Hand Gesture Recognition

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Abstract - An integrated way to combine both the information concerning speech and hand gestures, is a more user-friendly interface. These are known as the "hand gestures" which are used to transmit the speaker's or the user's intention. They aim to recognize the hand gestures interface. Machine Learning or ML is used for coding of these gesture recognitions. This human computer interaction is used in a diverse range of application. From automations to medical kits, a virtually connected environment always surrounds us. The patterns of the gestures are recognized by mapping the number of defects formed with the assigned gestures. The project aims at developing an application the employs computer vision algorithms which in turn helps in developing a low cost device helping to interface the objects with the virtual environment.

Index Terms – Human-Computer Interaction, Background Subtraction Technique, Contour Extraction, Convex Hull

1. INTRODUCTION

In the current advancing world, we never know what the future beholds. Every day new inventions, modifications and updates are going on across the globe. Among the various topics, hand gesture recognition is one of the most advancing topics these days. In this project, the hand is detected and separated from the background using background subtraction method. By using contour extraction and convex hull, the palm and the fingers are segmented. By using the various algorithms, the fingers and the hand is recognized. Finally by converging all the algorithms, the hand gesture is recognized and used in various applications such as home automation, medical uses, video games, etc.

2. RELATED WORK

A detailed research was done for the project. They are lested as below:

2.1 Hand gesture recognition using Kinect

This paper is published by Muhammad Asad. It gives us an idea about how to use kinect theory for hand gesture recognition.

2.2 Hand Recognition and Gesture Control Using a Laptop Web-camera

This paper is published by Zi Xian Justin Yeo. It helps us to know how we can recognize the gestures through the simple web camera attached to our laptops.

2.3 Map Navigation using hand gesture recognition: a case study using MYO Connector on Apple Maps

This paper is published by by Mithileysg Sathiyanarayanan and Tobias Mulling. It helps us to know how we can use the hand gestures for navigational purposes.

2.4 Hand Gesture Recognition: a Lliterature Review

This paper is published by Rafiqul Zaman Khan and Noor Adnan Ibraheem. It helps us to know about the extraction method and the various recognizable gestures.

2.5 Hand Gesture Recognition System

This paper is published by Swapnil D. Badgujar, Gourab Talukdar, Omkar Gondhalekar, Mrs. S.Y. Kulkarni. It gives us an insight about the working of the image processing and the steps to systematically recognize the gestures.

3. PORPOSED MODELLING

The existing system is such that the conventional commands needs to be remembered for the different gestures. This leads to fatigueness of the user and the repeated commands given to the system is also tiring. All these drawbacks are solved in the proposed system. It is much more advanced and with the introduction of machine learning the process of execution becomes easier with this advancement, it might seem that the lives will turn out to be lethargic but on the positive side it will make our lives easier and with its vast array of applications, the lives of physically challenged as well.

4. ALGORITHMS USED

The various algorithms required are described as follows:

i. Edge Detection

The images are captured using the cameras and the images captured are separated into frames and converted into gray scale. The contrast of the image is improved using histogram equalization. MATLAB is used for the binary function and the boundary pixels are detected and stored in linear array.

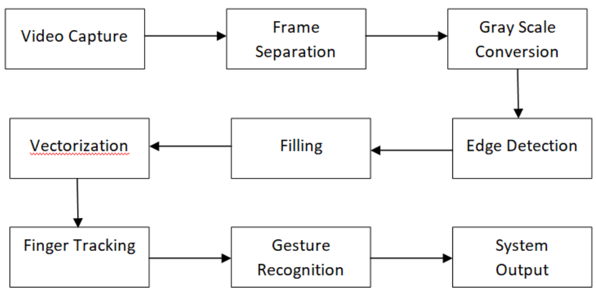

Figure 1: Block Diagram for Edge Detection

The gesture is recognized based on the motion and the finger tips can be recognized using segmentation algorithm. The gestures are given as input to the device.

ii. Hand Tracking using Cam shift Algorithms

(a) Finding mean location using mean shift algorithm

Here, first the initial location of the image is captured and its mean location is computed. The mean location is created until a perfect threshold is obtained.

The mean position can be then calculated as:

$$\widehat{P}_k(W) = \frac{1}{|W|}\sum_{j\in W}^{n} P_j$$

After the centre point is achieved to obtain the centre of the window at that point, we use the formula,

$$\widehat{P}_k(W)$$

Repeat the above steps until convergence.

iii. Cam Shift algorithm

After finding out the perfect threshold of the search window using Mean Shift Algorithm new search window can be found out using the formulas given below:

Θ = abs(Θ)

P = $\tan^{-1}$(1/height to width ratio)

Θ = abs(Θ - ρ)

$$Z=\sqrt{(\text{window Multiplier})^2 + (\text{Height to width ratio})^2}$$

New search window . Height = round (Z*, sin(Θ+ρ))

New search window . Height = round (Z. cosΘ(Θ))

iv. Skin Detection

There are a few steps used for skin detection. Once, the image is captured and separated into frames skin detection algorithms is used to detect the skin and separate it from the background images.

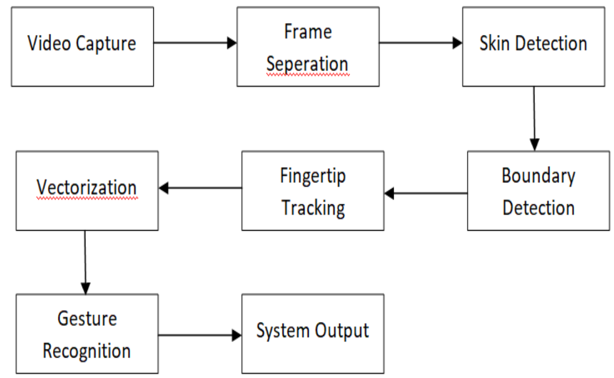

Figure 2: Block Diagram for Skin Detection

Even in the presence of noise the closed contrast of the finger is identified. Vectorization technique is used to detect the finger tips.

v. Background Subtraction Technique

This algorithm is used to build an explicit model of the background. It is used to extract the background objects by the calculated difference between the objects in the front and the background model.

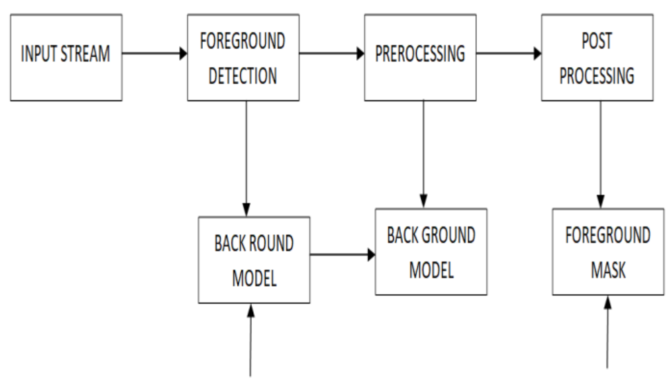

Figure 3: Black diagram for Background Subtraction

In the segmentation algorithm, the foreground process detects the foreground image separates the foreground and the background image. It also masks the foreground image and produces the output.

5. SYSTEM ARCHITECTURE

The overall system is divided into two parts-back end and the front end.

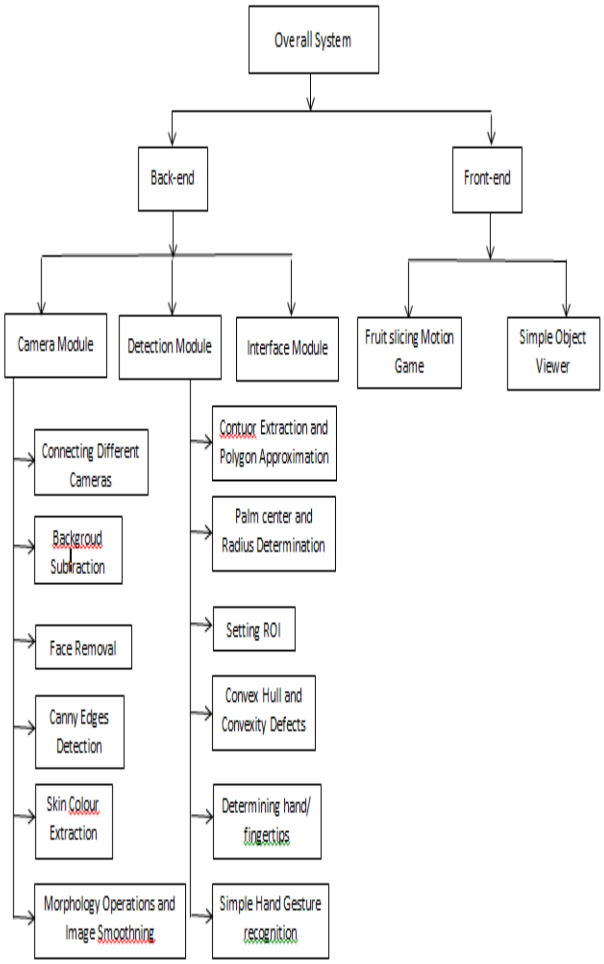

Figure 4: The overall System Architecture

The front-end consists of :

- Camera Module
- Detection Module
- Interface Module

The back-end consists of:

- Fruit Slicing Motion Game
- 3D-0bject viewer

6. MODULE IDENTIFICATION

The various modules and their respective sub-modules are described as follows:

i. Camera Module

This module is solely responsible for capturing images from different types of detectors and then processing the output.

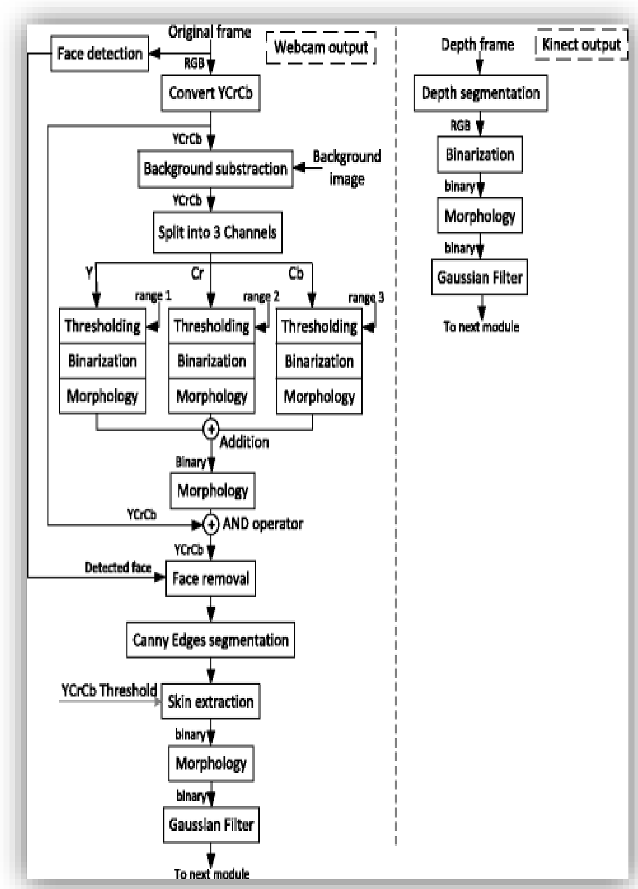

Figure 5: Camera Module Architecture

It has the following sub-modules:

a) Connecting different cameras

Here, the aim is to design a system which is able to utilize a USB webcameras which is readily available low cost depth cameras can also be used. Depth cameras are better for hand segmentation but it has lower resolution and frame rates. The HCI is also less smooth. Moreover its expensive then USB webcam. This module retrieves the image frames at 30-6-frames per second depending on the type of camera used.

b) Background Subtraction

This module is used to separate the user from the background usually RGB colour space is used but HSV or YCrCb can also can be used as effective alternative. We use YCrCb colour space and split in three channels of Y, cr and cb and the work on the different process independently. Different minimum and maximum values are calculated and their threshold is recorded and noise is removed using morphology operators. Finally, these are added together using AND operator. The output obtained is YCrCb image.

c) Face Removal

In some cases, the system cannot recognize the difference between a closed fist and face. So we use the well trained classifies provided to us in the openCV library.

d) Canny Edges Segmentation

Sometimes, it might happen that the user's face might be blocked or not visible clearly or the user is not facing the camera. This will result in single connected contour having both the hand and face. To solve this problem, we use canny edges segmentation. Through this we can effectively separate out the face and the hand.

e) Skin Colour Extraction

It is seen that YCrCb colour ranges are best for representing skin colour region. It also provides a full coverage for the humans from different races. The basic values chosen for our implementation is based on the values that are suggested by D.Chai.

$$77 \le Cb \le 127 \text{ and } 133 \le Cr \le 173 \quad (a)$$

$$54 \le Y \le 163$$
$$131 \le Cr \le 157$$
$$110 \le Cb \le 135 \quad (b)$$
$$\text{where } Y, Cb, Cr = [0, 255]$$

Figure 6: Default threshold value for YCrCb skin extraction a D. Chai b modified version

Those values are used as the threshold values. It may occur that other objects having a similar colour as the skin are also detected. This will create a faulty extraction. Hence, it call be modified setting a narrow range so that it extracts only the skin region. This may not be applicable for all the skin colours. Hence we use on-click calibration mechanism. Through this, the user just places the hand is front of the cameras and click the area of the hand. A rough estimate will automatically be taken by the system.

f) Morphology Operation and Image Smoothing

Morphology used to remove the noise present in the background effectively. After removing the noise, Gaussian filters are used to smoother the image recognized.

ii. Detection Module

The output obtained from camera module is a binary image having smooth and polished contours. In this module, finger counts, finger directions, hand location, etc, are detected.

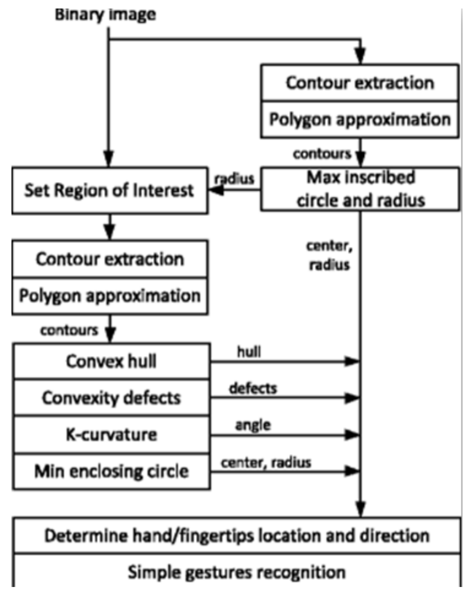

Figure 7: Detection Module Architecture

It has the following sub-modules:

a) Contour extraction and polygon approximation

The output from the camera module is simply a black and white image. The white blobs, known as the contours are the set of points that represent a curve. Polygon approximation is used to make the shape the image more suitable for shape analysis vivid informations are not given by the simple contours. The interior contours combined with other information are used to determine specific hand gestures.

b) Palm centre and radius determination

Palm centre is regarded as the maximum circle inscribed inside the contour. It calculated from the distance of each point in the contour to the contour perimeter.

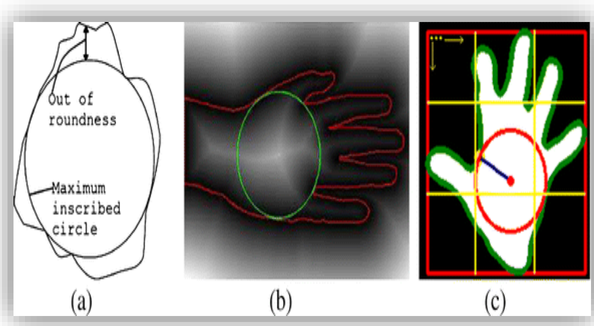

Figure 8: (a) Maximum inscribed circle, (b) Inside hand, (c) Limiting region of interest

The point with the largest distance is taken as the centre of the maximum inscribed circle. This distance is known as r_a.

c) Setting Region of Interest (ROI) and finding minimum enclosing circle

The radius (r_a) is used to limit the ROI to only the area surrounding the palm centre. The circle with radius r_a=3.5 is defined for reference. This removes the arm area. We again perform polygon approximation and contour extraction on this ROI. We obtain the radius as r_b. This radius is used for checking palm openness.

d) Convex hull and convexity defects extraction

The shape of the hand or palm is detected using convex hull technique. The image below shows the convexity defects using human hand image. The dark line is the convex hull drawn around the hand. This guided regions (A,B,C….,H) is the convexity defects in the hand. The starting point (P), depth point (P_d), end point (P_e) and depth length (l_d) for single convexity defect is shown. All the points are then stored in an array for further detailing.

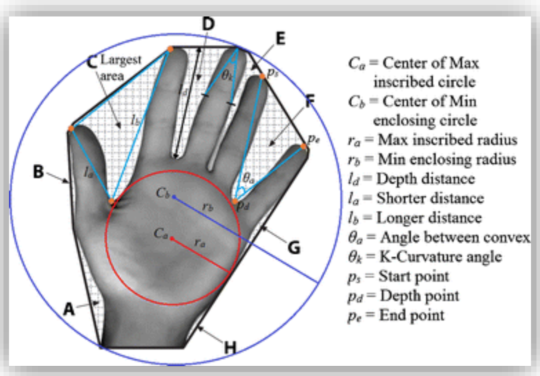

Figure 9: Convex hull, convexity defects of the hand

e) Determining hand/fingertips location and direction

By knowing the contour characteristics, we can precisely determine the fingers and locations. It meets several steps to be recognized as a fingertip. They are:

a. Each defect's depth (l_d) must be longer than the centre of the palm radius (r_a) but must be shorter than the enclosed circle radius (r_b), i.e. $r_a<l_d<r_b$.

b. The angle (Θ_a) between the starting (P_s) and end point (P_e) must be less than 90°, i.e., $\Theta_a<90$.

c. The local K-curvature (Θ_k) of point must be lower than 60°, $\Theta_k<60$.

f) Hand Gesture Recognition

After combining all the information from the previous steps, we can definitely be able to recognize the several gestures that are shown. Some of them are shown below:

Figure 10: Several Static Gestures

- Open palm, 4-5 fingers detected
- Closed palm, 0-1 fingers detected
- Claw , 4-5 fingers detected
- OK Sign, 3 fingers detected
- O Sign, no fingers detected
- Gun Sign, 2 fingers detected
- Pinch Sign, 2 fingers detected
- Pointing Sign, 1 finger detected
- Finger Tip

iii. Interface Module

This module is responsible to translate the detected fingers and hands into functional inputs and interface with other applications to obtain the output.

The front end consists of sample applications that utilizes the inputs from the back end.It has the following categories namely:

a. Fruit slicing motion game

This method is inspired from a game which moves hand in mid-air. It uses the concept of multi-layered networking.

b. 3D-0bject viewer

It allows users to perform the views operation such as zoom, rotate, swipe, drag, etc. The hardware components include a detector i.e. the USB or web camera, a computing apparatus (desktop) and a video display i.e. monitor or projector.

7. WORKING PRINCIPLE

The image of the hand obtained from the low cost USB or web camera is a black and white image. The image is converted to its negative self and then it converted into lines which the machine learning or ML model process to give a specific output. This process is known as image processing in the field of Artificial Intelligence or more commonly known as AI. The ML model is to be made in such a way that the position of the changing lines will give out a certain output which specifies to a related function.

8. APPLICATIONS

A lot of applications are being developed each day to make our lives easier. Some of them are as follows:

- WiSee, a prototype which when connected to the wifi, the gestures such as waving, punching, kicking can be recognized to control the house-hold applications.
- Modern cars installed with gesture recognition devices are useful for handicapped people for driving purposes.
- Data Gloves are used for investigating the coding of hand shaped motion information.
- Other applications include analysis of complex scientific data, military simulation, phobia therapy and virtual prototyping.

9. FUTURE ENHANCEMENTS

There a lot going on across the globe in the field of gesture recognition some of the future scopes are as follows:

- It can help a lot in medical applications where advance robotics system with gesture recognition can be used to recognize heart attacks or strokes.
- Combined application of gesture, voice, facial, lip movement and eye tracking is used to create PUI or Perceptual User Interface which is a complete different technique to improve computer-human interaction.
- Gesture recognition will change the whole concept of video games if they are once launched.
- It will also solve a huge barriers for the disabled or blind or handicapped.
- It can even take home automation to another level.

10. CONCLUSION

The arena for the development of this project is huge. The perspective to see the digital world will change once the world knows what this field of research has the potential of. They can bring a new spark in the lives of the physically challenged. The technology will help them to do work without any barriers. This technology will be another stepping stone towards a more advanced human-computer interaction.

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