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Development of Real-Time HCI for Hands-Free PC Operations using Facial Gestures

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Abstract: ***For human-computer interface, hand-free control has been very important nowadays. For hand-free solution, tracking movements of human is used in video input and utilize the tracking is an important kind of solution. Human-Computer Interaction (HCI) examines the plan and utilization of PC innovation, concentrated on the interfaces between individuals (clients) and PCs. Human-Computer Interaction studies the ways in which human make, or do not make, use of computational artifacts, systems and infrastructures. The principle object is to work sans hands, PC mouse activities will be controlled by outward appearances like flickering of eye, moving of tongue to left or right, grinning et cetera utilizing a minimal effort USB web camera. The PC mouse operations include the movement of the cursor in addition to clicking operation. A facial gesture based Human-Computer Interaction (HCI) system is developed here. The combination of head movement and facial expression are used to control the mouse and calling pre-defined programs such as MS-Word, MS-PowerPoint, Window Media Player and Paint. The main goal of the system is to make a simple and flexible application which can be operated through the human expressions. This system can prove very beneficial for the people who cannot use computer because of their disabilities.***

Keywords: Face Detection, Image Processing, Human Computer Interaction (HCI), Template Matching, Haar Classifier, Hand-free Mouse.

I. INTRODUCTION

In recent years applications like Human-Computer interaction (HCI) have been active research areas. Human-Computer Interaction (HCI) researches the design and use of computer technology, focused on the interfaces between people (users) and computers. Human-Computer Interaction studies the ways in which human make, or do not make, use of computational artifacts, systems and infrastructures. The main purpose is to operate hands-free, computer mouse actions will be controlled by facial expressions like blinking of eye moving of tongue to left or right, smiling and so on using a low cost USB web camera. The computer mouse operations involve the motion of the cursor plus clicking operation.

To use human body movement tracking for hand-free solution in video input and utilize the tracking is an important kind of solution. A hand-free head mouse control based on mouth tracking system is proposed where firstly transformation of nonlinearly input video frame of human head into RGB color space is done, then the visible chrominance feature of face in this color space to detect human face region is used [1]. And then for face candidate, use of the nearly reversed relationship information cluster of face feature is used to detect mouth position.

Perceptual User Interfaces (PUI) is a highly interactive, multimodal interfaces modeled after natural human-to-human interaction, with the goal of enabling people to interact with technology in a similar fashion to how they interact with each other and with the physical world. Vision Based Interfaces (VBI) is a subfield of perceptual interfaces which concentrates on developing visual awareness of people where computer vision algorithms are implemented to locate and identify individuals, track human body motions, model the head and face, track facial features, interpret human motion and actions [2].

A robust, accurate, and low cost real-time solution for the eye and face detection problem is introduced where the method uses two infrared illumination sources to generate bright and dark pupil images, which are combined to robustly detect pupils [3]. Once the pupils are detected, the inter-ocular distance is used to determine the size and position of the bounding box around the face.

The human factors and technical considered that arise in trying to use eye movements as an input medium. The goal was to measure visual line of gaze, that is, the absolute position in space at which the user's eyes are pointed, rather than, for example, the position of the eyeball in space or the relative motion of the eye within the head [4].

A multi-camera vision-based eye tracking method is introduced to robustly locate and track user's eyes as they interact with an application. The enhancements were proposed to various vision-based eye-tracking approaches, which include (a) the use of

multiple cameras to estimate head pose and increase coverage of the sensors and (b) the use of probabilistic measures incorporating Fisher's linear discriminant to robustly track the eyes under varying lighting conditions in real-time [5].

The concept of face tracking is deeply focused in [6] [7] where, the theoretical and by experiments conducted with ordinary USB cameras the system shows that, by properly defining nose - as an extremum of the 3D curvature of the nose surface, nose becomes the most robust feature which can be seen for almost any position of the head and which can be tracked very precisely even with low resolution cameras, whereas, the vision-based technology which allows one in such a setup to significantly enhance the perceptual power of the computer. The described techniques for tracking a face using a convex-shape nose feature as well as for face-tracking with two off-the-shelf cameras allow one to track faces robustly and precisely in both 2D and 3D with low resolution cameras [7].

Motivated by the goal of providing a non-contact means of controlling the mouse pointer on a computer system for people with motor difficulties using low-cost, widely available hardware, the required information is derived from video data captured using a web camera mounted below the computer's monitor. A color filter is used to identify skin colored regions.

False positives are eliminated by optionally removing background regions and by applying statistical rules that reliably identify the largest skin-colored region, which is assumed to be the user's face [8].

Hands-free Interface is an assistive technology that is intended mainly for the use of the disabled. It would help them use their voluntary movements, like head movements; to control computers and communicate through customized educational software or expression building programs. People with severe disabilities can also benefit from computer access to partake in recreational activities, use the Internet or play games. The system uses a USB camera to capture the user's face motion. The algorithm tracks the motion accurately to control the cursor, thus providing an alternative to the computer mouse or keyboard [9].

Detecting faces in images with complex backgrounds is a difficult task. The approach, which obtains state of the art results, is based on a new neural network model: the Constrained Generative Model (CGM). Generative, since the goal of the learning process is to evaluate the probability that the model has generated the input data, and constrained since some counterexamples are used to increase the quality of the estimation performed by the model. To detect side view faces and to decrease the number of false alarms, a conditional mixture of networks is used. To decrease the computational time cost, a fast search algorithm was proposed. The level of performance reached, in terms of detection accuracy and processing time, allows applying this detector to a real world application: the indexation of images and videos [10].

Human Computer Interaction focuses on the interactions between human and computer systems, including the user interface and the underlying processes which produce the interactions. The contributing disciplines include computer science, cognitive science, human factors, software engineering, management science, psychology, sociology, and anthropology. Early research and development in human-computer interaction focused on issues directly related to the user interface. Some typical issues were the properties of various input and output devices, interface learn ability for new users versus efficiency and extensibility for experienced users, and the appropriate combination of interaction components such as command languages, menus, and graphical user interfaces (GUI). Recently, the field of human-computer interaction has changed and become more devoted to the processes and context for the user interface. Functionality of a system is defined by the set of actions or services that it provides to its users. However, the value of functionality is visible only when it becomes possible to be efficiently utilized by the user. Usability of a system with a certain functionality is the range and degree by which the system can be used efficiently and adequately to accomplish certain goals for certain users. The actual effectiveness of a system is achieved when there is a proper balance between the functionality and usability of a system.

II. PROBLEM STATEMENT

Computer vision is used to interact with computers in new innovative ways. The task was to use head motion and face detection to control mouse operation and trigger pre-defined PC operations. The input components of a normal computer system include keyboard, mouse and so on. The wires used to connect these devices to the main system increases the overall count of wires. Use of keyboard and mouse consumes a lot of space on the desk. Hence there was a necessity of eliminating this problem. The availability of low-cost webcams has opened up pathways for hands-free controlling of PC operations. This can prove a convenient and very beneficial ways of controlling PC mouse for people who have disabilities. There are many challenges associated with the accuracy and usefulness of gesture recognition software. For image-based gesture recognition there are limitations on the equipment used and image noise. Images or video may not be under consistent lighting, or in the same location. Items in the background or distinct features of the users may make recognition more difficult.

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The variety of implementations for image-based gesture recognition may cause an issue for viability of the technology to general usage. For example, an algorithm calibrated for one camera may not work for a different camera. The amount of background noise also causes tracking and recognition difficulties, especially when occlusions (partial and full) occur. Furthermore, the distance from the camera, and the camera's resolution and quality, also cause variations in recognition accuracy.

In order to capture human gestures by visual sensors, robust computer vision methods are also required, for example for hand tracking and hand posture recognition or for capturing movements of the head, facial expressions or gaze direction.

III. FLOW OF THE SYSTEM

A flowchart is a type of diagram that represents an algorithm, workflow or process, showing the steps as boxes of various kinds, and their order by connecting them with arrows. This diagrammatic representation illustrates a solution model to a given problem. Flowcharts are used in analysing, designing, documenting or managing a process or program in various fields. The system works on the flow given below, which can be seen in Figure 1.

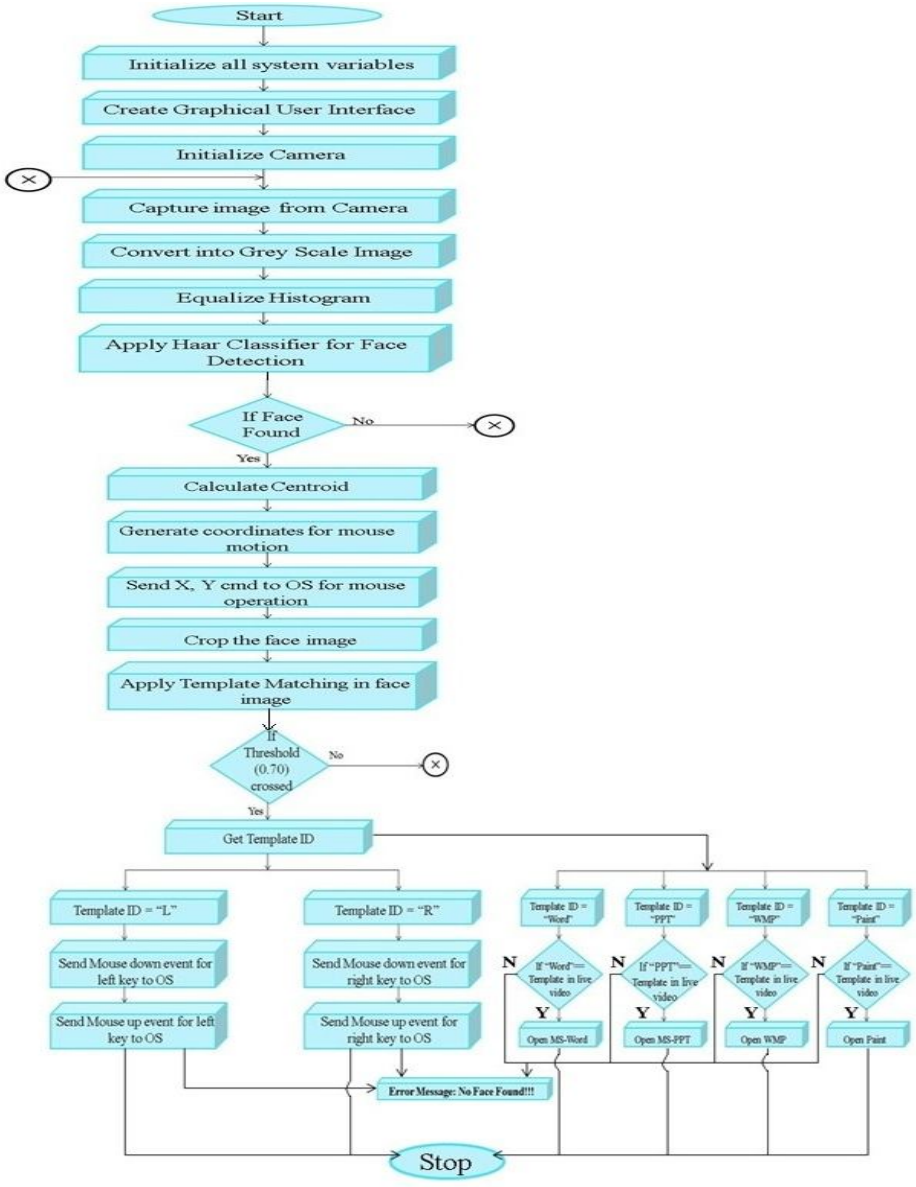

Fig. 1: Flowchart of the system.

A. Camera Interfacing

The webcam is needed to be connected to the computer in order to obtain the live feed for the extraction of the images of the user. This image will be used in the entire process.

B. Image Capturing

The webcam will obtain a live video through which images of the user will be captured. These images will be processed further to form frames.

C. Grey-Scale Conversion

A grayscale or greyscale digital image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information. Images of this sort, also known as black-and-white, are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest. Grayscale images are distinct from one-bit bi-tonal black-and-white images, which in the context of computer imaging are images with only two colors, black and white (also called bi-level or binary images). Grayscale images have many shades of gray in between.

D. Histogram Equalization

Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. It can also be used on color images by applying the same method separately to the Red, Green and Blue components of the RGB color values of the image. However, applying the same method on the Red, Green, and Blue components of an RGB image may yield dramatic changes in the image's color balance since the relative distributions of the color channels change as a result of applying the algorithm. However, if the image is first converted to another color space, Lab color space, or HSL/HSV color space in particular, then the algorithm can be applied to the luminance or value channel without resulting in changes to the hue and saturation of the image. There are several histogram equalization methods in 3D space. Trahanias and Venetsanopoulos applied histogram equalization in 3D color space. However, it results in "whitening" where the probability of bright pixels is higher than that of dark ones.

E. Face Detection

Face detection is a computer technology being used in a variety of applications that identifies human faces in digital images. Face detection also refers to the psychological process by which humans locate and attend to faces in a visual scene. Face detection process is shown in figure 4.6. Face Detection can be applied in the following fields:

1) Face Recognition: Face detection is used in biometrics, often as a part of (or together with) a facial recognition system. It is also used in video surveillance, human computer interface and image database management.

2) Photography: Some recent digital cameras use face detection for autofocus. Face detection is also useful for selecting regions of interest in photo slideshows that use a pan-and-scale Ken Burns effect. Modern appliances also use smile detection to take a photograph at an appropriate time.

3) Marketing: Face detection is gaining the interest of marketers. A webcam can be integrated into a television and detect any face that walks by. The system then calculates the race, gender, and age range of the face. Once the information is collected, a series of advertisements can be played that is specific toward the detected race/gender/age.

F. Template Matching

Template matching is a technique in digital image processing for finding small parts of an image which match a template image. It can be used in manufacturing as a part of quality control, a way to navigate a mobile robot, or as a way to detect edges in images.

Haar-like Feature: Haar-like wavelets are binary rectangular representations of 2D waves. A common visual representation is by black (for value, minus one) and white (for value. plus one) rectangles. The figure below shows a cut through a binary wavelet between x = 0 to x = 1. The square above the 0-1-interval shows the corresponding Haar-like wavelet in common black-white representation. The rectangular masks used for visual object detection are rectangles tessellated by black and white smaller rectangles. Those masks are designed in correlation to visual recognition tasks to be solved, and known as Haar-like wavelets. By convolution with a given image they produce Haar-like features.

For face detection, Viola & Jones's face detector is used based on the Haar-like features. Paul Viola and Michael Jones, describes a visual object detection framework that is capable of processing images extremely rapidly while achieving high detection rates. There are three key contributions. The first contribution is a new a technique for computing a rich set of image features using the integral image. The second is a learning algorithm, based on AdaBoost, which selects a small number of critical visual features and

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yields extremely efficient classifiers. The third contribution is a method for combining classifiers in a "cascade" which allows background regions of the image to be quickly discarded while spending more computation on promising object-like regions.

The parameters for face recognition system in OpenCV Haar classifier and face recognizer functions are as follows: Scale increase rate: This parameter in the call to DetectHaarCascade() specifies how quickly OpenCV should increase the scale for face detections with each pass it makes over an image.

1) Setting this higher makes the detector run faster (by running fewer passes), but if it's too high, you may jump too quickly between scales and miss faces. The default in OpenCV is 1.1, in other words, scale increases by a factor of 1.1 (10%) each pass. This parameter may have a value of 1.1, 1.2, 1.3 or 1.4. The default value is set it to 1.2, which means it will run the moderate number of passes, thus will accurate as well as fast. The lower the value, the more "thoroughly" Haar detector will check the image for the "face", but naturally will take more time.

2) Minimum Neighbors Threshold: The next parameter in the call to DetectHaarCascade() is the "The minimum-neighbors threshold" which sets the cutoff level for discarding or keeping rectangle groups as "face" or not, based on how many raw detections are in the group. This parameter's value ranges from 0 to 10. A minimum neighbors = 10 is used i.e. only an object to be marked as a face is needed if it has the highest probability and vote of being the "face". If set minimum neighbor to a value n, then detector will mark an object as "face" in any image IF there is a group of n rectangles (hits) identifying it as a "face".

3) Minimum Detection Scale: The third parameter in the call to DetectHaarCascade() is the size of the smallest face to search for. The default can be changed for this by changing its value from the Haar cascade classifier xml file. Set it to 25X25, which gives us the best results. A good rule of thumb is to use some fraction of your input image's width or height as the minimum scale - for example, 1/4 of the image width. If you specify a minimum scale other than the default, be sure its aspect ratio (the ratio of width to height) is the same as the defaults. i.e., aspect ratio should be 1:1.

4) Threshold: Threshold is the maximum value of the Euclidean distance between the database image and input image. A database of 25 persons was created wherein 50 images of each person were stored. For simulation the face recognition system tested for 3 known persons and 1 unknown person. The observations were carried out in artificial fluorescent lighting conditions. The scale increase rate was kept at 1.2, minimum neighbors threshold at 10 and minimum detection scale at 25X25. The subjects were asked to show their face 10 times in the camera.

IV. SYSTEM DESIGN

The block diagram of the system is shown in the Figure 2. As shown in the figure, the proposed system consists of 3 main parts:

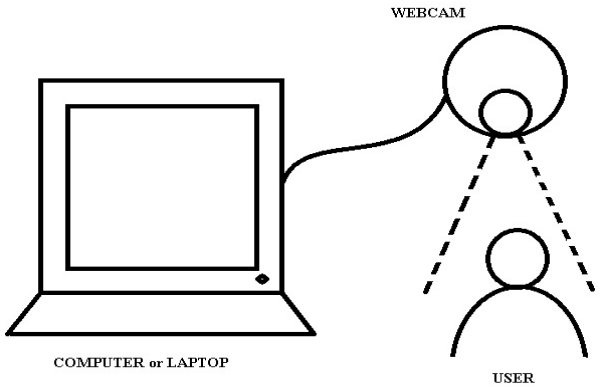

Fig. 2: Block Diagram of Developed System.

A. Computer or Laptop

The computer or laptop is required to perform the specified task. The mouse controlling and triggering of pre-defined PC operations can be operated using a PC or laptop. A computer is a device that can be instructed to carry out an arbitrary set of arithmetic or logical operations automatically. The ability of computers to follow a sequence of operations, called a program, make computers very flexible and useful. Such computers are used as control systems for a very wide variety of industrial and consumer devices. This includes simple special purpose devices like microwave ovens and remote controls, factory devices such as industrial robots and computer assisted design, but also in general purpose devices like personal computers and mobile devices such as smartphones. The Internet is run on computers and it connects millions of other computers.

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B. User

The User is required and is the most important part of the proposed system because the mouse will be operated through the actions of the user by making use of the camera. A system user is a person who interacts with a system, typically through an interface, to extract some functional benefit. User-centered design, often associated with human–computer interaction, considers a wide range of generic systems. System user also defines the behavior of the system operations and how the audience (end-user) would interact with the system using pre-designed triggers such as buttons/mouse/keyboard.

C. Webcam

The webcam is the third entity of the setup. A webcam is a video camera that feeds or streams its image in real time to or through a computer to computer network. When "captured" by the computer, the video stream may be saved, viewed or sent on to other networks via systems such as the internet, and email as an attachment. When sent to a remote location, the video stream may be saved, viewed or on sent there. Unlike an IP camera (which connects using Ethernet or Wi-Fi), a webcam is generally connected by a USB cable, or similar cable, or built into computer hardware, such as laptops. The term "webcam" (a clipped compound) may also be used in its original sense of a video camera connected to the Web continuously for an indefinite time, rather than for a particular session, generally supplying a view for anyone who visits its web page over the Internet. Some of them, for example, those used as online traffic cameras, are expensive, rugged professional video cameras.

1) Techniques:

a) Camera Interfacing: Camera Interfacing provides a standard output which can be further used for subsequent image processing. Here camera interfacing is required for mapping co-ordinate system.

b) Frame Image Capturing: Image capturing will be attained by using the camera, which further separates the frames from the captured image.

c) Grey Scale Conversion: A greyscale or grayscale digital image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information. Images of this sort, also known as black-and-white, are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest. Grayscale images in the context of computer imaging are images with only two colors, black and white (also called bi-level or binary images).

d) Face Detection: Face detection is a computer technology being used in a variety of applications that identifies human faces in digital images. Face detection also refers to the psychological process by which humans locate and attend to faces in a visual scene. Face detection can be regarded as a specific case of object-class detection. In object-class detection, the task is to find the locations and sizes of all objects in an image that belong to a given class. Examples include upper torsos, pedestrians, and cars. Face-detection algorithms focus on the detection of frontal human faces. It is analogous to image detection in which the image of a person is matched bit by bit. Image matches with the image stores in database. Any facial feature changes in the database will invalidate the matching process.

2) Steps for Execution:

a) At first, an external camera is attached to the system. Then the “Start Camera” button is clicked through which a live video is captured and is shown in the “Camera…” image box. A live video which captures face detected which can be seen in a green rectangular box with a centroid in yellow color dot in the middle of that box.

b) Now, Templates are to be selected which are in the form of image of facial gestures (eg: blinking of eye,moving tongue to left or right, so on). Two image boxes are given in which left and right template will be saved which will be used for left and right operations. These operations are clicking and dragging.

c) Movement of mouse will be controlled by head motion. In simple words, In the live video as the face or head moves, the mouse will move in that direction.

d) Then the “Start Process” button is clicked which then starts the process of finding number of faces in the live feed. This number will be shown in the “Faces Detected” text box below the “System Messages…”.Similarly number of eyes in the live feed will be shown in the “Eyes Detected” text box below the “System Messages…”.

e) Now, as the head or face moves the mouse movement is controlled. The radio button above the “Camera…” image box must be checked so that the external mouse is not a problem in the mouse movement which is done by head movement. The Speed value is set on 10 for mouse movement.

f) If click/drag operation is to be performed, the template which is saved must be followed by the user and the operation will be performed whether left or right.

g) The trigger values are given so that the system knows which operation to perform based on these trigger value. These trigger values are set up for single click, double click and drag operation.

h) Whatever operation is performed will be shown in the "System Messages…" and if no face appears in the live feed then an error message is displayed as "No Faces Found…!!!".

i) When user is done with all the work the "Stop Process" button is clicked and finally "Stop Camera" button is clicked.

V. SYSTEM DESIGN

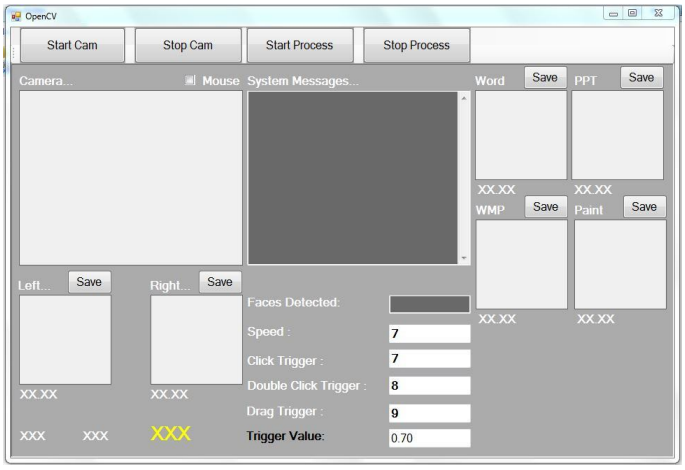

Fig -3: Form

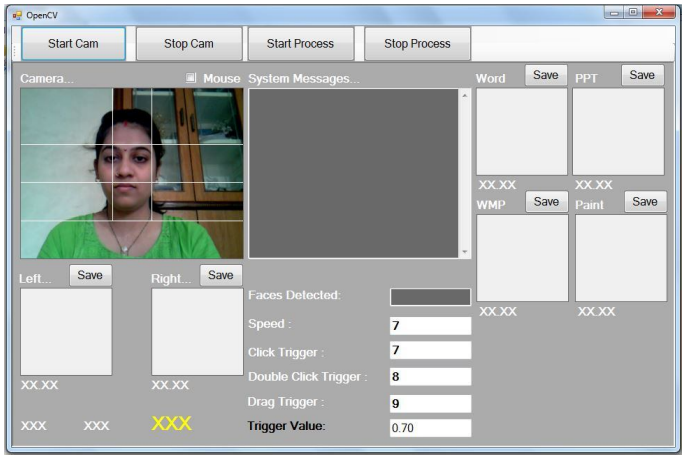

Fig -4: Start Cam

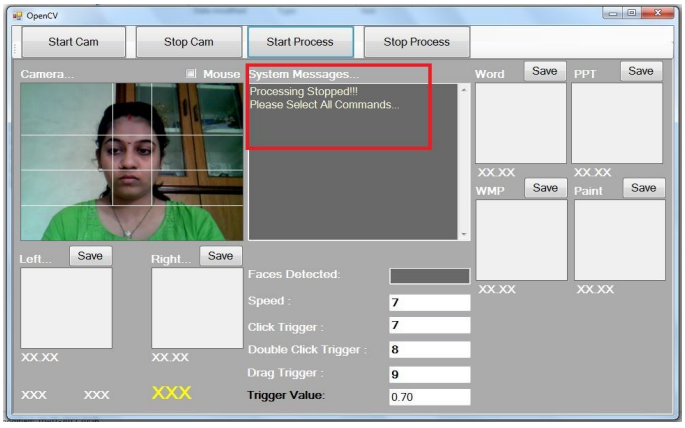

Fig -4.1: Error message shown

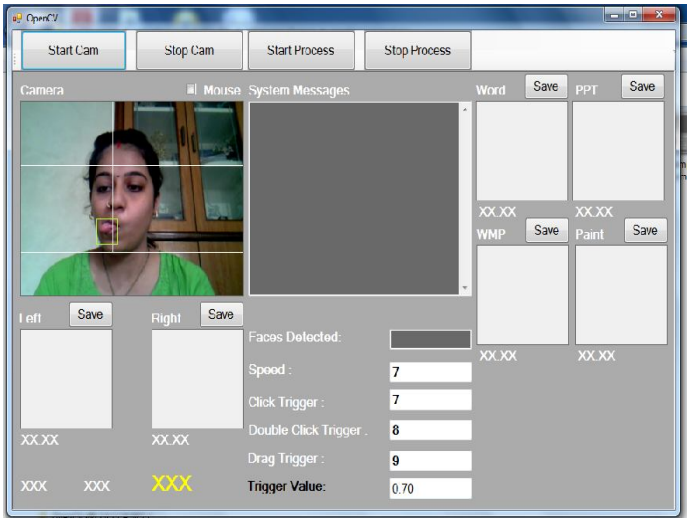

Fig -5: Template selection for left

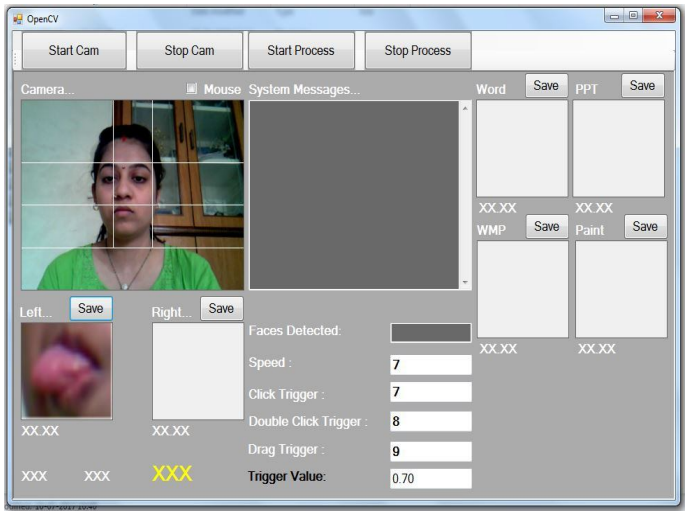

Fig -6: Left template

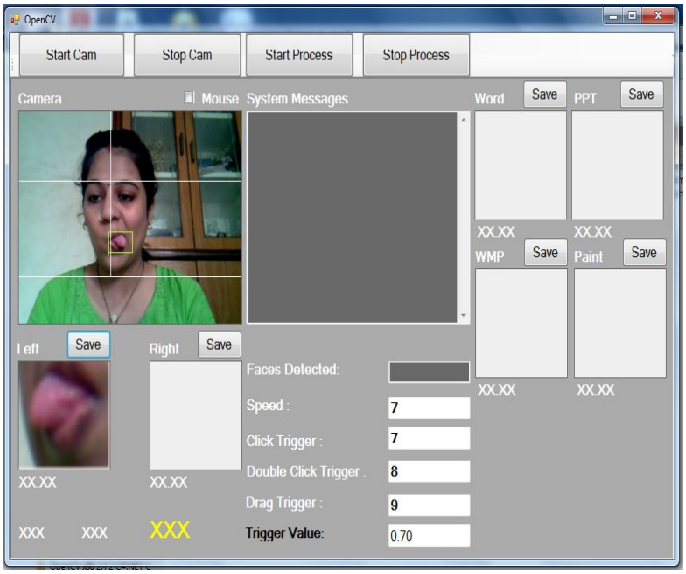

Fig -7: Template selection for right

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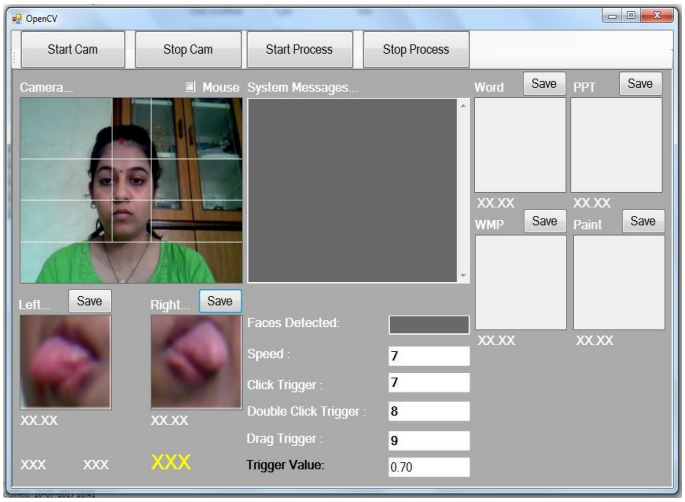

Fig -8: Right template

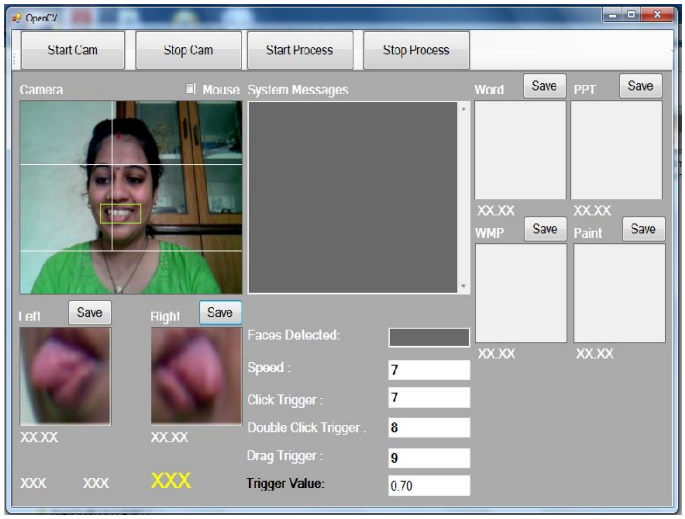

Fig -9: Template selection for word

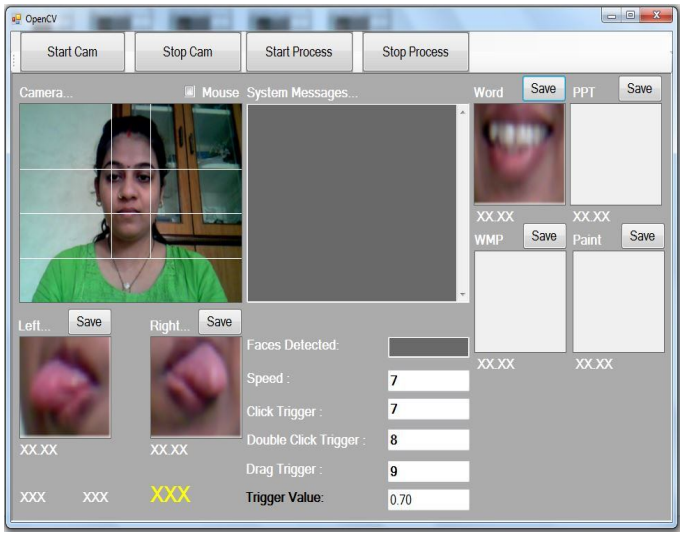

Fig -10: Template for word

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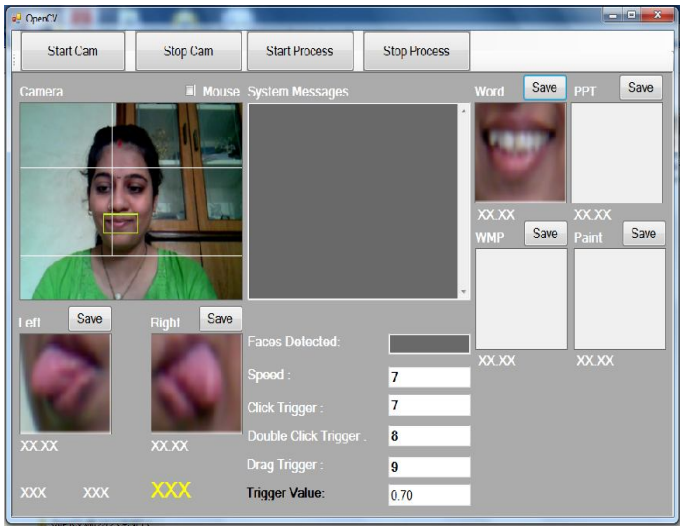

Fig -11: Template selection for ppt

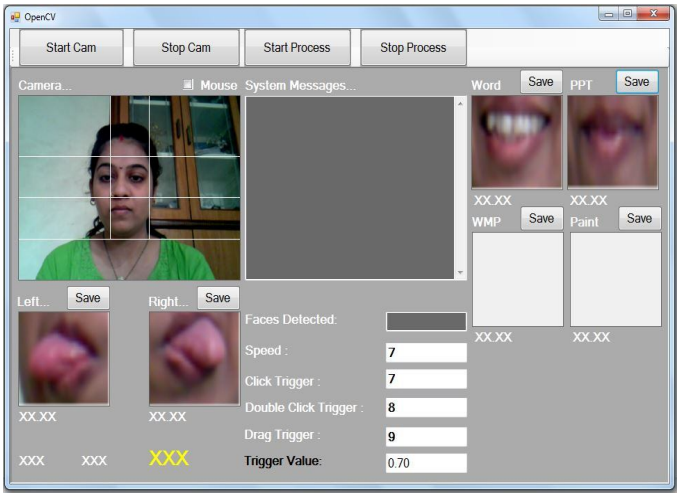

Fig -12: Template for ppt

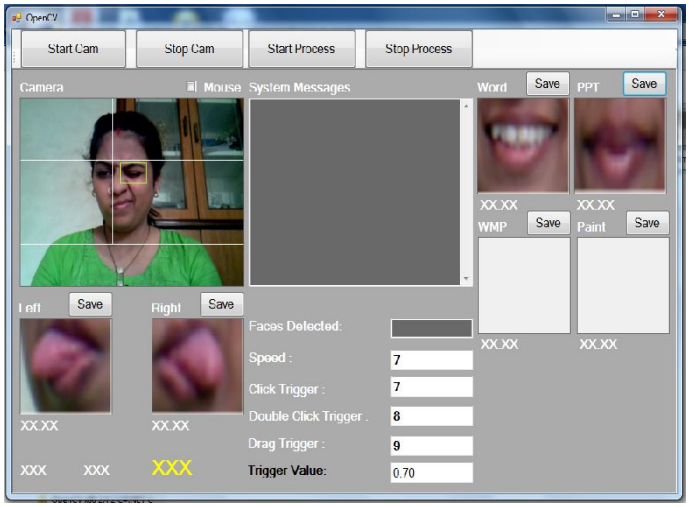

Fig -13: Template selection for wmp

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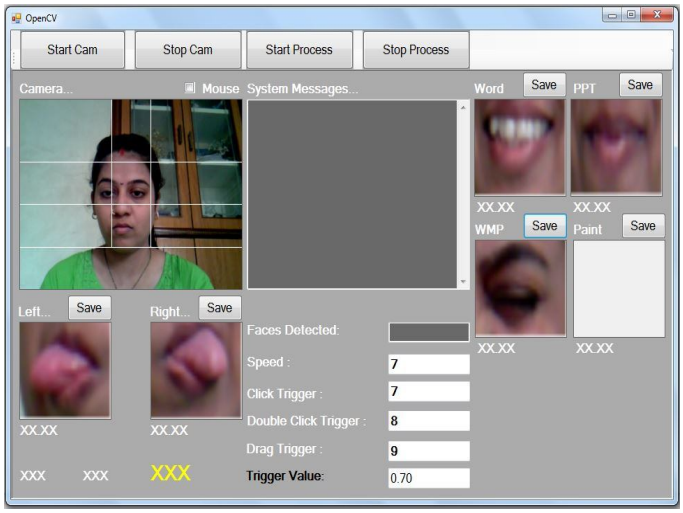

Fig -14: Template for wmp

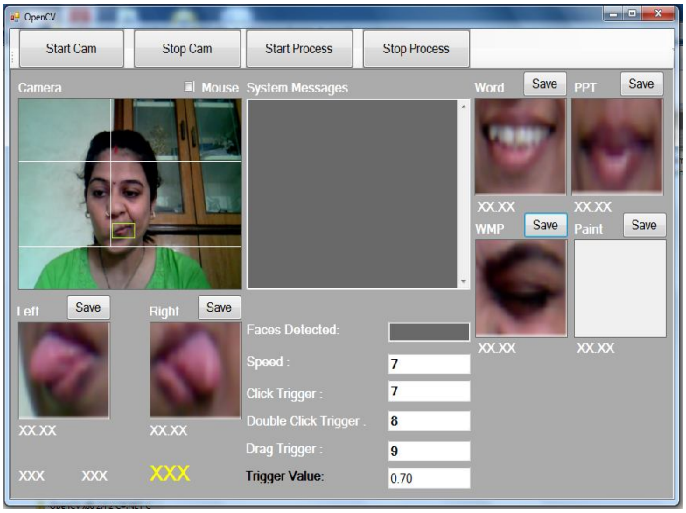

Fig -15: Template selection for paint

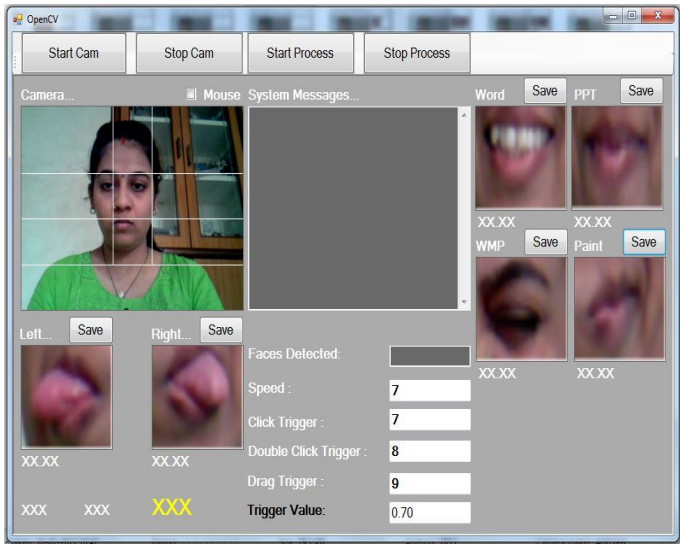

Fig -16: Template for paint

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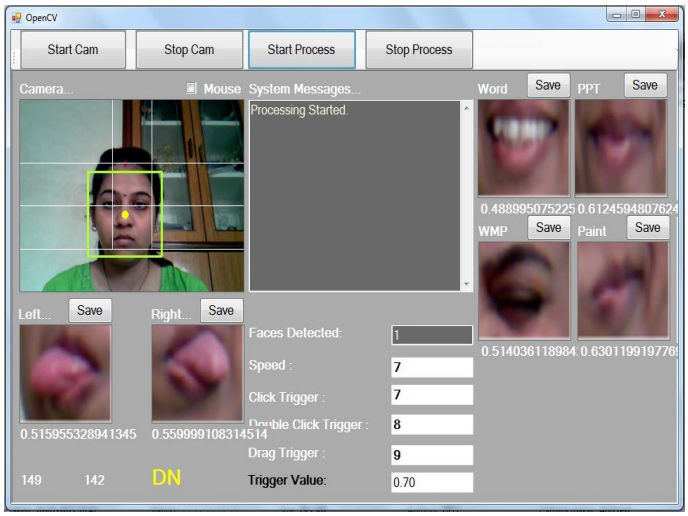

Fig -17: Process started

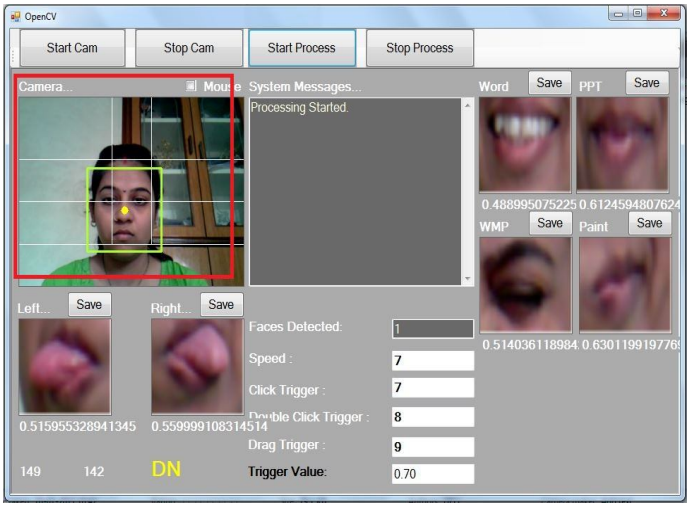

Fig -18: Face & centroid detected shown

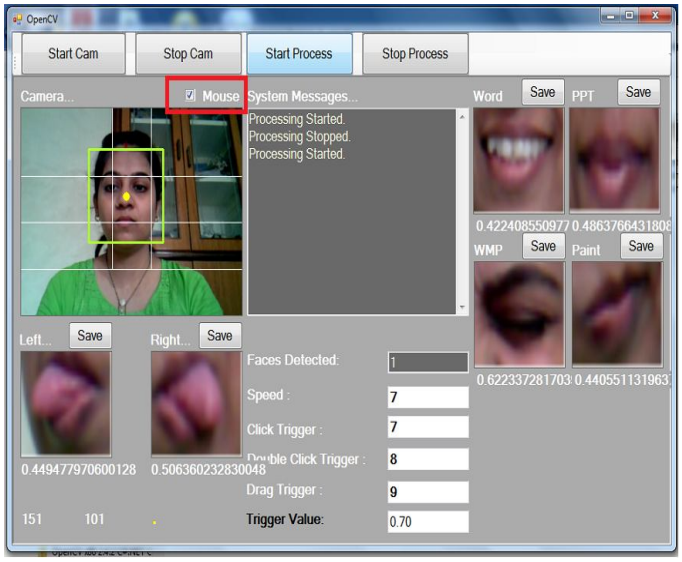

Fig -19: Mouse radio button checked shown

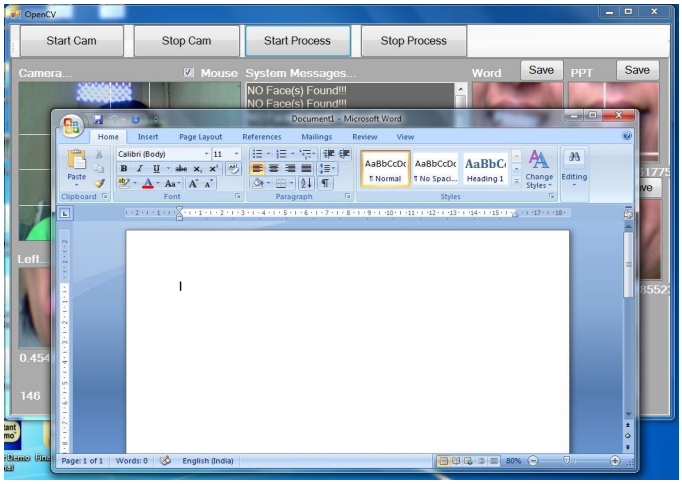

Fig -20: Word opened

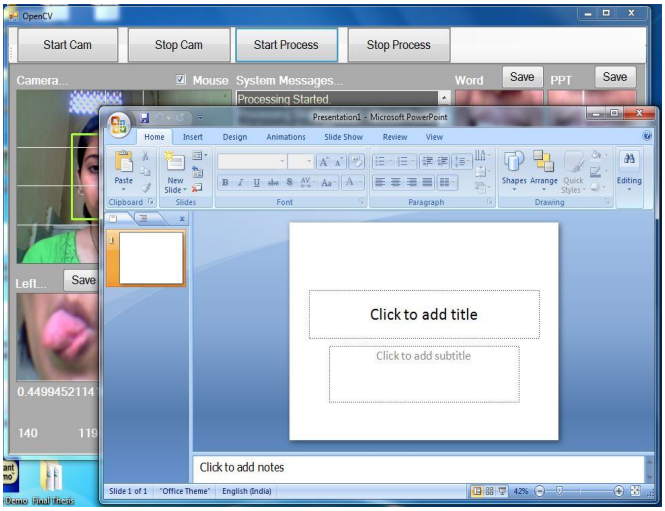

Fig -21: ppt opened

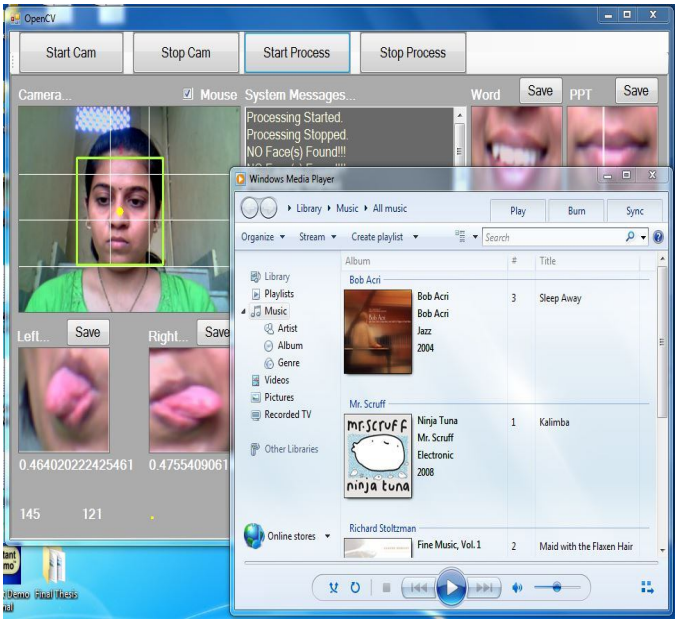

Fig -22: wmp opened

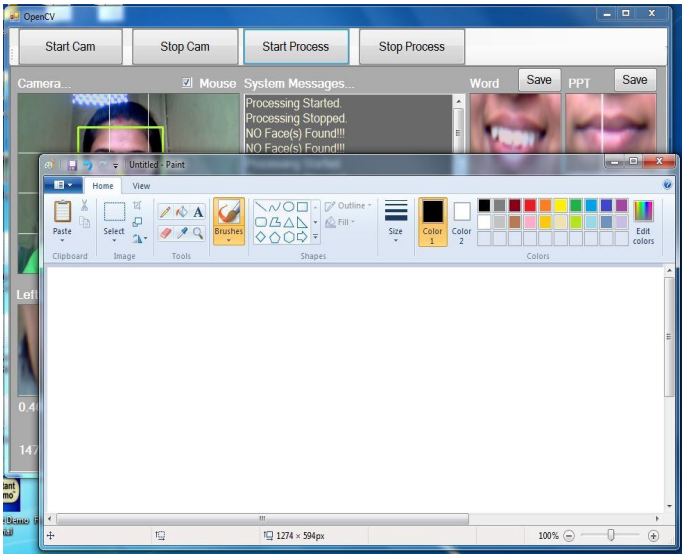

Fig -23: Paint opened

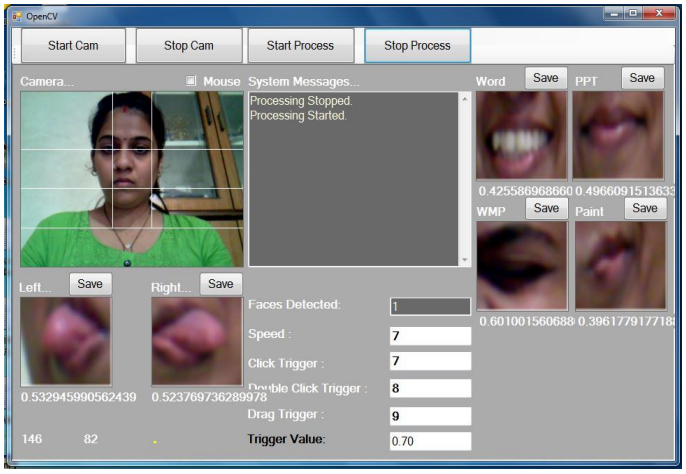

Fig -24: Process stopped

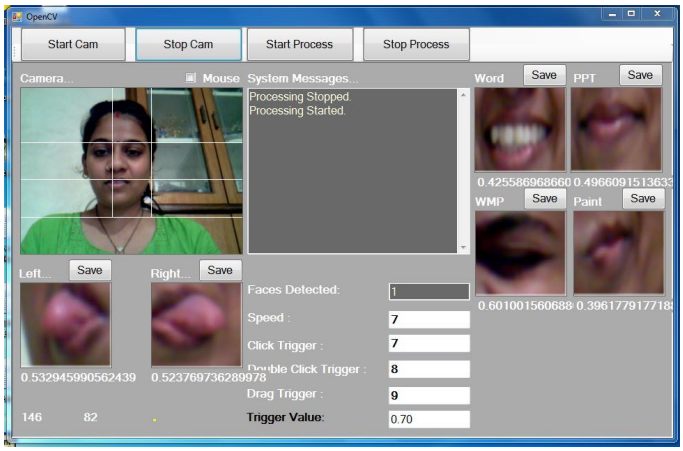

Fig -25: Stop Cam

VI. CONCLUSIONS

The system can be useful in many different ways. It makes use of the RGB color space. It is implemented in OpenCV as it provides Haar classifier. It is based on Computer Vision technology. As of now only movement and Clicking operation can be performed.

But in future, after calling the programs typing operation can also be performed. Using the developed system in future the system can be made work as fully automated system, with any manual help.

VII. ACKNOWLEDGMENT

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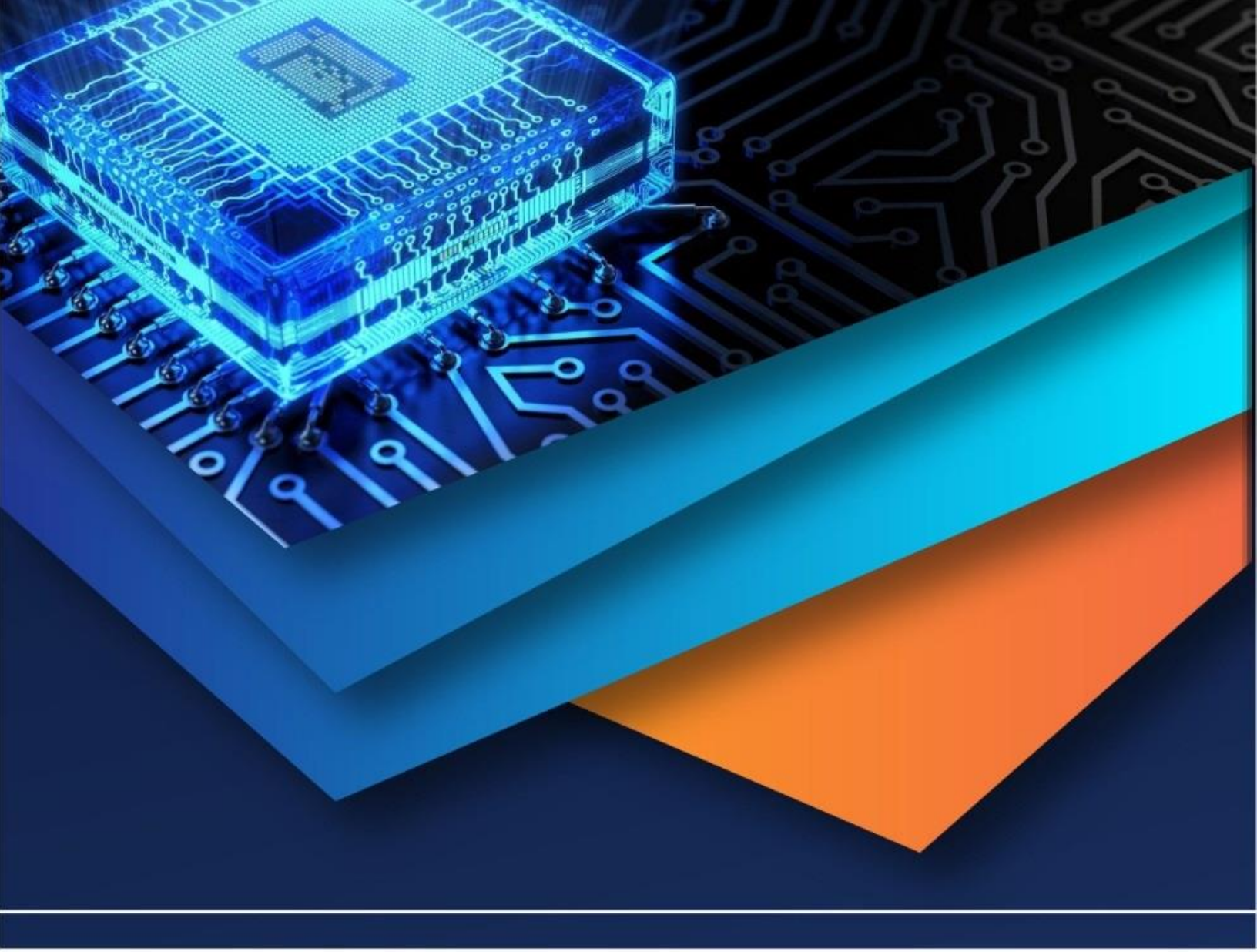

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