

3D Hand Tracking in Virtual Environments

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Abstract—The paper presents the design and development of a short range motion detector based droid. Hand gesture interface has been becoming an active topic of human-computer interaction (HCI). The utilization of hand gestures in human-computer interface enables human operators to interact with computer environments in a natural and intuitive manner. In particular, bare hand interpretation technique frees users from cumbersome, but typically required devices in communication with computers, thus offering the ease and naturalness in HCI. Meanwhile, virtual assembly (VA) applies virtual reality (VR) techniques in mechanical assembly. It constructs computer tools to help product engineers planning, evaluating, optimizing, and verifying the assembly of mechanical systems without the need of physical objects. However, traditional devices such as keyboards and mice are no longer adequate due to their inefficiency in handling three-dimensional (3D) tasks. Special VR devices, such as data gloves, have been mandatory in VA. This project proposes a novel hand tracking interface for the application of VA. It develops a hybrid approach to incorporate an appearance-based hand localization technique with a skin tone filter in support of hand tracking in the 3D space. With this interface, bare hands become a convenient substitution of special VR devices. Experiment results demonstrate the flexibility and robustness introduced by the proposed method to HCI. The work presented in this paper is the mini-project work of the under-graduate students of the engineering college guided by their supervisors.

Index Terms— Gesture recognition, OpenCV, human-computer interaction, python, machine learning.

I. INTRODUCTION

Real-time Hand Gesture Recognition using TensorFlow & OpenCV - Gesture recognition is an active research field in Human-Computer Interaction technology. It has many applications in virtual environment control and sign language translation, robot control, or music creation. In this machine learning project on Hand Gesture Recognition, we are going to make a real-time Hand Gesture Recognizer using the MediaPipe framework and Tensorflow in OpenCV and Python [1][2].

OpenCV is a real-time Computer vision and image-processing framework built on C/C++. But we'll use it on python via the OpenCV-python package. Hand gestures are unprompted and also robust transmission mode for Human Computer Interaction (HCI). For a long time, however, research on HCI has been restricted to techniques

based on the use of a graphic display, a keyboard, and a mouse. These devices have grown to be familiar but inherently limit the speed and naturalness with which we can interact with the computers. It is regrettable that these limitations have become the major bottleneck in the developments of related areas such as VR, robotics, game, remote sensing, robot human collaboration, and virtual assembling. Keyboard, mouse, joystick or touch screen are some input device for connection with the computer but they don't provide appropriate interface whereas, the current system will contain either desktop or laptop interface in which hand gesture can be done by wearing data gloves or web camera used for snapping hand image [3][4].

The long-term goal of HCI is to pursue the ease and naturalness with which the user can interact with the computers. Inspired by the natural means employed in the human-to-human communication environment, researchers have started to explore the potentials of introducing other communication means constantly used by humans into the HCI context. One of such means is the movement of human arms and hands, also called hand gestures. Human hand gestures are common in non-verbal interaction among people. They range from simple actions of using our hand to point at and move around objects to the more sophisticated ones that express our feelings and allow us to communicate with others [5][6].

The first step towards this gesture recognition is hand capturing and analyzing. Sensors are used in Data-Glove methods for initializing fingers movement and other sensor will program hand movements. In comparison the vision based method only needs a camera and hence identifying the actual interaction between human and computer without using any other devices. The challenges of this system are constant background, sometimes person and lighting also. Different procedure and algorithms which are used in this system are elaborated here along with the recognition techniques. The method of searching a connecting region in the picture with particular specification, being it colour or intensity, where a pattern and algorithm is adjustable is known as segmentation [7][8].

II. PROBLEM STATEMENT

To develop a real time and reactive hand tracking system in virtual environment for efficient human computer interaction. And also considering many lacunas in current technology we have defined our mini project's problem statement as "*3D hand tracking in virtual environment using OpenCV*" [9][10].

III. OBJECTIVE

To create a hand tracking system using hand landmark system to create virtual hand pattern and then create other 3D objects and move them using the movement of hand which is captured by the laptop's webcam and give real time responses [11][12].

IV. LITERATURE REVIEW

A number of researchers have worked on this topic chosen & presented in this paper. To name a few of them is presented in this context. D.J. Sturman and D. Zeltzer (Sturman & Zeltzer, 1994) - The authors proposed technologies such as position tracking, optical tracking, marker systems, silhouette analysis, magnetic tracking or acoustic tracking. P. Garg, N. Aggarwal, and S. Sofa (Garg, Aggarwal, & Sofa, 2009) - This paper is a review about Vision based Hand Gesture Recognition techniques for human computer interaction, combining the various available approaches, listing out their general advantages and disadvantage [13][14].

V. METHODOLOGY USED

In our work presented in this paper, PyCharm IDE, etc. has been used, i.e., we are going to install OpenCV. and program to turn on the devices webcam using necessary libraries [15][16].

- Then from the hand tracking module import the hand detector module to track the movements and gestures of our hand.
- Now install MediaPipe and create hand gesture recognition program.
- We would be able to see the dimensions of our hand during its movement.
- Now we are supposed send the landmark list of hand detector to Unity project.
- Now open Unity and open our UDP script and attach it to the current Unity project.
- Then create object i.e., hand using the landmark list, later on create C# script to program the hand tracking using the UDP data.

- Create the required 3D environment in order to know the working of our project feature that enables users of devices to use their hands as an applicable input method, instead of using the device controllers.

VI. FLOW CHART

Fig. 1 gives the flow chart that is being used in the mini-project work along with the block diagram of the mini project work respectively [17][18].

OpenCV : OpenCv is a widely used tool in computer vision. It is a computer vision library for real-time applications, written in C and C++, which works with the Windows, Linux and Mac platforms. OpenCv was started by Gary Bradsky at Intel in 1999 to encourage computer vision research and commercial applications and, side-by-side with these, promote the use of ever faster processors from Intel. OpenCV contains optimised code for a basic computer vision infrastructure so developers do not have to re-invent the proverbial wheel. The basic tutorial documentation is provided by Bradsky and Kaehler. According to its website, OpenCV has been downloaded more than two million times and has a user group of more than 40,000 members. This attests to its popularity. A digital image is generally understood as a discrete number of light intensities captured by a device such as a camera and organized into a two-dimensional matrix of picture elements or pixels, each of which may be represented by number and all of which may be stored in a particular file format (such as jpg or gif). OpenCV goes beyond representing an image as an array of pixels. It represents an image as a data structure called an *IplImage* that makes immediately accessible useful image data or fields.

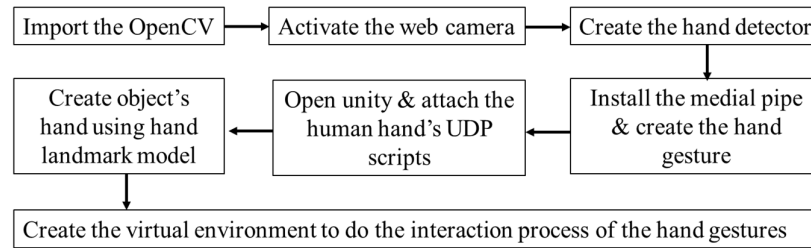


Fig. 1 : Flow-chart used in the project work

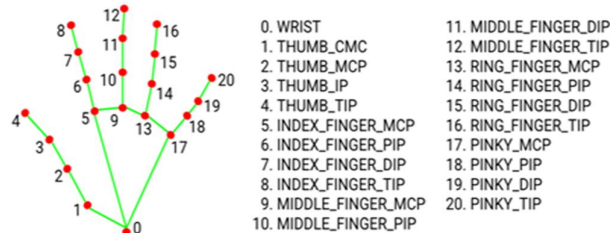


Fig. 2 : Hand mark list

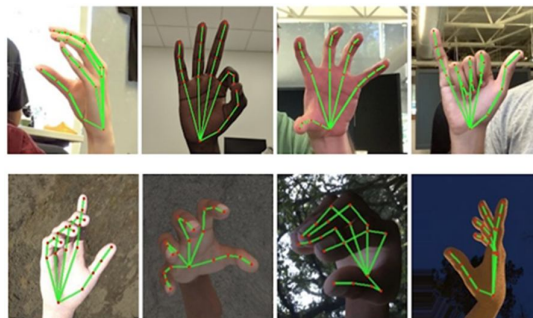


Fig. 3 : Example of the pictures of land marks in 3D-direction of the hand's fingers

Hand Landmark Model - After the palm detection over the whole image our subsequent hand landmark model performs precise keypoint localization of 21 3D hand-knuckle coordinates inside the detected hand regions via

regression, that is direct coordinate prediction. The model learns a consistent internal hand pose representation and is robust even to partially visible hands and self-occlusions. To obtain ground truth data, we have manually annotated ~30K real-world images with 21 3D coordinates, as shown below (we take Z-value from image depth map, if it exists per corresponding coordinate). To better cover the possible hand poses and provide additional supervision on the nature of hand geometry, we also render a high-quality synthetic hand model over various backgrounds and map it to the corresponding 3D coordinates. Example of the pictures of land marks in 3D-direction of the hand's fingers is shown in the Fig. 3. Next, the hand gesture's 20 points is shown in the Fig. 4 [23][24].

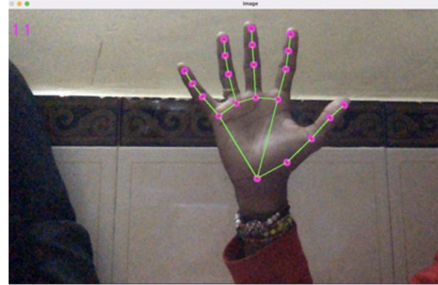


Fig. 4 : Hand gesture points 20 in number

VII. HAND LANDMARK LISTS

In this section, we present the hand's land mark lists in different modules, which are explained one after the other in succession [25][26].

VIII. RESULTS

The hand tracking system created using hand landmark system in virtual environment to function as reactive and real time. The simulated result is shown in the Fig. 5 as shown below.

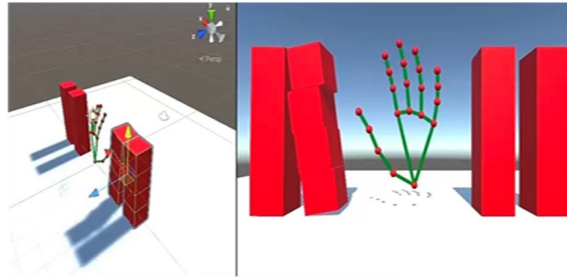


Fig. 4 : Simulated result

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