

Eye Gesture Controlled Wheel Chair

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Abstract: Eye gesture controlled wheelchair is an attempt to make the lives of people simpler, who are suffering from physical disorder. It an initiative to make their livelihood self-reliant, which will thereby reinstate their confidence and their happiness. The eye monitored system controls the movement of the patient's wheelchair depending on the eye movement. The device supports a patient sitting on the Wheel Chair assembly looking directly at the camera and can be able to move in the desired path just by looking in that specified direction. The camera signals are monitored by a MATLAB script, which will then guide the motors wired to the Microcontroller over the ZIGBEE to move in a particular direction. The system is cost effective and thus can be used by patients spread over a large economy range. The features provided are sufficiently affordable for middle class people and ultimately has been a contribution to the society.

Keywords—MATLAB script, movements, physical disorders, eye monitored system, particular direction.

I. INTRODUCTION

The number of persons who are paralyzed and therefore dependent on others due to loss of self-mobility is growing with the population. The development of the wheel chair for paralyzed users is surprisingly recent starting with the conventional manually powered wheel chairs and advancing to electrical wheel chairs. Conventional wheel chairs tend to focus exclusively on manual use which use which include users able to use their hands and exclude those unable to do so. Diseases or accidents injuring the nervous system also frequently because people lose their ability to move their voluntary muscle. Some voluntary muscle is the main actuator enabling people to move their body, paralysis may cause a person not move their locomotors organ such as arm, leg and others.

Scientist Stephen W. Hawking is perhaps the most well-known victim of major paralysis. Hawking was diagnosed with incurable Amyotrophic Lateral Sclerosis (ALS) in 1962, thereafter using a wheel chair to move. Many of those suffering close to or complete paralysis usually however still can control their eye movement which inspired us to develop an eye controlled electric wheel chair. The idea of an eye-monitored wheel chair was inspired by a past project voice based wheel chair where the voice of the handicapped person were used to guide the wheel chair in the desired direction. Quadriplegia is paralysis caused by illness or injury to the humans that results in partial or complete loss of limbs and torso. Its a phenomenon which confines the ability of a person to move by himself, and he has to rely on someone to carry

him around. Researchers suggest that this leads to a drop in the self-reliance of these people. We realized that technology can intervene and help reinstate confidence of people suffering from Quadriplegia, by creating a medium, through which they can move at will. The complexity lies in the fact that they may be able to move only their eyes and partially their head.

Hence the idea of eye gesture controlled wheel chair was developed of making the system completely isolated from the person physically, and extend the usability of the system to a person suffering from quadriplegia. Here the camera is used to acquire user images and to control the movement of the wheel chair in the desired direction.

II. PROPOSED IDEA

The basic steps involved in controlling the wheel chair using eye-gesture are as follows:

- 1) Capturing the image of the eyes.
- 2) Locating eye position using matlab algorithm.
- 3) Use gradient features and Haar classifier for detection.
- 4) Interfacing the matlab results with hardware.
- 5) According to the

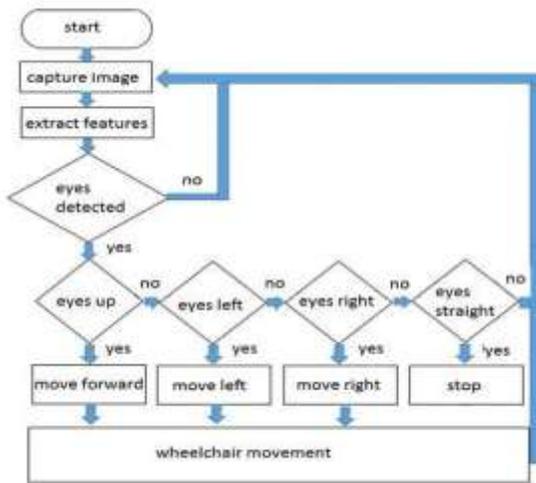


Fig. 1. Flow chart for wheelchair control

There are two major components from the system design standpoint:

- 1) Eye-Detection and motion tracking.
- 2) AT89S52 microcontroller controlled Wheel Chair Assembly.

A. EYE-DETECTION AND MOTION TRACKING

The laptop camera is continuously stares at the user's eyes.

The laptop is running a MATLAB application designed to monitor and respond to eye movements. Based on a series of snapshots taken and thereafter processed, the motion of the users eyes are detected, decision to move the Wheel Chair in a particular direction is taken and communicated serially to microcontroller AT89S52. MATLAB 7.0.1 has an image processing toolbox which is utilized for the eye detection

The Cascade Object Detector is capable of detecting eye shaped objects based on their shape and size. It uses the Viola Jones Algorithm for the same. A description of the Algorithm is given in the software section of the report. Continuous snapshots of every 25th frame are taken and feature points extracted are saved i.e. approximately 1 snapshot every second is captured and processed. Based on the position of the feature points in previous snapshot and current snapshot, a movement is detected and this is communicated to the wheel chair assembly via the serial port.



Fig. 2. Eye detection using MATLAB interface screenshot

B. AT89S52 MICROCONTROLLER CONTROLLED WHEEL CHAIR ASSEMBLY

A decision based on the processing done by the MATLAB application is communicated and received by the c AT89S52. The controller on reception forces the port pin high on which the motors have been connected for desired motion of the Wheel Chair.

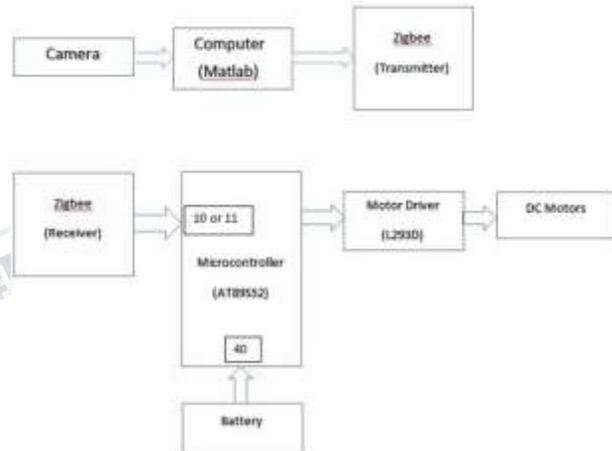


Fig. 3. Block diagram of the system

Working Principle: 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: Here 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.

5) Error Handling: To avoid detection errors, we incorporated an error handling mechanism, which specifies a threshold for the height and width of a valid eye, by calibrating it for the user. If the detection results give a height and width value lesser or greater than the threshold, the value is voided and not considered for the decision making.

6) 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. 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.

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.

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.

7) Safety Considerations: Given the application of the system, we incorporated a safety mechanism, wherein if the user wants to halt the wheel chair in case of an emergency, he can close his eyes, causing the wheel chair to halt.

8) Zigbee: Now according to the detected command, the MATLAB application will transmit 1, 3, 4 or 5 for forward, left, right and stop respectively to the controller which will drive the motors.

III. PROCESSING UNIT

A. MICROCONTROLLER [AT89S52]

The AT89S52 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). The on-chip Flash allows the program memory to be reprogrammed in-system or by a Conventional non-volatile memory programmer.

B. DC MOTOR

A DC motor is a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in part of the motor. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings.

C. DC Motor Driver

Motor driving of the rehabilitative aids, viz. wheel chair, is to be achieved by controlling two dc motors, placed at the right and left wheel of the device that can rotate independently of each other. The control signals generated by the right and left timers are to be fed to the right and left motor, respectively; via an appropriate motor driving circuitry. While, small test motors are used to validate the control signals generated by the setup; actual motors will be required to maneuvered rehabilitative aids. However, it must be noted that in such a case, no changes will be required to be made to the control setup, as the mere replacement of the motor driving circuit will suffice. IC L293D is used for driving the motors. In L293D, pin no. 2, 6 attains the inputs for left motor and 10, 15 attain the inputs for the right motor. The output to the left and right motor is given from the pins 3, 6 and 11, 14 respectively. Pins 4, 5, 12, 13 are connected to ground.

D. Motor Control

The signal that is obtained from the MATLAB script, and is then used to drive the motors. The MATLAB program does all the decision making for the motor to run

in the detected direction. So, the script sends the bit 4, 3, 1 and 5 for left, right, forward and stop respectively. The circuit shown below is fairly safe and used to drive the motors. An optoisolator completely isolates the microcontroller from the motor. The diode placed across the motor shorts out spikes when the motor is turned off. The resistor grounding the base of the phototransistor is set for best fall time, probably around 1Mohm. The motor capacitor should start around 0.1f. The pinout of the 4N35 optoisolator and BUZ73 are also shown. Note that the bandwidth of the 4N35 is very small, so we use a low PWM frequency is used, perhaps about 1000 Hz.

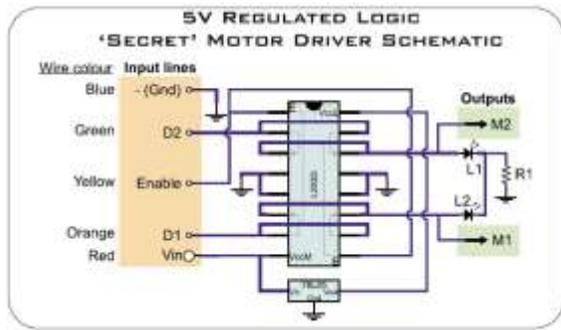


Fig. 4. Circuit diagram of L293D

E. ZIGBEE

The ZigBee Alliance is an association of companies working together to define an open global standard for making low power wireless networks. The intended outcome of ZigBee Alliance is to create a specification defining how to build different network topologies with data security features and interoperable application profiles. The association includes companies from a wide spectrum of categories, from chip manufactures to system integration companies. The name ZigBee is said to come from the domestic honeybee which uses a zigzag type of dance to communicate important information to other hive members. This communication dance (the "ZigBee Principle") is what engineers are trying to emulate with this protocol a bunch of separate and simple organisms that join together to tackle complex tasks.

1) Features of zigbee:

- 1) Supports Multiple Baud rates (9600)
- 2) Works on ISM band (2.4 GHz)
- 3) No complex wireless connection software or intimate knowledge of RF is required to connect serial devices
- 4) Designed to be as easy to use as cables
- 5) No external Antenna required
- 6) Plug and play device

- 7) Works on 5 DC supply
- 2) Specifications of zigbee:
 - 1) Input Voltage - 5Volts DC
 - 2) Baud Rate 9600
 - 3) RS 232 Interfaces and TTL Interface
 - 4) Range Max 30 Mtrs - Line of Sight
 - 5) Channels - 3 Ch-JP1 and JP2 - Ch1 On

F. Hardware interfacing

Here, port 0 and port 3 of ATMEL89S52 are used where port 3.0 and 3.1 is connected to the receiver and transmitter of zigbee respectively. Port 0.0, 0.1, 0.2 and 0.3 is connected to the motor 1(left motor) and motor 2(right motor) as the input for the motor .Pin 20 and 40 is connected to the ground and +5V respectively. Since, motor driver L293D is used to drive the motor in L293D, pin no. 2, 6 attains the inputs for left motor and 10, 15 attain the inputs for the right motor. The output to the left and right motor is given from the pins 3, 6 and 11, 14 respectively. Pins 4, 5, 12, 13 are connected to ground. The control logic is established as:

- 1) When the eyes are looking straight it means no movement.
- 2) When the eyes are moved to right and then straight, the dc motor is directed to move right and then stop.
- 3) When the eyes are moved left and then straight, the dc motor is directed to move left and then stop.
- 4) When the eyes are moved to right then straight and then again right and back to straight, the car is directed to move forward until it is stopped.
- 5) When the car is moving forward, if the eyes are moved to left then straight and then again left and back to straight, the car is directed to stop

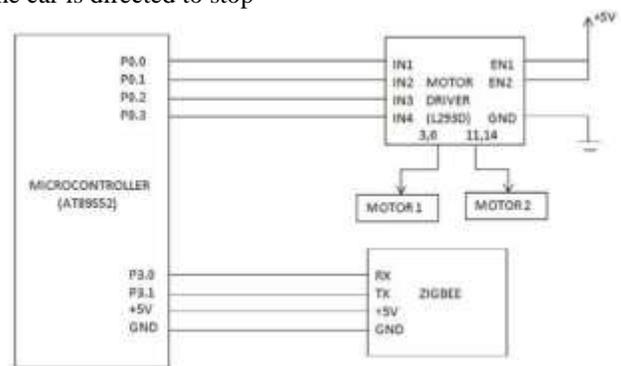


Fig. 5. Interfacing microcontroller with zigbee and Motor driver (L293D)

IV. SOFTWARE REQUIREMENTS

The webcam in the patients 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 users eyes are detected, decision to move the Wheel Chair in a particular direction is taken and communicated serially to ATMEL89S52 microcontroller.

A. MATLAB 7.0.1

It performs two functions namely:

1) Image Capturing Method : Image Capturing is to capture a series of iris images from the topic using a specially designed camera. In iris identification image capturing is a very important step. In sight of the fact that iris is small in size and dark in color, it is not easy to acquire good image. The image is then altered from RGB to gray level for more processing. It is to capture a series of iris images from the topic using a specifically arranged camera. A standard diameter of 12 mm camera is required to have sufficient motion to capture the details of the iris pattern.

2) Image Processing Method : The role of segmentation is to remove non useful information, exclusively the pupil part and the part outside the iris (sclera, eyelids, skin). Daugman recommended an Inter grow differential operator to position both the pupil and the iris outline. The algorithm will carry out the IRIS recognition in two phases. In the first phase, uses the facts that a pupil is a very dark blob of certain minimum size picture and no additional segment of continuous dark pixels are of the same size. The algorithm discovers the center of the pupil and the two radial coefficients as the pupil is constantly a perfect circle. The second algorithms receive the information of the pupil center and try to find direction in which the eye looks. MATLAB 7.0.1 has an image processing toolbox which is utilized for eye detection. The Cascade Object Detector 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 i.e. we capture approximately 1 snapshot every second and process it. The requirement of the design was to continuously look at different frames, based on which determine the motion. It is practically impossible to do a lot of processing on a per frame basis. That is why every 25th frame is sampled. So, a snapshot of every 25th frame is captured and processed. The get snapshot command to capture these snapshots. The image is then converted to grayscale image, as colour information is not needed to detect eye feature points.

The conversion in fact makes the detection easier. The misadjusts command is used then to contrast stretch the image to make darker sections even darker, enhancing the eye feature points useful for the application. Hence, pre-processing of the image makes the image easier to process and extract the eyes. After the initial pre-processing, next stage is the eye detection. The Eye Detection is done using the Viola-Jones Object Detection Algorithm. Primarily the algorithm was designated for face detection though it is used for all sorts of object detections. The algorithm is designed to work on sum of pixels in a rectangular area. Viola-Jones algorithm says that face can be detected by looking for rectangle and then the large rectangle is made up of many such smaller rectangles, which are fundamentally feature points on a human face. The cascade object detector in MATLAB, utilized this algorithm to extract and detect the eyes of the person. The detected eye is then showed by plotting the rectangle at the appropriate position of the eye.

B. Viola-Jones Algorithm for eye detection

The Viola-Jones object detection framework is the first object detection framework to provide competitive object detection rates in real-time proposed in 2001 by Paul Viola and Michael Jones. Although it can be trained to detect a variety of object classes, it was motivated primarily by the problem of face detection. The main characteristics of Viola-Jones algorithm which makes it a good detection algorithm are:

- 1) Robust very high detection rate (true-positive rate) and very low false-positive rate always.
- 2) Real time For practical applications at least 2 frames per second must be processed.
- 3) Face detection and not recognition - The goal is to distinguish faces from non-faces (face detection is the first step in the identification process).

The algorithm has mainly 4 stages:

- 1) HAAR Features Selection
- 2) Creating Integral Image
- 3) ADABOOST Training algorithm
- 4) Cascaded Classifiers

The features employed by the detection framework universally involve the sums of image pixels within rectangular areas. As such, they bear some resemblance to basic functions of HAAR, which have been

used previously in the realm of image-based object detection. However, since the features used by Viola and Jones all rely on more than one rectangular, they are generally more complex. The figure illustrates the four different types of features used in the framework. The value of any given feature is always simply the sum of the pixels within clear rectangles subtracted from the sum of the pixels within shaded rectangles. As is to be expected, rectangular features of this sort are rather primitive when compared to alternatives such as filters that are steerable. Although they are sensitive to vertical and horizontal features, their feedback is considerably coarser.

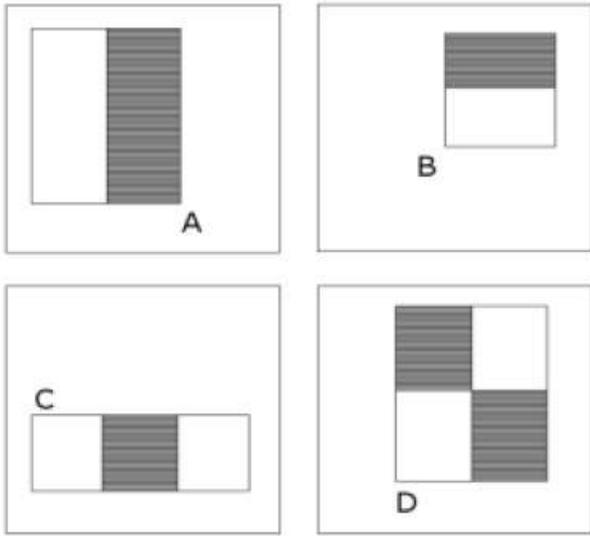


Fig. 6. Feature types used by Viola and Jones

V. HAAR FEATURES

All human faces share some similar properties. This knowledge is used to construct certain features known as Haar Features. The properties that are similar for a human face are:

- 1) The eyes region is darker than the upper-cheeks.
- 2) The nose bridge region is brighter than the eyes.

That is useful domain knowledge:

- 1) Location - Size: eyes and nose bridge region
- 2) Value: darker / brighter

The four features applied in this algorithm are applied onto a face and shown on the left. Rectangle features:

- 1) Value = (pixels in black area) - (pixels in white area)
- 2) Three types: two, three, four-rectangles, Viola and Jones used two-rectangle features. For example: the difference in

brightness between the white and black rectangles over a specific area

3) Each feature is related to a special location in the sub-window. However, with the use of an image representation called the rectangular features can be evaluated in constant time, which gives a considerable speed advantage over more sophisticated relatives.



Fig. 7. Haar Feature that looks similar to the eye region which is darker

Than the upper cheeks is applied onto a face

C. Kiel Vision4

Features:

1) The Vision4 Simulator is the only debugger that completely simulates all on-chip peripherals. Simulation capabilities may be expanded using the Advanced Simulation Interface (AGSI).

2) Vision4 incorporates project manager, editor, and debugger in a single environment.

3) The Vision4 Device Database automatically configures the development tools for the target microcontroller.

4) The Vision4 IDE integrates additional third-party tools like VCS, CASE, and FLASH/Device Programming.

5) The ULINK USB-JTAG Adapter supports both Debugging and Flash programming with configurable algorithm files.

6) Identical Target Debugger and Simulator User Interface.

7) The Code Coverage feature of the Vision4 Simulator provides statistical analysis of our program's execution.

D. Embedded C

When designing software for a smaller embedded system with the AT89S52, it is very common place to develop the entire product using assembly code. The trouble with projects done with assembly code is that it might be difficult to read and maintain, especially if they are not well commented. Use of a higher-level language like C can directly address these issues.

A program written in C is easier to read than an assembly program. Since a C program possesses greater

structure, it is easier to understand and maintain. Because of its modularity, a C program can better lend itself to reuse of code from project to project. The division of code into functions will force better structure of the software and lead to functions that can be taken from one project and used in another, thus reducing overall development time. A high order language such as C allows a developer to write code, which resembles a humans thought process more closely than does the equivalent assembly code.

By using a language like C, the programmer does not have to be intimately familiar with the architecture of the processor. This means that someone new to a given processor can get a project up and running quicker, since the internals and organization of the target processor do not have to be learned.

Additionally, code developed in C will be more portable to other systems than code developed in assembly. Many target processors have C compilers available, which support ANSI C. For time critical operations, assembly code is frequently the only way to go. One of the great things about the C language is that it allows we to perform low-level manipulations of the hardware if need be, yet provides we the functionality and abstraction of a higher order language.

E. Testing and Result Testing Strategy

The debug screen was the most useful aspect of our testing strategy. The debug screen showed whenever nothing was detected as a valid eye by the cascade object detector. When a valid eye is seen, the length, height, x and y pixel co-ordinates are displayed on the debug screen. This is done for every snapshot. After taking the difference between two snapshots, a tilt movement is indicated by either saying moved right or moved left. After determining if the motor has to be moved or not and before transmitting the serial signal, on the debug screen, the intended motion of the motor was indicated. This allowed to debug if any error. If the movement suggested on the debug screen and then movement of the wheel chair are in conjunction. This allowed to test consistently with ease. Speed of Execution The speed of execution was never actually limited. Up to 15 frames a second could have been taken, evaluating and determining the face tilt. But there were couple of issues because of which the speed of execution was limited. One being, the person should not get a jerk whenever he wants to move. Hence it was computed and drove the motor at a slow pace, as compared to the ability the speed could be executed. Also, there was an intent keep the system secure by taking a while to evaluate the movement and thereafter making a decision, given the criticality of the application.

NAME	ATTEMPTS	SUCCESSFUL ATTEMPTS	ACCURACY IN PERCENTAGE
Bishal	100	84	84
Pravallika	50	37	74
Ayushi	25	14	56
Bedayan	25	13	52

Fig. 8. User Performance Results

VI. RESULT

The proposed system performs satisfactory with performance accuracy of around 70-90 percent. The results after testing it for 100 to 200 attempts to move in a random direction were made. The results were tabulated as shown. Bishal and pravallika were trained about the system, because of which the accuracy is higher for them as compared to Ayushi and Bedayan. Accuracy could have been improved for Ayushi and Bedayan if they were trained to move their eyes in such a way that camera will detect with ease. Better lighting can improve the accuracy by providing brighter snapshots to process. The initial pre processing contrast stretches the image around the mean, which helps in improving the accuracy by making the detection more accurate. Successful attempts were counted as all those attempts which resulted in movement of the wheel chair in the desired direction. For the system to be accurate, each time a system is configured the person is to be trained in a way such that the height and length of the specified eye is recognized by the system and direction can be determined with high precision.

VII. ADVANTAGES, DISADVANTAGES AND APPLICATIONS

A. ADVANTAGES

- 1) The eye gesture controlled wheel chair is affordable for the middle class.
- 2) It can be controlled by the user independently.

B. DISADVANTAGES

- 1) Performance and accuracy depends on camera used, illumination conditions and environment levels.
- 2) Need further modifications and features to be incorporated for use by people with squint eyes.

C. APPLICATIONS

- 1) Alternative for conventional wheel chairs.
- 2) Can be extensively used for people with disabilities and chronic disease.

VIII. CONCLUSION

The eye gesture controlled wheel chair contributes to the society in a small way by setting out an idea for a system which could actually better the lives of millions of people across the globe. The system functions with an accuracy rate of approximate 75 percent. As test results suggest, the image capture, eye movement detection and the algorithm for validating movement performs very reliably.

FUTURE SCOPE

Though the prototype performs satisfactorily, but a ample work needs to be done before making the product commercially viable. Some sort of sequence of events should trigger start of detection, because the wheel chair should not move when the user is just casually glaring in different directions. Similarly, in future the wheel chair can be incorporated for people with squint eye. Also since the criticality of the application is high so safety precautions need to be maintained before making such a product a reality.

REFERENCES

- [1] S. Tameemsultana and N. Kali Saranya, Implementation of Head and Finger Movement Based Automatic Wheel Chair, Bonfring International Journal of Power Systems and Integrated Circuits, vol. 1, Special Issue, pp 48-51, December 2011.
- [2] Manuel Mazo, Francisco J. Rodriguez, Jose L, Lazaro, Jesus Urena, Juan C. Garcia, Enrique Santiso, Pedro Revenga and J. Jesus Garcia, Wheel chair for Physically Disabled People with Voice, Ultrasonic and Infrared Sensor Control , Autonomous Robots, vol.2, no. 3, pp. 203- 224 ,Sep 1995
- [3] Tabasum Shaikh, Naseem Farheen Sayyed, Shaheen Pathan, Review of Multilevel Controlled Wheel chair, 4th National Conference On Electronic Technologies, pp. 275-279, April 2013.
- [4] Chung-Hsien Kuo, Yi-Chang Chan, Hung-Chyun Chou, and Jia-Wun Siao, "Eye-glasses based electrooculography human-wheelchair interface," Proceedings of the IEEE 2009 International Conference on Systems, Man and Cybernetics, San Antonio, Texas, Oct 2009.
- [5] S.Yathunathan, L.D.R. Chandrasena, A. Umakanthan, V. Vasuki and S.R. Munasinghe, "Controlling a wheelchair by use of EOG signal," Proceedings of 4th IEEE International Conference on Information and Automation for Sustainability, Colombo, Srilanka, 2008
- [6] Chen Y, Newman W A human-robot interface based on electrooculography. In: Robotics and Automation, 2004. Proceedings. ICRA '04. 2004 IEEE International Conference on volume 1, 243 248 Vol.1, 2004
- [7] Sarangi, P., Grassi, V., Kumar, V., Okamoto, J.: Integrating Human Input with autonomous behaviors on an Intelligent Wheelchair Platform, Journal of IEEE Intelligent System, 22, 2, 33-41, [2007].
- [8] Barea, R., Boquete, L., Mazo, M., Lopez, E.: System for Assisted Mobility using Eye Movements based on Electrooculography, IEEE Transaction on Neural System and Rehabilitation Engineering, 10, 4,209-218, [2002].
- [9] Implementation of Wheelchair Controller using Eyeball Movement for Paralytic People, A.kamaraj, April -2013.
- [10] Matt Bailey, ET. Al, Development of Vision Based Navigation for a Robotic Wheelchair, in Proceedings of 2007 IEEE 10th International conference on rehabilitation robotics