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Design and Development of Air Gesture Interface Using Wheelchair Motion and Access

Shreya Manjunath
VTU, Electronics and Communication Department, RNS Institute Of Technology, Bengaluru, Karnataka, India

Sowmya V
VTU, Electronics and Communication Department, RNS Institute Of Technology, Bengaluru, Karnataka, India

Shwetha S M
VTU, Electronics and Communication Department, RNS Institute Of Technology, Bengaluru, Karnataka, India

Chethana J
Electronics and Communication Department, RNS Institute Of Technology, Bengaluru, Karnataka, India

Abstract: ***Many people are suffering from temporary or permanent disabilities due to some medical issues or accidents. Wheelchairs are the evaded partner for most of disabled people lives, especially for those with limbs disability. Driving the wheelchair by hand may not be feasible for a physically challenged person with limited hand movement and as an alternate, simple finger movement-based control system can assist them. The main aim is to develop an easier interface for wheelchair motion along with gaining access to do other activities through Air-gestures, without depending on another person using the concepts of video processing. The main theme is to control the wheelchair according to the gestures recognized from the input source. This method is feasible under different lighting conditions.***

Keywords: Air-gestures; Home automation; Video processing; Wheelchair; Webcamera

I. INTRODUCTION

Approximately 1% of the entire world's population depend on a wheelchair due to their inability to move a certain portion of their body either because of a disease or an accident or lacking the strength to do so [1]. In order to improve the quality of life of a physically challenged person with restricted hand movement without being dependent on another person, a simple single finger movement based approach can be used. People suffering from quadriplegia require wheelchair to meet their daily needs [2]. Most of the wheelchairs, the patients either push the wheelchair normally or use a joystick based wheelchair [3]. However, these two techniques are used only for direction control of the wheelchair. For all the other activities the patient has to be dependent on some other person.

The proposed method involves identification of the finger movement in rea+l time using the data obtained by a camera. The location of finger is then calculated and the corresponding action is taken i.e. the movement of wheelchair in a particular direction or access of home appliances (light, fan) using the concepts of video processing and machine learning. The person sitting on the wheelchair is self-reliant which therefore contributes to one's overall development.

Initially, the gesture is shown to the camera by the user, after which image is acquired. The next step involves processing the video frames based on the proposed algorithm and thereby extracting the region of interest in order to recognize the gesture. The corresponding task for the gesture shown is then executed.

II. METHODOLOGY

Basic steps involved in the recognition of the finger movement is shown with the help of a simplified block diagram in Fig:1.

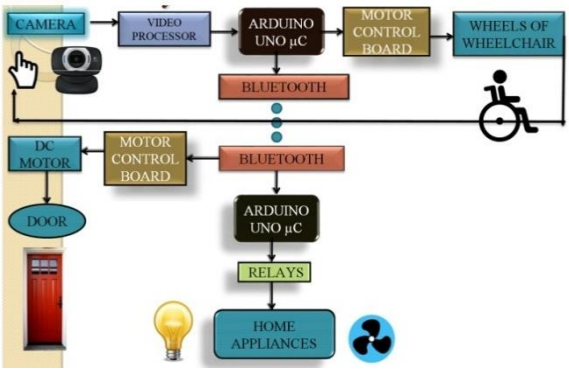

Fig 1. Block diagram of Wheelchair motion and Home Access System

Firstly, choose a webcam /any other suitable camera to capture the gestures shown by the user. The camera should

be capable of capturing images even under low lighting condition, therefore choose a camera which has built in illuminating source. Since, a prototype is being created we preferred to use a webcam(JIL-2244).

Place the webcam, such a way that it faces upwards and only captures the defined area. This is achieved by fixing the webcam to a suitable base and creating walls around the webcam and setting the height of these walls based on the focal length of the webcamera. Ensure that the webcamera is capable of capturing the images when the finger tip is placed at all the corners of the walls.

Fig 2. Top view of the webcamera placement

The shape and size of the base on which the webcam is placed depends on the user requirement. Divide the region enclosed by the walls into various blocks. The number of boxes depends on the different tasks that is to be done. In the project, for wheel chair motion 5-movements is required namely :

1. Forward
2. Backward
3. Right
4. Left
5. Stop

Similarly, the different home access operations are

1. Bulb on
2. Bulb off
3. Fan on
4. Fan off
5. Door activation

To perform the above mentioned tasks we divided the area into 4*4 , as shown in fig:3. In order to differentiate between the boxes ,we used threads to mark the boundaries ,observe fig:2.

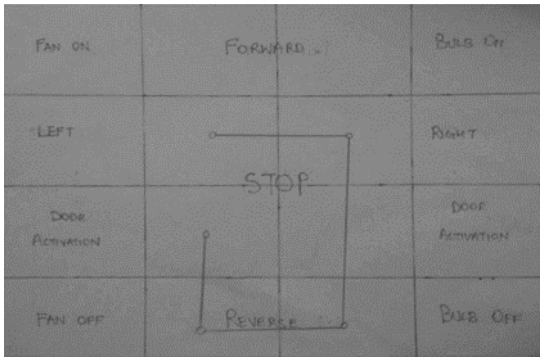

Fig 3. Overview of area division

A. Image Acquisition

To create the database .Capture the images by placing the finger tip at different positions and under different lighting conditions. For real-time processing, the video frames are captured.

Fig 4. Images captured at different lighting conditions.

B. Conversion to different color models

Convert the captured image to suitable color model. Such a way that the finger tip is easily identifiable. On experimental analysis, saturated images are chosen for further processing.

Fig 5. S-plane images after binarization.

C. Linear Regression approach

Calculate the mean of the image and minimum pixel value of the saturated image. Plot mean v/s Smin (minimum value of saturated image) curve for a set of images. Derive an equation from the curve and select that degree of equation which is suitable to process the image.

$$Smin = c_1m^3 + c_2m^2 + c_3m + c_4 \quad (1)$$

Where, 'Smin' refers to minimum value of saturated image, 'm' refers to mean value of the image and c_1, c_2, c_3 and c_4 are coefficients of the equation.

This method outputs an image,

$$Op(x,y) = White \ ; S(x,y) >= Smin \quad (2)$$

$$Op(x,y) = Black \ ; S(x,y) < Smin$$

D. Dilation

To extract the pixels at finger tip, it is necessary to recognise the pixels. This technique adds pixels to the boundaries of the object in an image and enhances the foreground of the image.

Fig 6. Dilated Images

E. Finger Tip Detection

After performing the above processing steps, we then search for the location of the finger tip. The image is traversed to find out the location that is, the row and column of the first white pixel encountered.

F. Control signals for motor driver

The detected location information is transmitted to the Arduino. The Arduino, controls the motion of the wheels based on this information.

The entire MATLAB code, is converted into a Simulink model. The whole system constitutes the Video processor. The model takes in Live video frames and performs the above mentioned operations.

Similarly, for home-access, different regions are allocated. When the user selects the region required, the respective operation is performed.

For door-unlocking, a region is specified for door activation, once the user selects this region, he/she can draw the door unlock pattern. Once the pattern is matched, door is unlocked. If the pattern is correct, a message "Door opening" is displayed, else message "Password incorrect " is displayed.

III. EXPERIMENTAL RESULTS

The Final Simulink Model is shown in Fig 7.

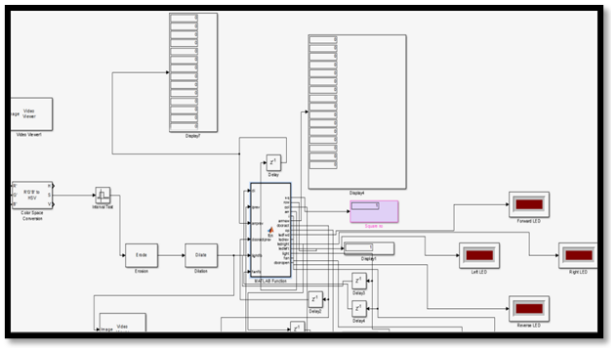

Fig 7. Simulink Model

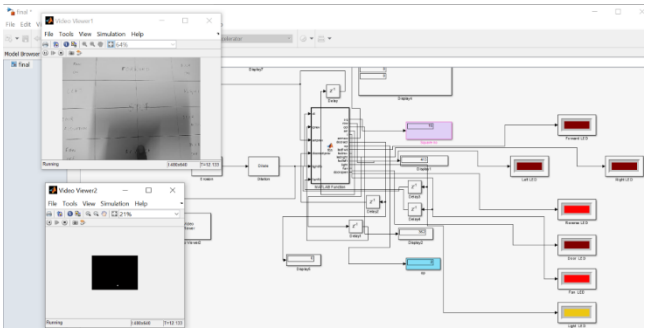

Fig 8. The working model. The finger is detected and the corresponding generic LED is “ON”.

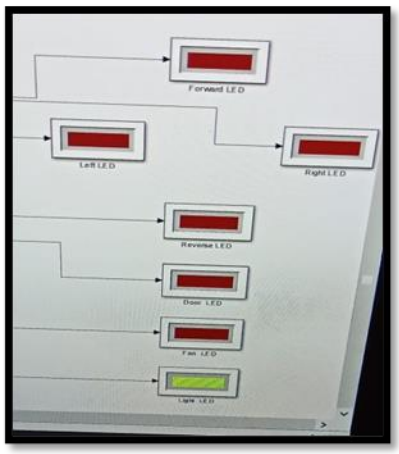

Fig 9. Simulation output, outcomes are shown using generic LED in Simulink.

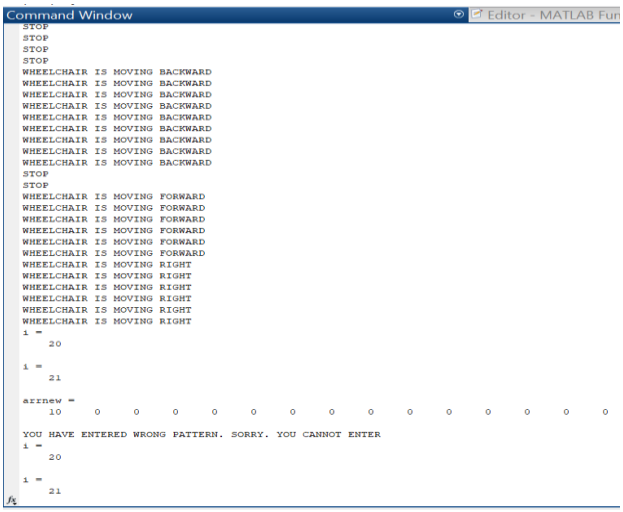

Fig 10. MATLAB command window which shows the corresponding messages.

IV. CONCLUSION

The proposed method involves identification of the finger movement in real time using the data obtained by a camera. The location of finger is then calculated, and the

corresponding action is taken i.e. the movement of wheelchair in a particular direction or access of home appliances (light, fan) using the concepts of video processing and machine learning. The person sitting on the wheelchair is self-reliant which therefore contributes to ones overall development.

A Droidcam can also be used instead of webcam setup. Droidcam is a tool for Android and PC that will allow you to use your mobile phone as a PC webcam.

There are a few disadvantages to this approach as well that includes, DC Motor is being run by batteries. Hence there comes a need to put a new battery each time the battery life gets over. There is a little bit of a time lag that is present when gesture switching takes place.

As the project's future scope, a training set with higher number of pictures collected using the webcam can be used, to improve the efficiency of the model.

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