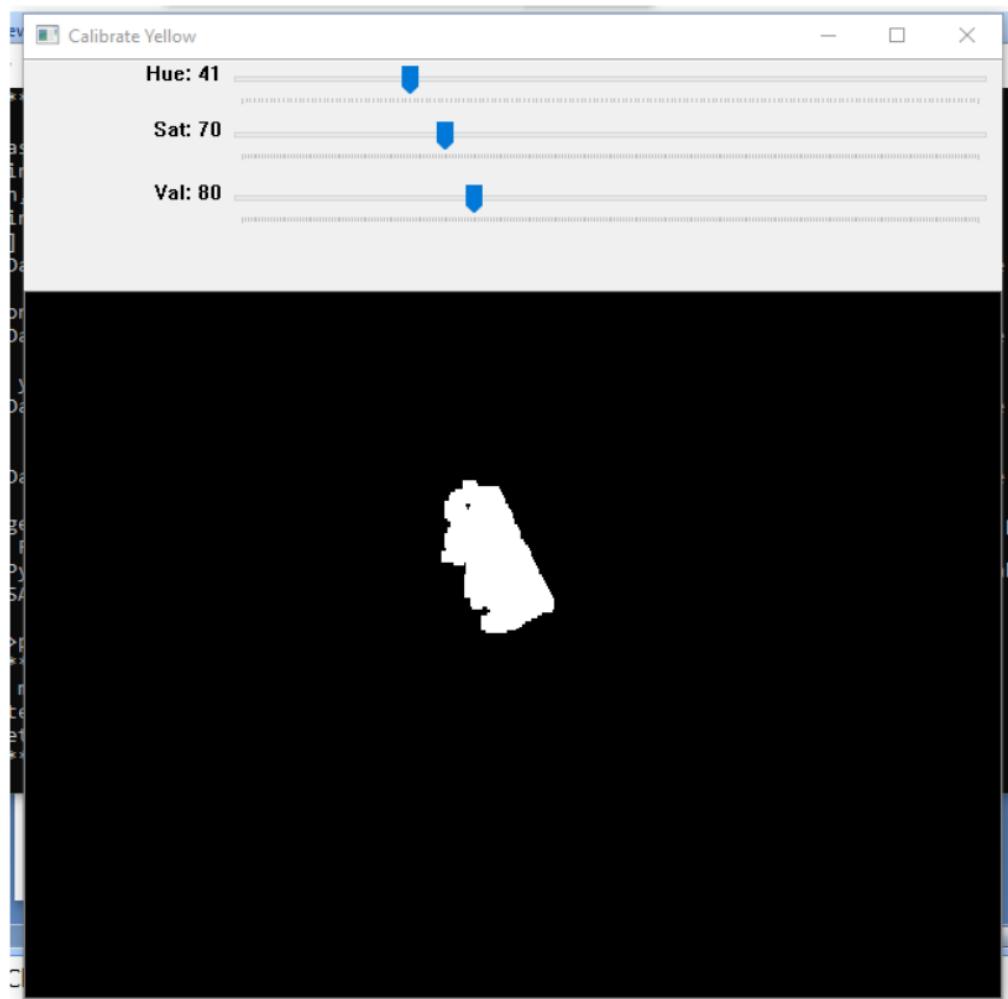


Fig 5.2.1 Calibrating Yellow color

In this we adjust the hue, saturation and value of the Yellow color so that the user need not use the same color coded bands or tapes. By this we can also reduce the noise and other background which may effect the system.

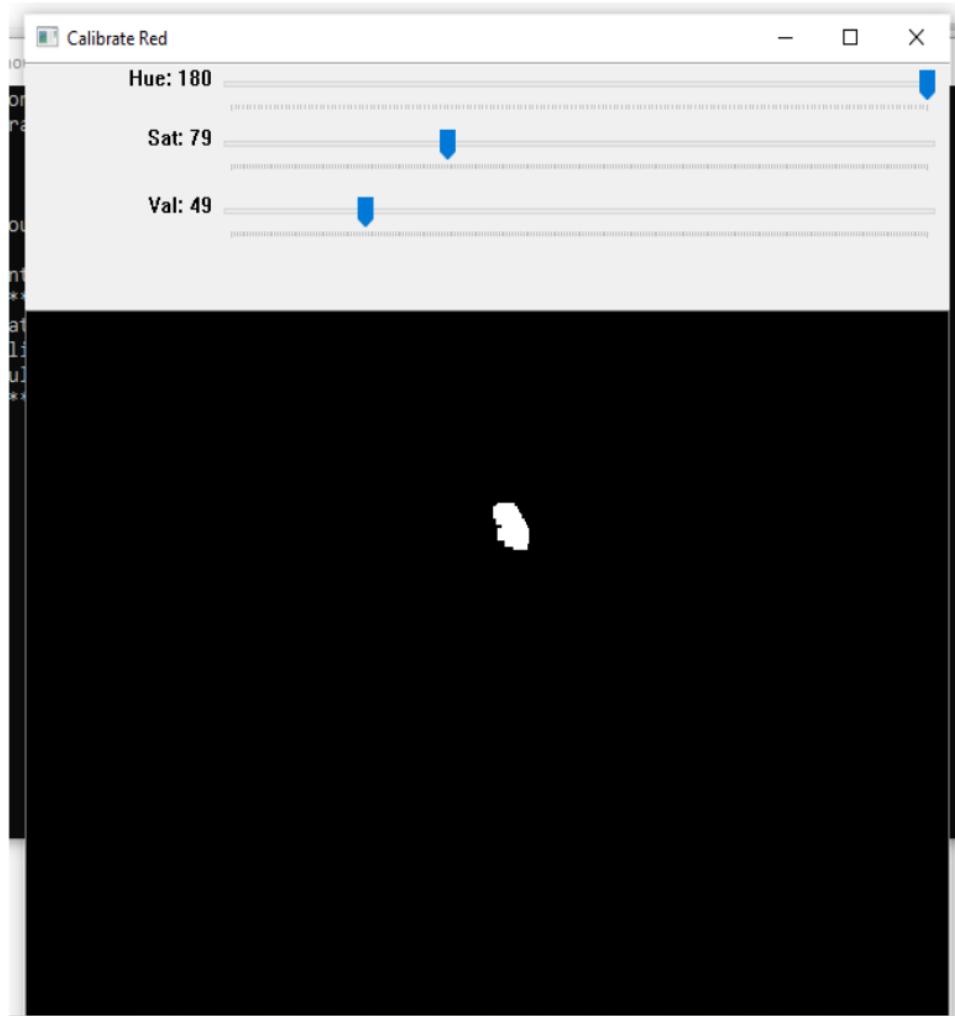


Fig 5.2.2 Calibrating Red Color

In this we adjust the hue, saturation and value of the Red color so that the user need not use the same color coded bands or tapes. By this we can also reduce the noise and other background which may effect the system.

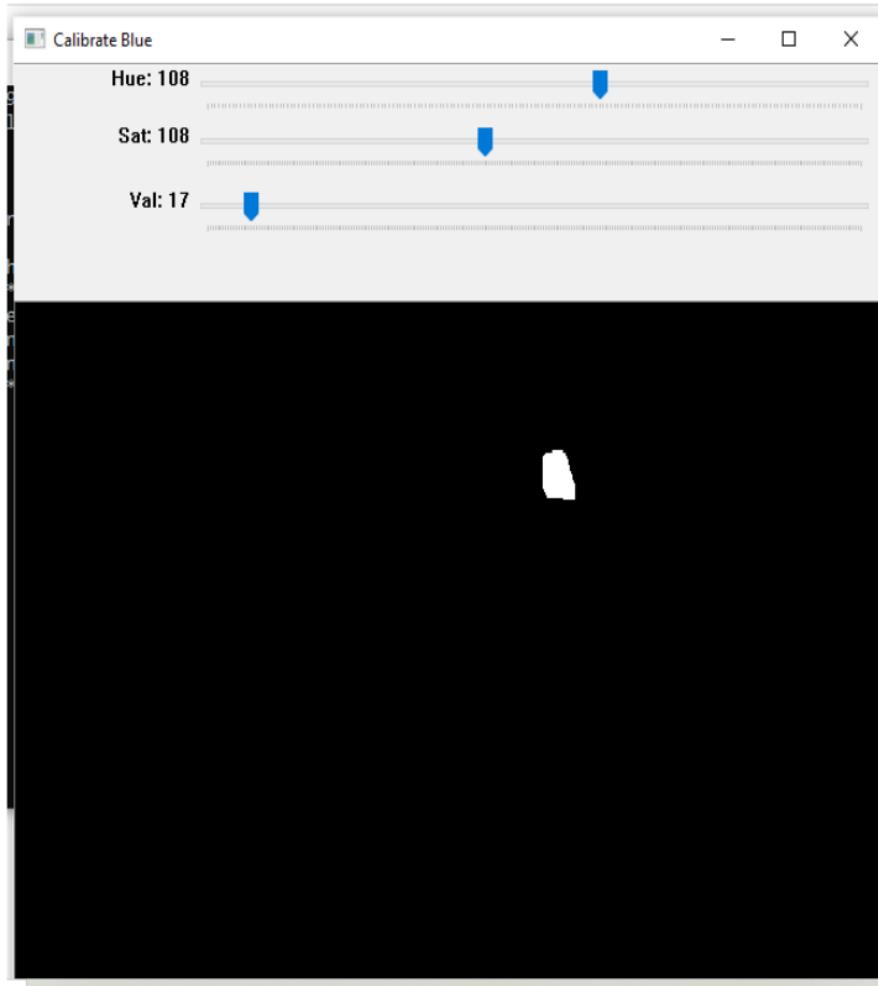


Fig 5.2.3 Calibrating Blue color

In this we adjust the hue, saturation and value of the Blue color so that the user need not use the same color coded bands or tapes. By this we can also reduce the noise and other background which may effect the system.

Output Screen

```
D:\mini project\Mouse_control>python mouse.py
*****
You have entered calibration mode.
Use the trackbars to calibrate and press SPACE when done.
Press D to use the default settings.
*****
Calibration Successfull...
*****
Press P to turn ON and OFF mouse simulation.
Press C to display the centroid of various colours.
Press R to recalibrate color ranges.
Press ESC to exit.
*****
```

Fig 5.2.4 Calibration Successful

In this output screen shot we can see the calibration is successful and there are various options available like P, C and R which performs various operations. We can also skip and press ESC to escape from screen exit.

5.2.2 Capturing the Image.

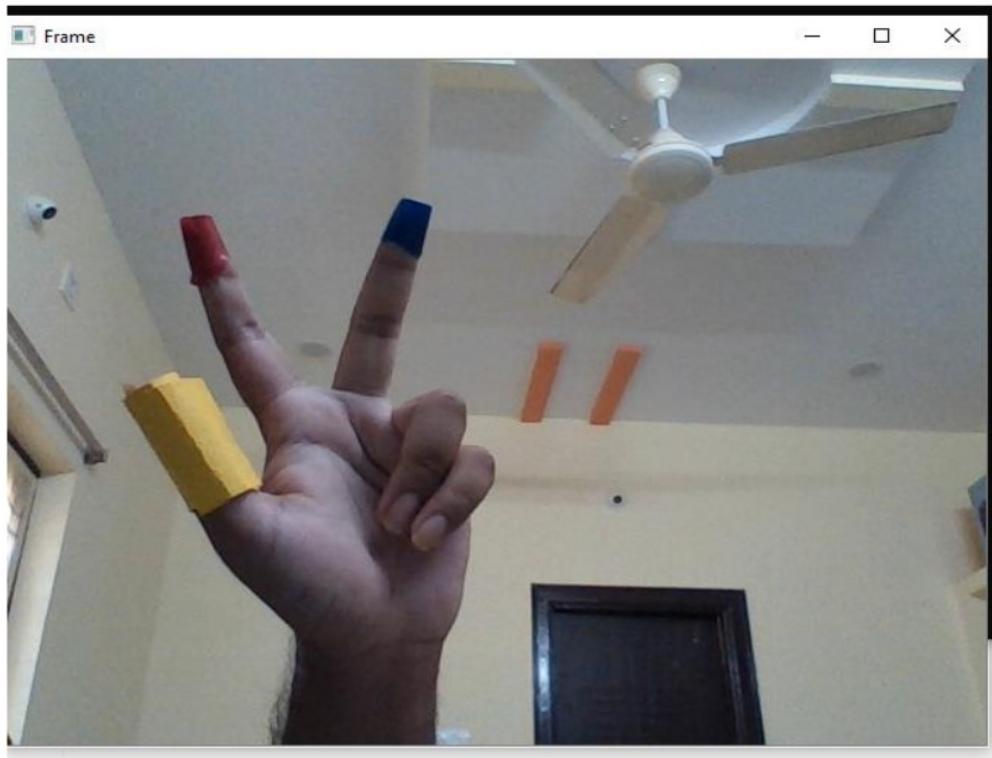


Fig 5.2.5 Capturing Frame

First the image from the webcam is captured which consists of user hand with the color band and tapes with the background. The three tapes yellow, red and blue is used by the user present in the frame.

5.2.3 Centroid Recognition

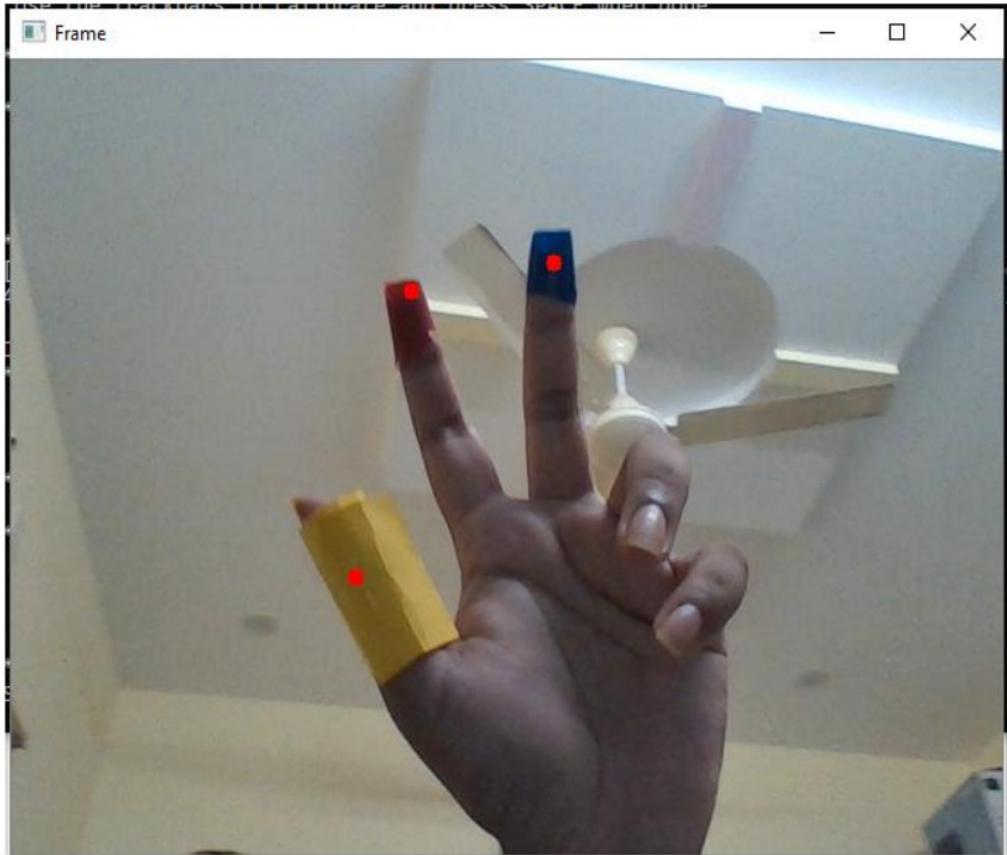


Fig 5.2.6 Centriod Detection

The centroids of the three color tapes are detected which uniquely defines the whole color bands or tapes by which the distance between the three colors are known and gestures are recognized.

5.2.4 Gestures for Actions

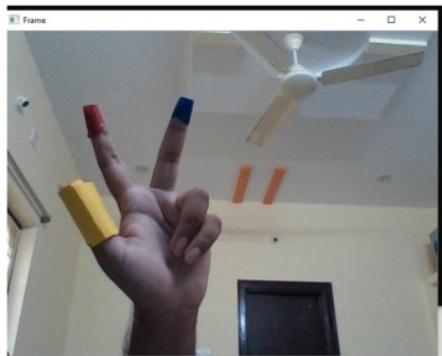


Fig 5.2.7 Free Movement

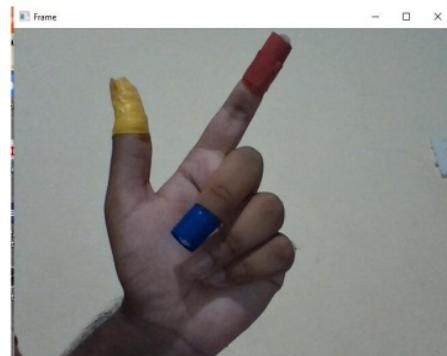


Fig 5.2.8 Scroll Up

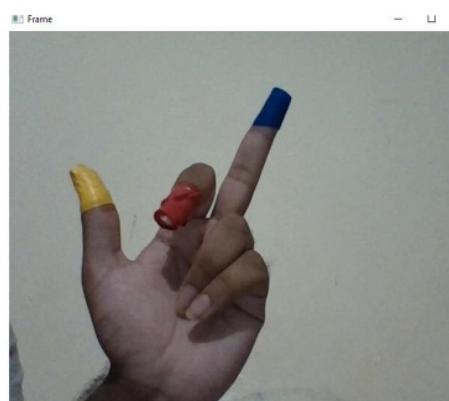


Fig 5.2.9 Scroll Down

Various gesture positions of the hand with three colors of the user by which he can use the variations to uniquely identify the hand gestures to perform actions accordingly.

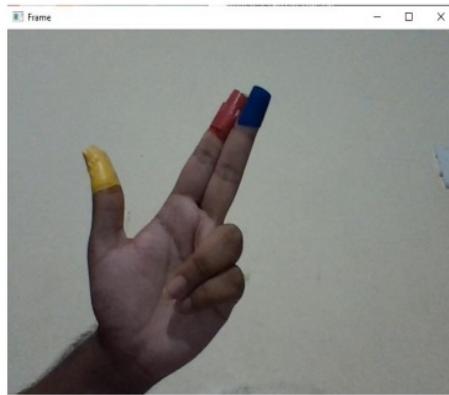


Fig 5.2.10 Left Click

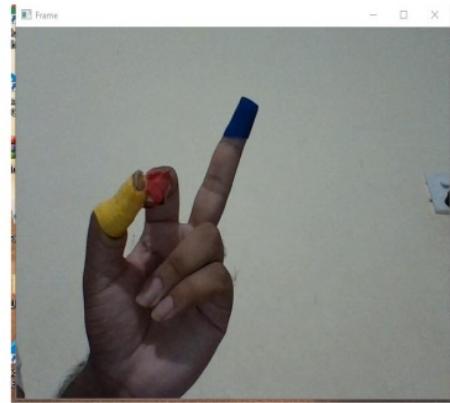


Fig 5.2.11 Right Click

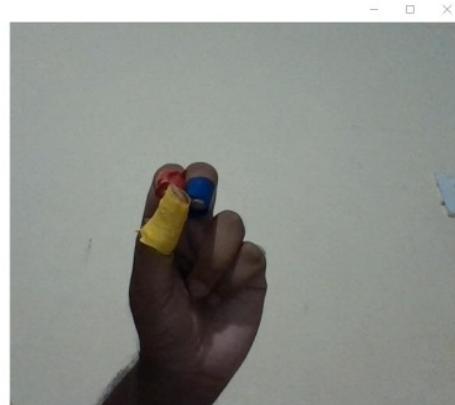


Fig 5.2.12 Select/Drag

Various gesture positions of the hand with three colors of the user by which he can use the variations to uniquely identify the hand gestures to perform actions accordingly.

5.2.5 Mouse Events

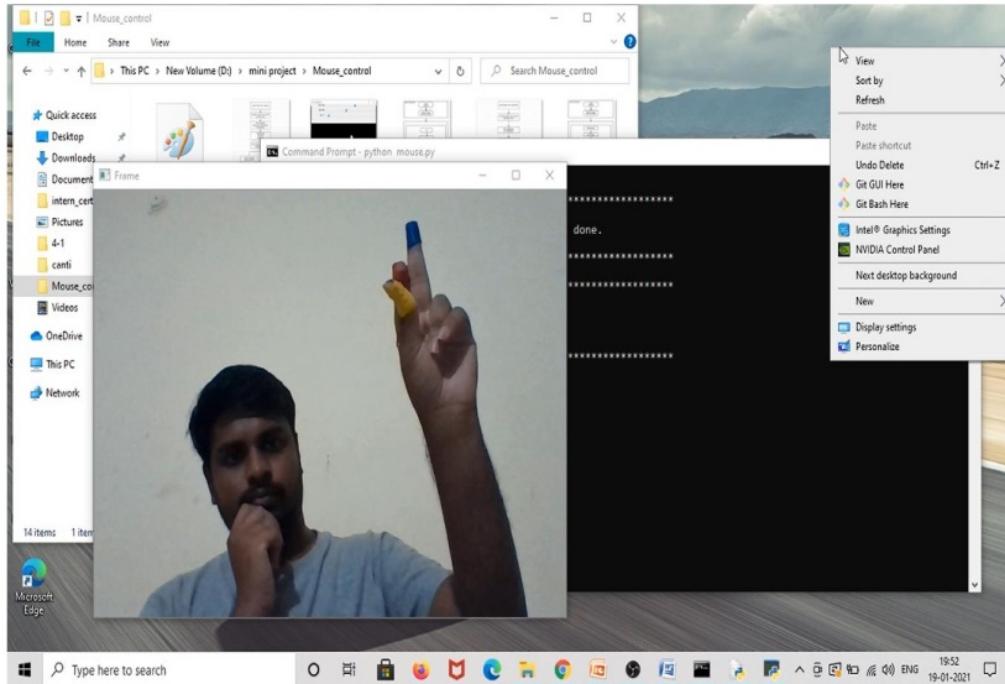


Fig 5.2.13 Right Click Event

The user image showing various hand positions and gestures and related mouse events and movements that are performed by the mouse. These are set accordingly in the code written and can be changed if required.

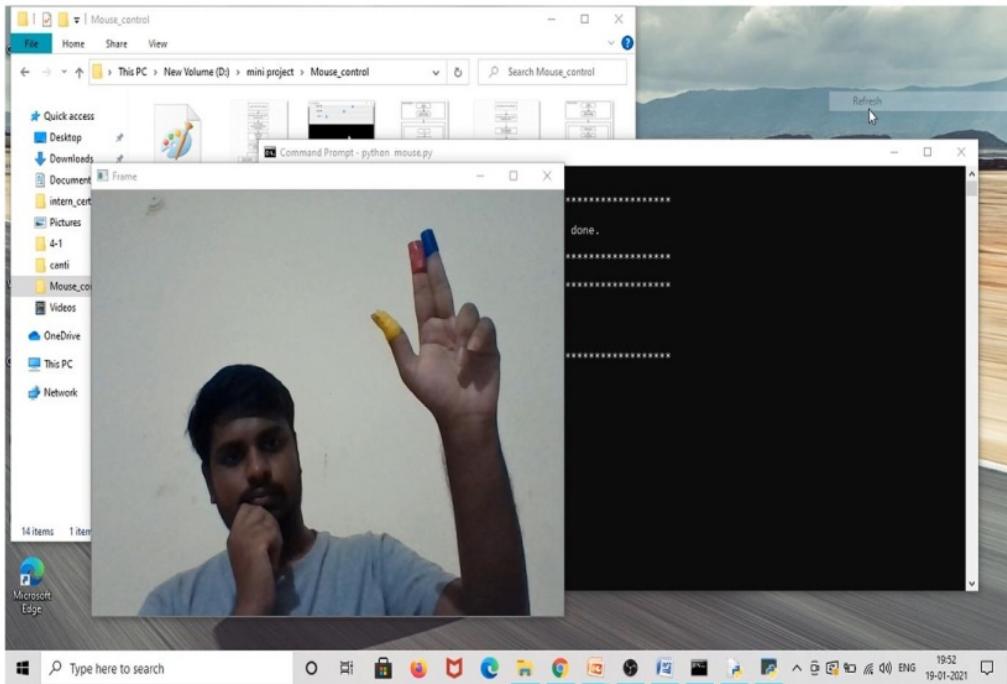


Fig 5.2.12 Left Click Event

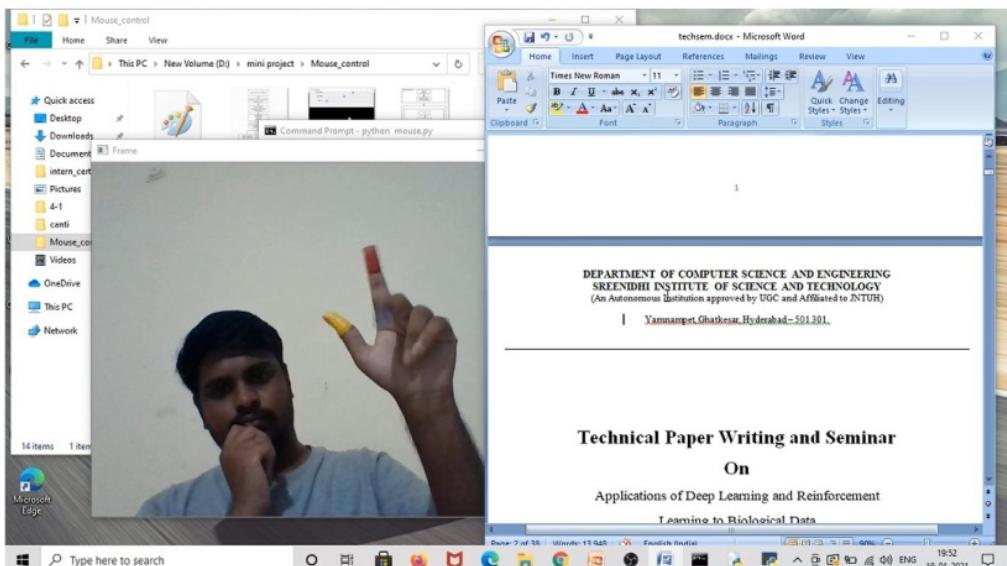


Fig 5.2.15 Before Scroll Up Event

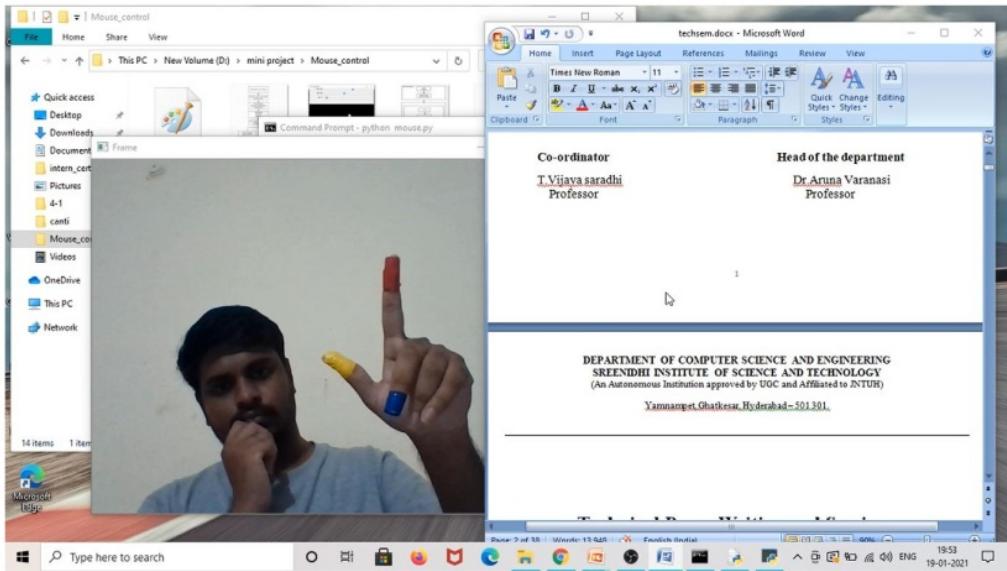


Fig 5.2.16 After Scroll Up Event

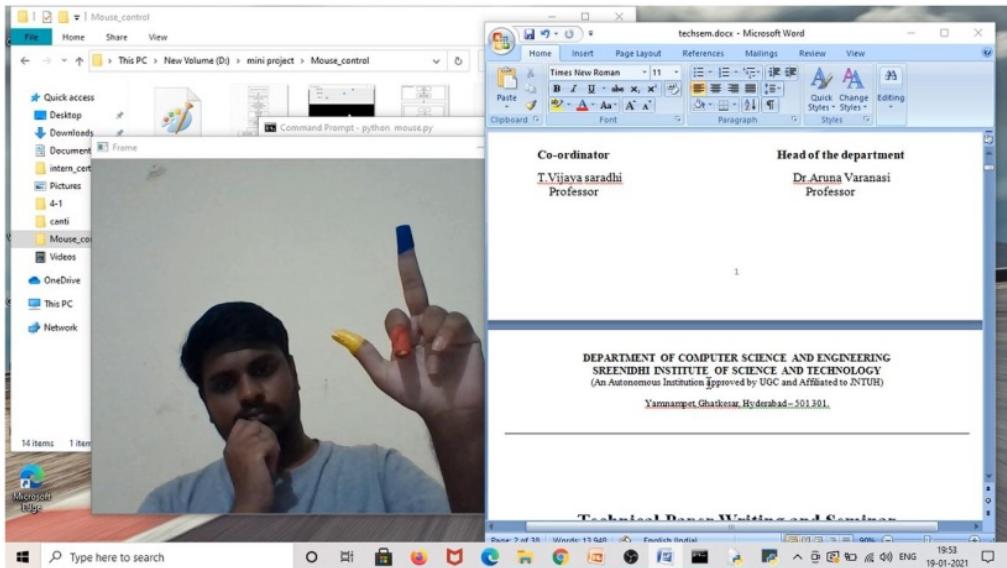


Fig 5.2.17 Before Scroll Down Event

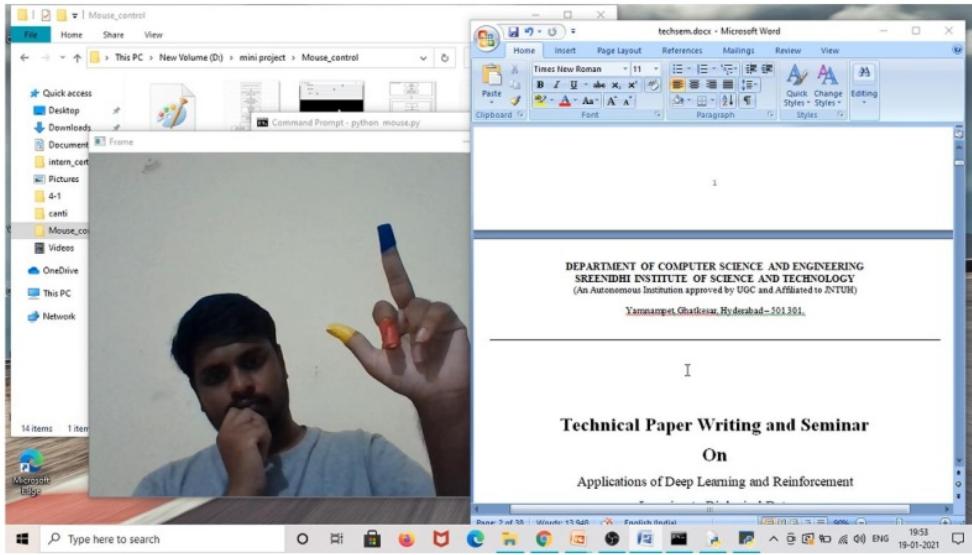


Fig 5.2.18 After Scroll Down Event

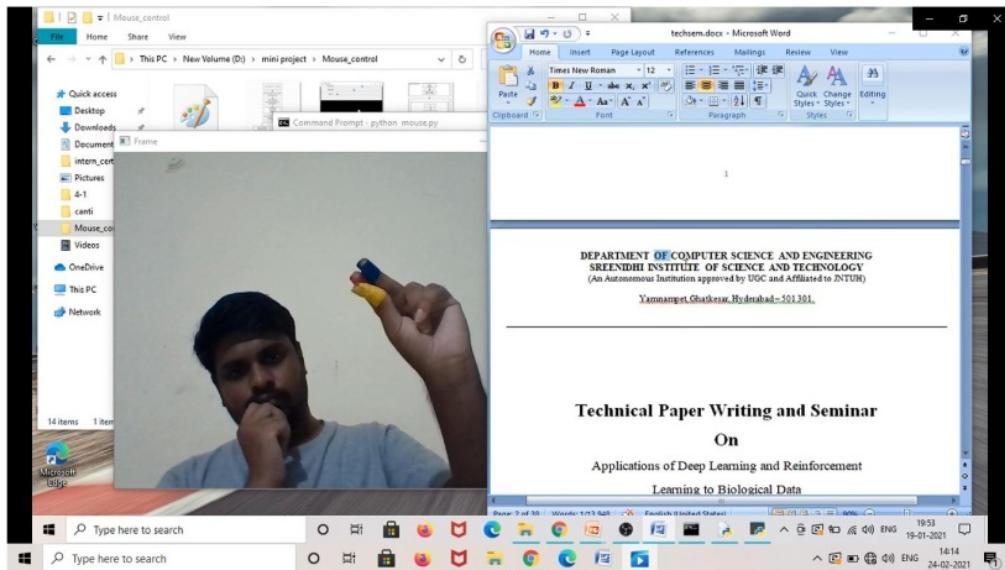


Fig 5.2.19 Drag/Select Event

6. TESTING

6.1 Types of Testing

We have implemented Integration testing and Regression testing methodologies for testing the working of this project. In the Integration testing we tested the code for each module and then integrated them based on the hierarchy to top and tested the final code to verify it passes all of the test cases. As we were doing Integration testing, we identified few bugs in final code and then we modified the code and retested it again and again until it satisfied all test cases.

6.2 List of Test Cases

S.NO	Description	Cursor Status	Test Case Result
1	Test Case with only blue and red colors	No movement of cursor or Action	PASS
2	Test Case with only yellow and red colors	Only Cursor Movement No Actions performed	PASS
3	Test Case with only yellow and blue colors	Only Cursor Movement No Actions performed	PASS
4	Test Case with only red color	No movement of cursor or Action	PASS
5	Test Case with only blue red color	No movement of cursor or Action	PASS
6	Test Case with only yellow color	Only Cursor Movement No Actions performed	PASS
7	Test Case with all the three colors	Free cursor Movements and Actions are performed	PASS

Table 6.2 List of Test Cases

7. CONCLUSION AND FUTURE SCOPE

7.1 Conclusion

Hand gesture tracking mouse control is developed using python language and OpenCv library. Using this model the system can perform all the mouse events and mouse movements without the need of the actual mouse. The system can control the Cursor by recognizing the hand of the user. And for every cursor function or mouse event a unique hand gesture is provided.

This developed model has the potential to replace the actual mouse but because of few constraints or drawbacks it cannot completely replace the mouse. If those drawbacks are tackled then it can completely replace the mouse. There are different tools for gesture recognition. We have used multiple functions from computer vision library and developed a model by tackling few limitations that are present in previous object tracking models.

7.2 Future Work

The problem with this model is that it works well only in a room with good lighting. If the lighting in the room is not good then its performance also decreases. Only because of this reason it cannot completely replace an actual mouse, as people generally use laptops in the outdoor environment as well where the lighting is not good. Therefore further improvements can be made to use it in the bad lighting environments as well. And improvements can also be made such that the three color bands are not required.

It can be further developed with AR technology for more human-machine interaction like in video games etc. More Gestures can be developed where each unique gesture can open certain applications.

8. BIBLIOGRAPHY

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APPENDIX-A: Python Modules

About PyAutoGui:

PyAutoGUI is an external gui library which supports python scripts. This library has functions which are used to control keyboard events and mouse events. Generally this library is used in the python scripts to automate the keyboard and mouse actions/events. The pyAutoGui API is developed in such a way that it is easy to use by anyone. This pyAutoGui library is supported by or it can be used on macOS, Windows and Linux systems, and compiles/runs on Python 2 and 3 versions.

PyAutoGUI features:

Controlling the mouse events and actions. Automated clicking and typing in various basic applications.

Automated keystroke sending to some applications like in filling a form.

Capture screen in the form of screenshots i.e. the function of print screen button on keyboard, Open an application in a window, move it, select it, resize it, maximize or minimize it.

Show Dialogue boxes on the screen during the automation process i.e. when the model or program is running for better user interaction.

About Opencv (cv2):

OpenCV or cv2 is a library which can be used along with python language or scripts. This library is developed to solve computer vision problems.

- Python is considered as a programming language initiated and developed by **Guido van Rossum**. And it became very popular in a very short period of time. The main reason for its popularity is its simplicity readability and reusability.
- Python is generally slower than other famous languages like c and c++ but python can be easily converted into c++ using python wrappers. Because of this features it can provide you with the best of both the worlds i.e. faster compilation and easy code writing and readability.
- Opencv has all the essential functions required for image processing. It uses another library called **Numpy**, which is a famous library for all the numerical calculations. The arrays that are produced from opencv functions are converted into numpy arrays for easy numerical calculations.

APPENDIX-B: UNIFIED MODELING LANGUAGE

The Unified Modeling Language (UML) is a modeling language developed to universally understand the implementations of the software. It is used to visualize, construct, specify, develop and document the artifacts of a software model or a software system. UML is not just for the developers of the model or software but the general users can also use them to understand the working of the system

It is generally used in developing process of software lifecycles, algorithm implementations, development methods etc. And by developing project reports or software documents using UML, it will be easy in implementing future projects or software as the knowledge about previous projects and the mistakes in previous projects can be easily analyzed from the previous reports as they are developed using UML. In this way refining of the software development process can be done to achieve good results.

The conceptual model of Unified modeling language has generally three elements. They are:

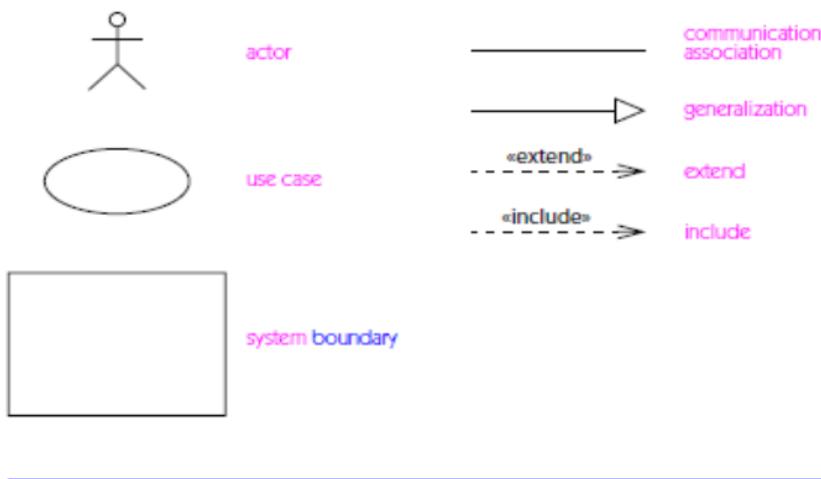
- Building blocks
- Rules for those building blocks
- Common mechanisms

The building blocks of uml are:

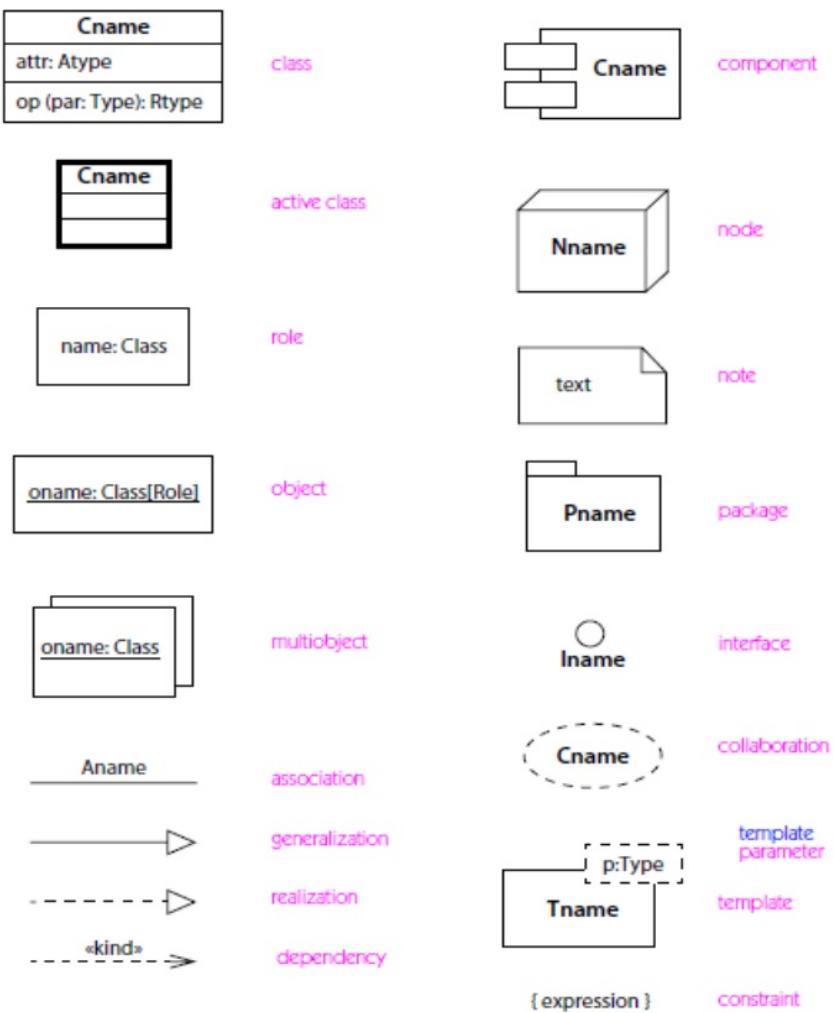
- diagrams
- Thing
- Relationships

UML is not considered as a programming language. But there are some tools which are used to perform reverse and forward engineering. Hence a UML model can be converted into a programming language like java and Code in a programming language can be converted into UML models. The UML is not considered as formal language which is basically intended in proving a theorem. There are few languages available in market for the above stated purpose but it is very difficult to understand those languages.

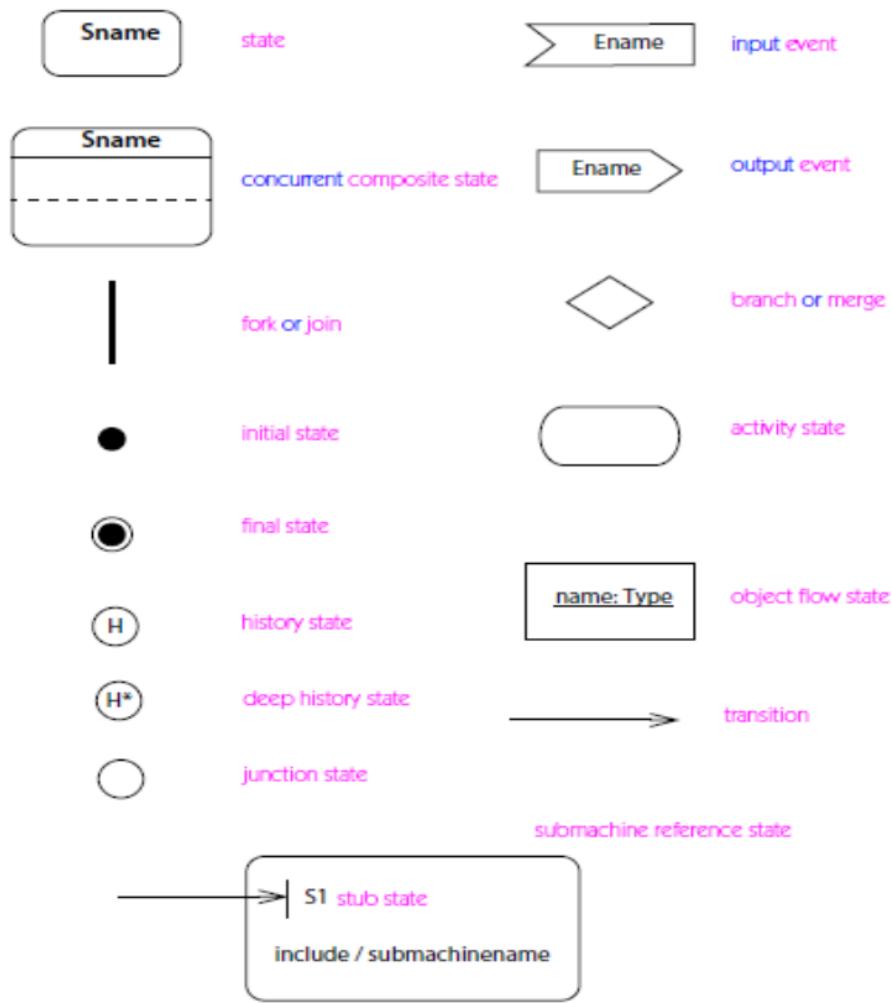
Icons on use case diagrams



Icons on class, component, deployment, and collaboration diagrams



Icons on statechart and activity diagrams





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