Implementation of Air Gesture Interface for Wheelchair Control

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Abstract: Physical disability is not considered as a curse anymore, due to the advancements in technology. Several devices have been lunched are proposed to keep these people to lead a normal life. This project is one such attempt to help the people who have got their legs amputated or lost their limbs due to birth defects or accidents. The aim of this project is to design and develop an air gesture interface to control electrical appliances and wheel chair using finger extraction algorithm and also use image processing. Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Nowadays, image processing is among rapidly growing technologies. It forms core research area within engineering and computer science disciplines too.

Keywords: Air gesture; finger extraction algorithm; image processing; signal processing

I. INTRODUCTION

The population of physically disabled in India is found to be 15% [1]. The disabilities can be due to the birth defects, diseases or accidents [2], considering the case of individuals who can find it difficult to move around, for example, people with amputated leg, paralysis, many techniques to assist them have been proposed [3]. Those are

1. Wheel chairs with joystick
2. Brainwave based interaction
3. Touch screen.

These may cause discomfort to the user and the maintenance cost will also be high. Thus an effective, easy to use & economic system has to be developed for these people. In this paper, we propose to develop an air gesture interface for the physically disabled to control wheel chair and other appliances.

II. LITERATURE SURVEY

A. The paper titled "First Person Movement Control with Palm Normal and Hand Gesture Interaction in Virtual Reality" by Chaowanan Khundam Multimedia Technology and Animation School of Informatics, Walailak University Nakhon Si Thammarat, Thailand say,

Human – computer interaction (HCI) is an interdisciplinary field in which computer scientists, engineers and design professionals play important roles. Virtual reality (VR) is a computer – simulated environment that can simulate the physical presence in places in the real world or imagined worlds. The goal of VR system is to immerse the participant or others within a computer – generated interact with the virtual environment. Human interaction with VR is making computer – based systems easier to use and more effective for people focus on control movement in VR. Therefore, HCI in VR consists of three parts such as the user, the computer and the way to work together. In this research user mean an individual player in VR while computer means all devices such as Oculus Rift, Leap Motion and computer PC. Interaction is the last part and will be the main part of this research. We studied HCI for design and development depend on interaction between all devices with user. Traditional way to control movement is discrete control by keyboard which using buttons. Users will press and release the key for movement in VR this method appropriate for PC's monitor display. If the system uses others device like HMD its will uncomfortable for controlling movement. Interaction in VR is very challenging for developers to create new method or applications with respond to the needs of users. Especially, continuous movement control by using hand gesture that able to track hand ranges which combination with various devices. Interaction devices in VR for movement control base on hand gesture in this paper categorized into 2 types. The first one is HMD devices these are tracking and signaling actions are the primary means of input into virtual environments. The HMD device that we use for this project is Oculus Rift DK2. The other one is hand tracking devices or in - controller for track user's hand. We use Leap Motion for tracking and determination of a hand's position and orientation. Then this device track and report the position and orientation of the game engine. The game engine is provided for connecting between users and all devices. By the properties of the game engine Unity3D appropriate for using with already supported with Oculus Rift and Leap Motion.

Oculus Rift will provide users for first person perspective in VR by stereoscopic display. VR with a first-person perspective are usually avatar-based, wherein the displays what the user's avatar would see with the avatar's own eyes. Thus, users typically cannot see the avatar's body, though they may be able to see the avatar's weapons or hands. Traditional control for first person in VR by use keyboard and mouse not fully support with HMD. For a more immersive VR, users should interact in virtual by their body, such as gesture by hand. VR will feel instantaneous as smooth and seamless as the real world when users are able to control movement of them. This reason motivated us to develop a new method for control user's movement in VR with hand gestures in real-time. The objective of this research will focus on a combination of Oculus Rift (HMD device) and Leap motion (in – air controller) for first person movement control in VR. We design hand gesture synchronize with movement and develop a method of control in our experiment covering simple path, turning path and complexity path. The result confirms that users are comfortable to use this input method for movement control in VR.

- Hand gesture design for movement control

The main objective of this research is developing a new input method in VR. Therefore, implementation of using Oculus Rift and Leap Motion are considered to apply for first person movement control in VR such as walk-through VR that allow user to immerse with the virtual environment by moving and observe them. In this section, we design single hand gestures by continuous motion of the hand during the walkthrough in VR separated as follows:

a) Forward Movement: For hand gesture if user wants to move the avatar forward in our method just raise a user's hand in front of their face with palm direction straight ahead. Try to open hand for better detection and control palm normal always forward.

b) Backward Movement: To move avatar backward (user still looking straight ahead not turn back) our method will use the hand gesture appearance to turn the direction of the palm or flipping the hand facing the body. In this case palm normal will point to the back of the user.

c) Step Left and Right Side step: In this case does not turn left or turn right, but it means walk step to left side or right side while character's face continue looking forward. To move a character step left by hand gesture we will push the palm to the left hand side. As same as step left, step right will push the palm to right hand side by rotating the wrist down out of the body.

d) Stop (Hold Position): To hold position of the character during moving with hand gesture there are 2 methods to do. The first way is grasping the hand another way is taking the hand out of display area. If no hand enables, character will stop immediately and move again when take the hand into the display.

e) Speed Control: We separated speed controller into 3 cases such as forward speed, backward speed and step side speed. For forward speed, users are able to increase movement speed by pushing the palm more forward. If user pushes less it will affect a little speed up, but if the user pushes more it will increase the more speed too. In case of backward speed, user can adjust moving backward speed by push and pull their hand. However, it has conversed way if user would like to speed up backward they have to pull their hand into their body. For step left and right speed is up to user pushing their hand to side of the screen more or less.

- Experimental evaluation

To test the overall performance of our movement control method by using gesture controlling. We compare movement control performance in Oculus Rift by using a gamepad or joystick and using Leap Motion by our gesture method. The variable that we are considering in this case is the time used during control the avatar from start to finish. We use 11 participants in this experiment most of all have some experience about first person shooting in computer games with keyboard and mouse control, whereas no experience of Oculus Rift and Leap Motion. Before testing, we will explain all missions and show how to control with gamepad and how to control movement by hand gesture. Furthermore, we will let user wear the Oculus Rift and test to rotate their heads with arbitrary angle for familiar with HMD device.

The average time in seconds by using hand gesture control of Leap Motion is less than using of gamepad in both of the scene. Even though there are unstable of Leap Motion detecting hand in any case made fault control of the device not users. To solve this problem we have to update firmware and clear data always before using. However, we will see that gamepad have less deviation (7.95 and 5.78) than hand gesture by Leap Motion (9.54 and 10.41) because of all users used to play some first person shooting game with a keyboard whereas no experience with hand control that made the value like this.

Hand gesture interaction for first person movement in VR is useful for users to control the movement of their hand. In this research, we apply palm normal with hand gestures and implement for single hand control. Hand controllers with palm normal have more efficient and stable than hand gesture without palm normal. Another advantage of this method is controlling the speed of avatar movement. In particular, by the value of front and lateral are continuous values that able to control the speed like accelerator meter up to the user requirement. Improvement of HCI, hardware and software of interaction technologies will help VR system designers develop more natural and effective for participants to interact with the VR. The future work in this research, we would like to use both on hand for more control movement of a user's avatar including access of many functions or menu in VR systems. Furthermore, we are looking for add more devices such as Virtuix Omni, Sixense, Depth VR, etc. in our system and create new scripts contact with each device for work together.

B. *The paper titled "Analysis of the Hand Motion Trajectories for Recognition of Air-Drawn Symbols" by Nimish Ayachi, Piyush Kejriwal, Lalit Kane, Pritee Khanna Computer Science and Engineering Discipline PDPM Indian Institute of Information Technology Design and Manufacturing Jabalpur,India say,*

Hand gestures provide easy and natural way to communicate with humans as well as machines. Illustrators are gestures which are used to illustrate physical items and to convey how they look like. A frequently witnessed example of illustrators is to write out some character or digit in air using bare hand motion. Usually, such an illustration is used to communicate a letter, word, or number instantly. However, to grasp these gestures successfully, the receiver (human/ machine) must be synchronized with the strokes being displayed by the conveyer, right from beginning up to the end of character trajectory. Perception of air-drawn strokes is difficult especially when the sync between the space and time is lost at some point by the receiver during the trajectory illustration. However, the task of air-drawn trajectory interpretation can be simplified with vision based computing. The development of an automated system interpreting hand trajectories would be extremely useful for efficient Human Computer Interaction(HCI).

Traditionally, vision based systems use 2D cameras (specifically webcams) to capture live gesture streams. Predominantly, color based segmentation schemes have been used to separate the objects of interest (hands) from the remaining background and face. Other segmentation schemes including gray level thresholding and background subtraction are also used. But these schemes fail to deliver a ubiquitous real time prototype due to their susceptibility to varying lighting conditions, infiltration of the false positives, and imperfect hand detection. New generation image acquisition devices like KinectTM sensor are capable of measuring the 'depth', i.e., distances of the objects appearing in front of the camera. To exploit this information, the proposed work uses depth sensing mechanism of KinectTM sensor to efficiently segment and track gesturing hand blobs. The proposed system recognizes some characters and decimal digits articulated in the air using bare hand motion. Trajectories are formed as a sequence of detected hand locations in each depth frame. Hand postures generated from a finger detection scheme are used as control gestures to mark the beginning and end of a trajectory. Unlike other works which use Dynamic Time Warping (DTW) for the trajectory matching, the proposed work uses majority vote of three different classifiers operating on different features. In case of a tie, decision of the classifier with highest priority is considered. Apart from decimal digits from 0 to 9, system is also capable of recognizing trajectories of additional characters '+', '-', and '×'. Input to the system is a trajectory traced from the hand motion and output is a tag pertaining to identified character. In addition,the system can be extended for numerous applications including smart, non-tactile gesture based calculator, writing boards, public transport inquiry panels, electronic devices(TV, media players etc.), game controllers, and yet more.

- Salient points of the proposed system

It provides an intuitive and easily adaptable interface for continuous gesturing. It is robust to background clutters and odd illumination conditions. It is resistant to occlusions caused by gesturing hand over the face, one hand over other hand, and self occlusions. Apart from scale and translation, it is also invariant to abrupt rotations. The direction of movement of the gesturing hand, does not affect the trajectory recognition.

- Proposed system

Flow of the proposed system is illustrated in Fig. 1. Live depth stream containing the gesturer is acquired through KinectTM sensor. On the basis of the depth threshold, a portion of the hand that appears within the thresholded depth region is considered as the object of interest.After removal of noise through morphological operations, a finger detection strategy is applied to establish three rule based control gestures. These control gestures help in coordinating the trajectory drawing process. Upon the detection of a trajectory completion, the trajectory formed by sequence of points is normalized for rotation, scale, and translation invariance. Three features extracted from the normalized trajectory points are classified by their individual classifiers. The similar responses of more than one classifier or response of the highest priority classifier identifies the symbol.

Implementation of this system began with a two dimensional camera (webcam) based signal acquisition scheme. However, the illumination and false positives introduced due to noise restricted this system from efficient computation of the features. Depth sensing camera like KinectTM came as a great rescue in this context making the system run in any live conditions of varying light and background. The classifier based on grouping of features proved more successful in recognizing symbols. System is also viable for real time implementations due to linear time taken in feature generation and classification operations. This is in contrast to DTW and HMM based implementations where time complexity turns quadratic. Enhancements in the proposed system are suitable for interaction applications where speech or physical writing with pen or stylus is to be avoided or not possible. Current system is limited to recognition of digits and a few symbols which can further be extended to recognize a variety of characters. System can also be upgraded to accommodate more variations and distortions of individual patterns.

III. PROPOSED TECHNIQUE

The video frames from the web camera are fed to the video processor, which houses the algorithm for finger extraction. Firstly, the finger has to be extracted from the background. Here, a suitable color model has to be chosen, such that any skin tone can be easily identified and background can be nullified.

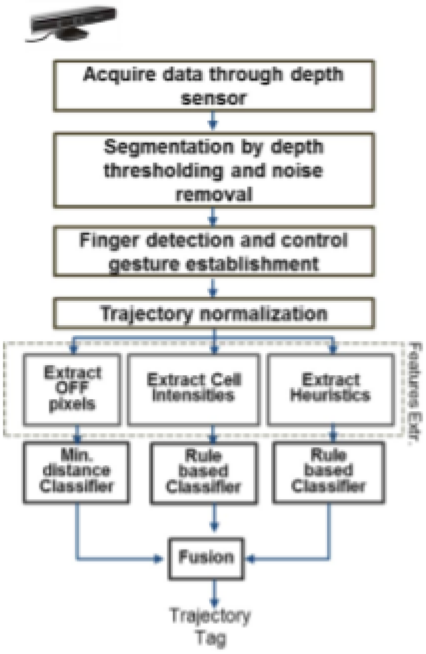

Fig 1. Workflow using Kinect Camera

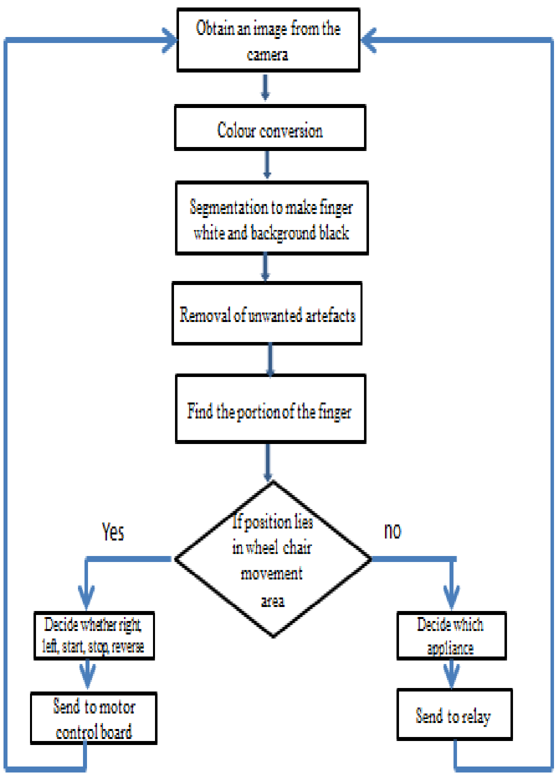

Fig 2. Flowchart of the proposed technique

Next, a process called 'segmentation' is carried out where, based on the properties of pixels corresponding to hand, the entire hand is converted to white and the back ground is black. This process sometimes generates noise pixels. Thus for noise removal, morphological operations such as erosion and dilation are carried out. Next, the coordinates of the finger are extracted to estimate the position of the finger and based on that particular action is carried out, such as movement of the wheel chair in specific direction and even controlling electrical appliances.

IV. BLOCK DIAGRAM

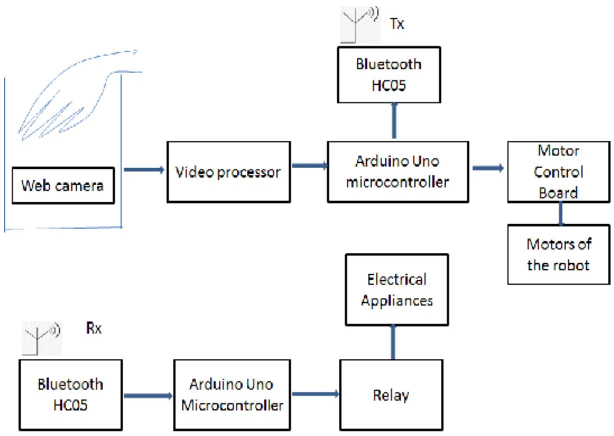

Fig 3. Block diagram of air gesture interface for wheelchair control and electrical appliances

As shown in the above block diagram (Fig.3) this set up consists of a camera, video processor, microprocessor, Bluetooth, motors for the robot, relay and electrical appliances.

The camera is attached to the wheelchair which captures the gestures. The camera is connected to a video processor which processes the video captured by the camera. The processed video is fed to a microprocessor i.e. arduino.

The microprocessor compares the movement of the hand with the previously stored gestures and the specific signal is sent to the Bluetooth module.

The Bluetooth module is used to connect the wheelchair to the appliances. The motors are used to run the robot.

Another Bluetooth is connected to the microprocessor and that is in turn connected to the all the electrical appliances used through a relay.

The specific action is performed for the particular gesture. When the user makes a particular gesture the microprocessor recognizes it and commands the appliances to perform the specific action through Bluetooth and the desired work is done by the device.

V. RESULTS

Image captured by the web camera is

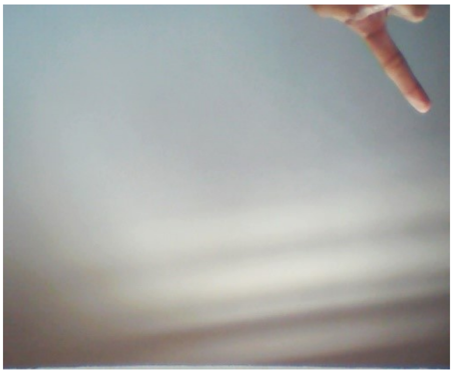

Fig 4. Captured image

The image obtained after performing morphological operation on the captured image is

Fig 5. Modified image

The prototype of the wheelchair is

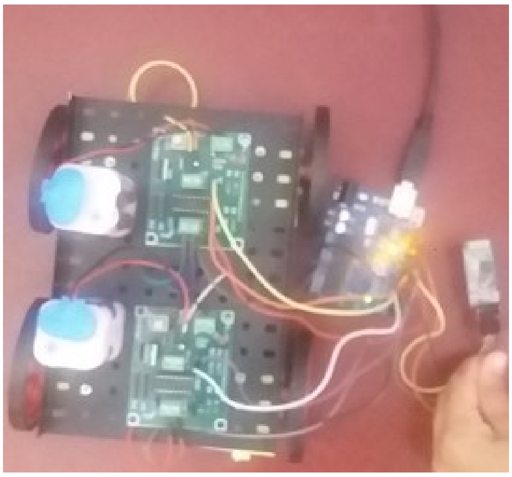

Fig 6. Prototype of wheelchair

Fig 7. Electrical appliances

VI. CONCLUSION

It is capable to control the wheelchair motion for disabled people using hand gesture. Improvements can be made by using various body gestures such as eye gaze, leg movement or head movement accordingly. In this proposed project the wheelchair movement can be done by using the air gestures. We have implemented this in such a way that the wheelchair can move right, left, forward, reverse and stop according to the location of the finger placed in front of the camera.

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