Eye Ball monitored Wheel Chair

Ankur Thakkar, Darshan Shah, Cornell University

Cornell University School of Electrical and Computer Engineering

Overview

Statistics suggests that there are 11,000 new cases of quadriplegia every year in United States of America. Great people like Stephen Hawking and Max Brito have been suffering from this crippling phenomenon. Our project is an attempt to make lives of the people suffering from this phenomenon simple and by simpler we mean self-reliant, which will thereby reinstate their confidence and their happiness. The idea is to create an eye monitored system which allows movement of the patient's wheelchair depending on the eye movements. We know that quadriplegic patients can only move their eyes thus presenting an opportunity for detecting those movements. We have created a device where a patient sitting on the wheel chair assembly looking directly at the camera, is able to move in a direction just by looking in that direction. The system is cost effective and thus can be used by patients spread over a large economy range.

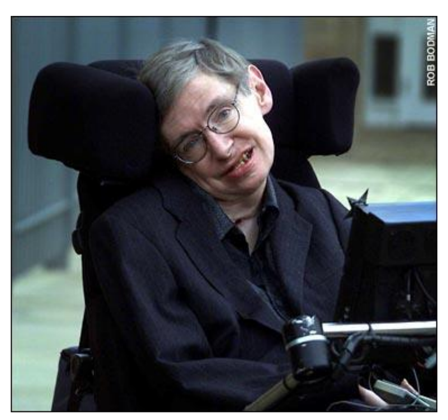

Fig. 1: Person suffering from quadriplegia

High level Design

There are two major components from the system design standpoint -
a) Eye-Detection and motion tracking.
b) ATMega1284P controlled Wheel Chair Assembly.

Eye-Detection and Motion Tracking -
A webcam is mounted on a cap, continuously staring at the patient's eyes. The webcam wired to the patient's laptop, is running a MATLAB application designed to monitor and react to eye movements. Based on a series of snapshots taken and thereafter processed, the motion of the user's eyes are detected, decision to move the Wheel Chair in a particular direction is taken and communicated serially to ATMega1284P microcontroller. MATLAB 2013, has a image processing toolbox which we utilized for the eye detection. We used the 'CascadeObjectDetector' capable of detecting eye-shaped objects based on their shape and size. It uses the Viola Jones Algorithm for the same.
Continuous snapshots of every 25th frame are taken and feature points extracted are saved. Based on the position of the feature points in previous snapshot and current snapshot, a movement is detected and this is communicated to the wheelchair assembly via the serial port.

ATMega1284P controlled Wheel Chair Assembly -
A decision based on the processing done by the MATLAB application is communicated and received by the ATMega1284P. The controller on reception forces the port pin high on which the motors have been connected for desired motion of the Wheel Chair.

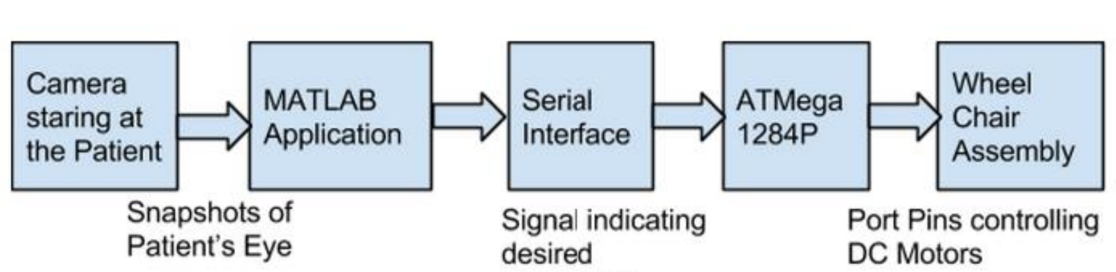

Fig. 2: High level System design

Code Structure

There are two parts in the code structure. The first part is to detect the eye movements and the other part is to drive the motors. The code structure can be explained in the following steps:

1. ***Initialization*** : Initially we set up the serial communication that will be used later for the interface between MATLAB and the controller, the video capture and the program variables.
2. ***Image and Video Processing*** : We then take continuous video frames and sample the input and save it as the screen shots. Each frame is then converted into the black and white frames. For the accurate results, we perform contrast stretching on each frames to make the dark region darker and bright region brighter. This will enable the detection of the eyes better.
3. ***Estimation*** : Now, after working on the each frame we try to detect the eyes. This we do by estimating the position of left as well as the right eye. Thus, we set the threshold and detect the position of the eyes which can be used for the further processing.
4. ***Detection*** : Now, in this step we actually detect the eye movements. The idea is to compare the current position of the eye with the previous position. Thus, the difference in the coordinates will help us to predict the motion in the particular eye. But sometimes, it may be possible that only one of the either eye will be detected. In that case, we will give preference to the eye that is detected currently.

Fig. 3: Eye detection using Web cam

5. ***Motion*** : Now after detecting the eye movements, we have to come up with a decision algorithm that will help the controller to drive the motors accordingly:
a. Valid Left: The decision to turn left will be considered as valid if the eye turns left and stays there for a cycle. This action will be detected as a left turn request. After that, the patient will turn right to again look forward. Thus, this signal should be considered as void.
b. Valid Right: Similarly, the decision to turn right will be considered as valid if the eye turns right and stays there for a cycle. This action will be detected as a right turn request. After that, the patient will turn left to again look forward. Thus, this signal should be considered as void.
c. Valid Straight: The signal to go straight is when a person looks left and right or right and then left. This will be detected as to go straight.
6. ***Serial Communication :*** Now according to the detected command, the MATLAB application will transmit 0,1 or 2 for left, right and straight respectively to the controller which will drive the motors.

Hardware Design

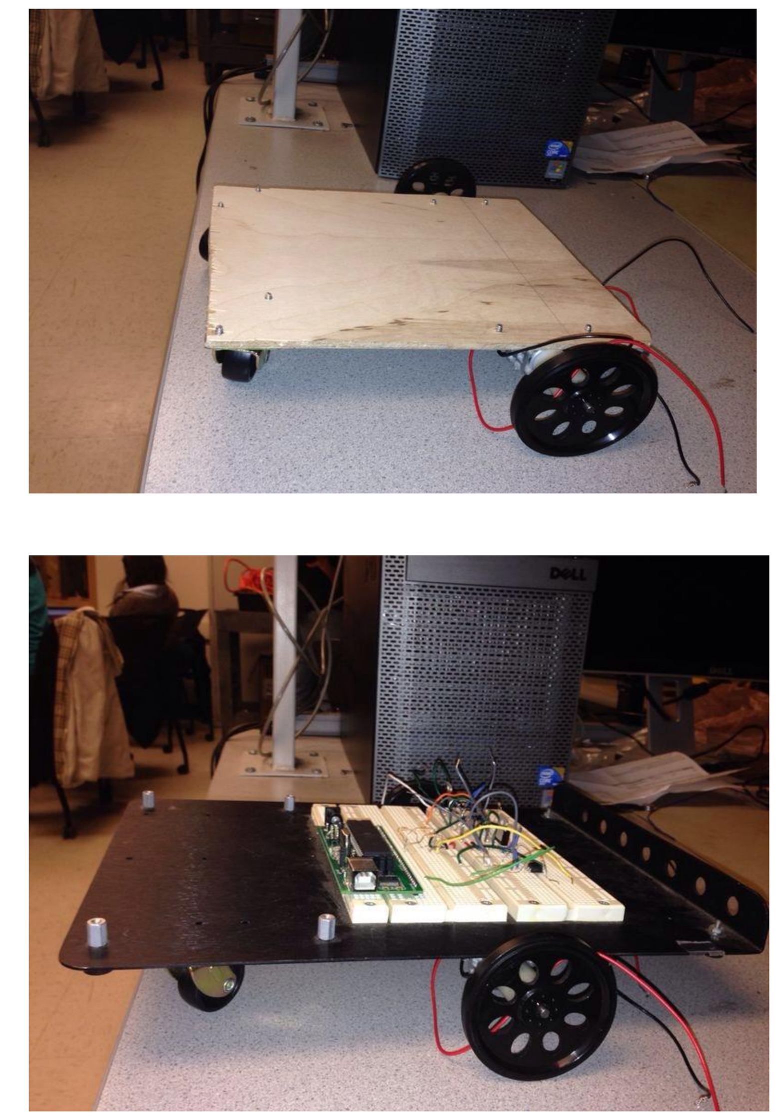

Fig. 4: Wheel chair prototype

We used the ATMega1284p controller for the system given the simplistic control of port pins and serial support, which was the basic requirement of our system.

Circuit diagram

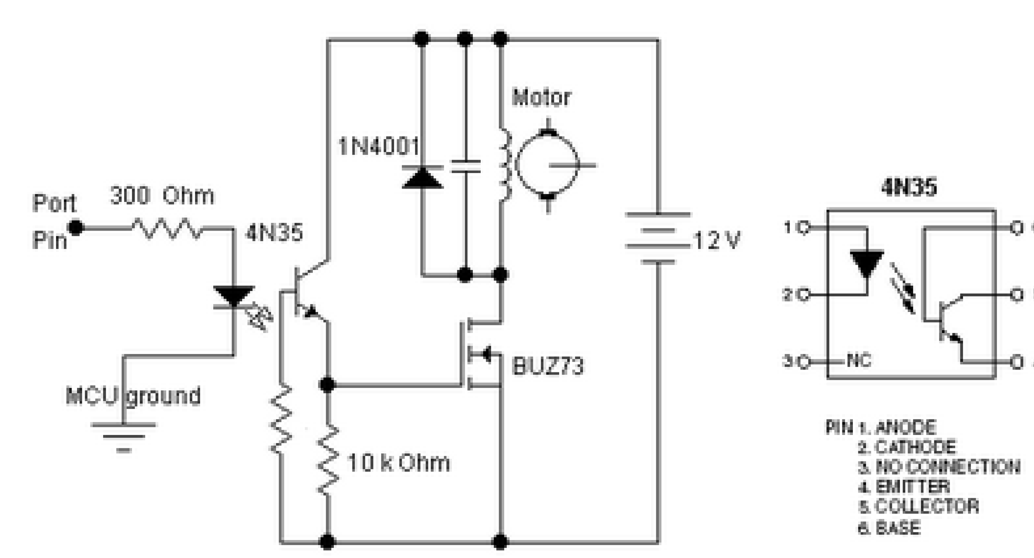

Fig. 5: Motor Driver Circuit

Testing

The initial software design had issues where it was detecting invalid eye signals. We used the height and length dimensions for an average human eye and thereby removed such detections affecting system performance.

For testing, we tried to print the Left Eye and Right Eye coordinates on the command window and display a rectangular box over both the eyes on the image window.

We also wanted to understand the system behavior, so at every right or left movement, it was shown on the command window. Also, the expected motor behavior is displayed, to test whether the actual behavior is in conjunction with the expected.

Results, Conclusions and Future work

The project performs satisfactorily with performance accuracy of around 70-90%. The results after testing it for 100 attempts to move in a random direction were made by both the project members. The results were tabulated as shown.

Name	Attempts	Successful Attempts	Accuracy
Ankur	200	172	86%
Darshan	100	76	76%

Fig. 6: Results

As this project is designed for patients, more safety features need to be taken care of. Also, certain mechanisms have to be defined to turn ON and turn OFF the detection system using eye movements. Moreover, future work can be done in the area of device control using similar detection mechanisms.

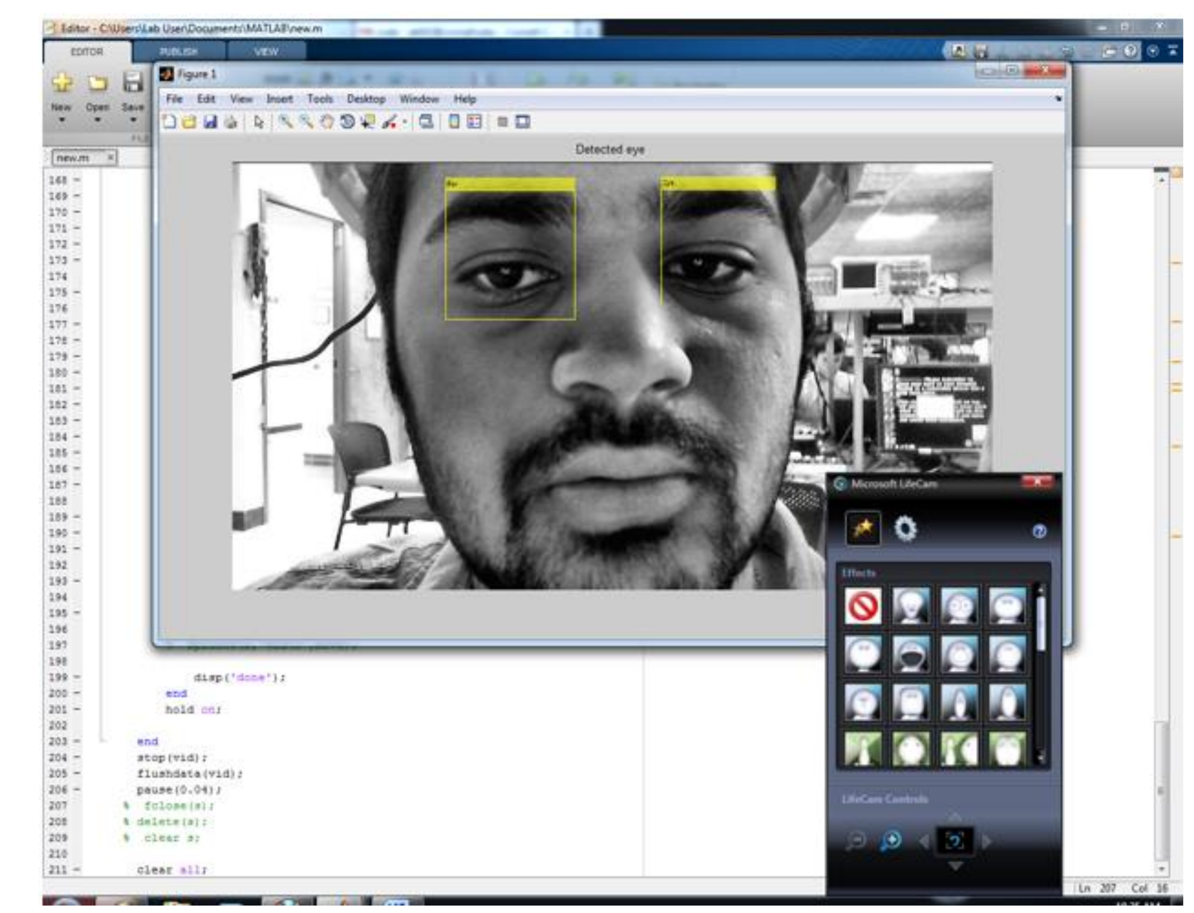

Fig. 7: Detection of Left and Right Eye

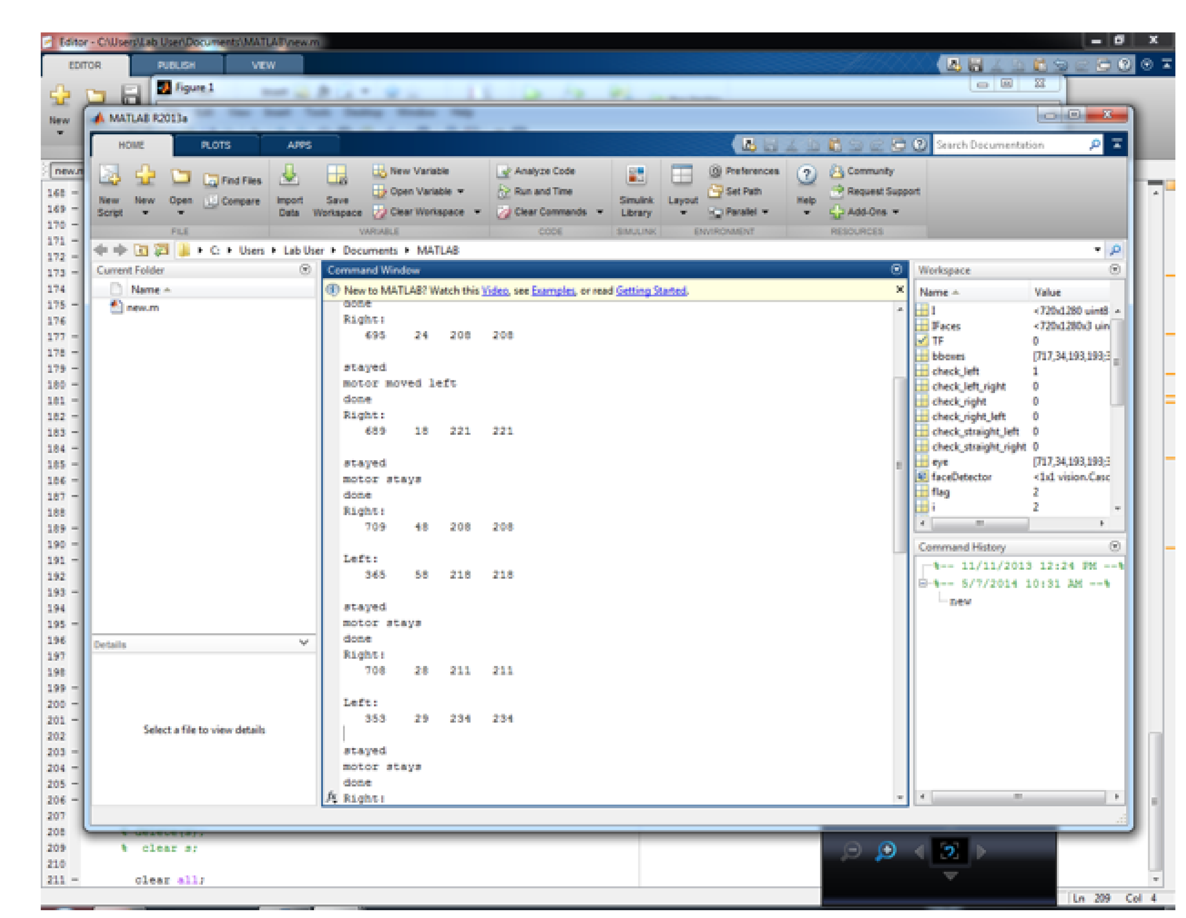

Fig. 8: Results showing the decision made by the algorihtm

Acknowledgement

We would like to acknowledge our advisor Prof.Bruce Land for the constant motivation and inspiration to think beyond the ordinary.