

# Eye Controlled Wheelchair using LabVIEW

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**Abstract:** a powered wheel chair is a mobility aiding device for people with moderate or severe physical disabilities. In order to take care of different disabilities, various kinds of interfaces have been developed for powered wheelchair control: such as joystick control, head control, etc. Though there are many methods available in recent times to enable their motility, they require efficient and accurate control which is most of the times not possible. The proposed model is a possible alternative for this. This model is mainly aimed at the quadriplegic patients who are completely paralysed but have good eye coordination. In this project an IR camera is used to take the image of the eye which is then processed in LabVIEW to track the intended motion of the wheelchair. DC motors along with a motor driver is used to apply torque to the wheels so that direction control can be ensured. This model helps the completely paralysed person to have command over the wheelchair and its direction

**Keywords:** IR Camera, Model of Wheelchair, LabVIEW, DC motor

## I. INTRODUCTION

The ability to move freely is highly treasured by all people. However, it is sometimes difficult for a person with a physical disability. Paralysis can be either partial or complete. Paralysis of both the arms and legs is traditionally called quadriplegia. Quad is the Latin word for four and plegia comes from the Greek for inability to move. The major cause of quadriplegia is a spinal cord injury. The amount of impairment resulting from the injury depends on the part of the spinal cord injured and the extent of damage done. Injury to the spinal cord can be devastating because the brain and the spinal cord are the main parts of the central nervous system, which sends messages throughout your body. When the spinal cord is injured the brain cannot efficiently communicate with it and so sensation and movement are impaired. So such patients will have good control of their sense but will not be able to move. According to the National Spinal Cord Injury Statistical Center, the distribution of the causes of quadriplegia have changed drastically since 2010.

- Vehicular 38%
- Falls 30%
- Violence (mainly gunshot wounds) 14%
- Sports/Recreation Activities 9%
- Medical/Surgical 5%
- Other 4%

Researchers have estimated that, as of 2015, 12500 new quadriplegia cases have occur each year and between 240,000 and 337,000 people are currently living with SCI in the United States. For people who no longer have the use of their limbs and torso, life must be navigated using a powered wheelchair. A powered wheelchair is commercially available for disabled people, which generally requires considerable skill to operate. Most of the mobility aided device are interfaced with mouse, keyboard, and the other computer input devices. These computer input devices cannot be operated by differently abled person. In this paper, a computer input device by human eyes only is proposed for handicap person. The

existing computer input devices interfaced with wheelchair are categories as:

A. Bio-potential based method which utilizes body potential from the user by using special instrument. Instrument such as Electrooculography (EOG) [2], Electromyography (EMG), and Electroencephalograph (EEG) [3], Search coil can be used for measuring bio-potential energy. The search coil output can be used as sources of computer input for handicap person. The major defect is poor gaze direction accuracy compared to video tracker and this method is relatively costly relatively costly

B. Voice Based method [5], which use user's voice as source input. Voice analyser is used to analyse user's voice and convert into digital data. The major defect of this system is that it gets easily affected by noise. The accuracy is highly dependent on background noise, speaker variability, speaking style, sex of the speaker and the speed of speech.

C. Motion based method [6], utilizes other normal movement organs to operate computer input. Head, hand, foot, and etc. can be used to control computer input. This technique use of joystick to navigate, for a patient suffering from quadriplegia this is not useful as all the four limbs are impaired. Moreover, some disabled people cannot drive a powered wheelchair manually with a joystick, because they lack the physical ability to control the movement [10]. To enable a disabled person to drive a wheelchair safely and easily researchers have proposed several powered wheelchair systems, one such alternative is the eye gesture controlled. The powered wheelchair is designed in such a way that it can move freely without any external support. Through this feature the patients can facilitate movements of their wheelchair on their own [1]. One of the key essentials of the proposed system is detecting and tracking the eye movements. A spectacle mounted camera will track the eye movement and control

the wheelchair. The most challenging aspects lies in finding a good way to differentiate iris and pupil locations, to determine the eye movement, and controlling the wheelchair movement. A commercially available web camera is head-mounted on the user and it will track the eye movement of the user, actuating the wheelchair to go forward, stop, left or right. A computer or laptop mounted on the electric chair processes the captured image data, compare it with the real time image of eye and track the movements of the user’s eyes using LabVIEW. An Arduino board is used to interface LabVIEW to the electric wheelchair. This paper proposes a novel method for hands-free control of an electric powered wheelchair based on an eye movement. The rest of the paper is organized as follows. Section II presents the kinematic model of the wheelchair and Section III the gives the model of wheelchair motor. Finally, a brief conclusion and potential future work are given in Section IV

## II. KINEMATIC MODEL OF WHEELCHAIR

Figure1 shows a kinematic model of the wheelchair [12]. This Wheelchair has two pairs of diametrically opposed drive wheels (radius r) and free-wheeling castors. The drive wheels are actuate and sensed, while the castors are neither actuated nor sensed. Thus, the castor wheels are not considered in getting of kinematic and dynamic models [12].

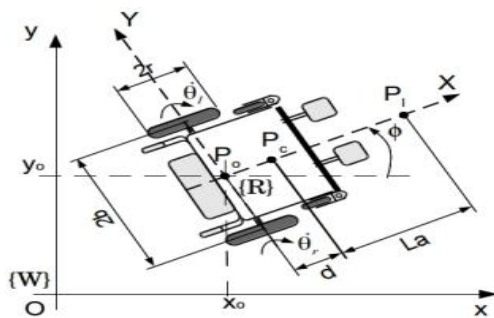


Figure 1: Wheelchair model with four driving wheels and four free wheels

P<sub>0</sub> defines the origin of the wheelchair coordinate system with coordinates (x<sub>0</sub>, y<sub>0</sub>). P<sub>c</sub> is the center of mass of the wheelchair with coordinates (x<sub>c</sub>, y<sub>c</sub>) and is placed in the X -axis at a distance d of P<sub>0</sub>. P<sub>1</sub> is a virtual reference point attached to the platform with coordinates (x<sub>1</sub>, y<sub>1</sub>) and is placed in the X -axis at a distance L<sub>a</sub> of P<sub>c</sub>. 2b is the length of the axis between the wheels of the mobile robot. Φ is the angle between x-axis of {W} and the X -axis of {R}. θ<sub>r</sub> and θ<sub>l</sub> are the angular velocities of the right and left wheels around the Y-axis [12]. The equilibrium of the wheelchair is maintained by two front free wheels and other two rear small wheels, whose effect it will ignore. Thus,

$$q = [x_c, y_c, \Phi, \theta_r, \theta_l] \quad (1)$$

Denotes the configuration of the system. In the kinematic model it is suppose that in each contact exist a pure rolling motion. Assuming that the velocity of P<sub>0</sub> must be in the

direction of the symmetry (X-axis) and the wheels do not slip, the following constraints set (m= 3), with respect to P<sub>c</sub>, is obtained [12]

$$\dot{y}_c \cos \Phi - \dot{x}_c \sin \Phi - \dot{\Phi}d = 0 \quad (2)$$

$$\dot{x}_c \cos \Phi + \dot{y}_c \sin \Phi + b\dot{\Phi} - r\dot{\theta}_r = 0 \quad (3)$$

$$\dot{x}_c \cos \Phi + \dot{y}_c \sin \Phi - b\dot{\Phi} - r\dot{\theta}_l = 0 \quad (4)$$

The equations can be written in the matrix form

$$A(q) \dot{q} = 0 \quad (5)$$

$$A(q) = \begin{bmatrix} -\sin \Phi & \cos \Phi & -d & 0 & 0 \\ -\cos \Phi & -\sin \Phi & -b & r & 0 \\ -\cos \Phi & -\sin \Phi & b & 0 & r \end{bmatrix} \quad (6)$$

Considering the wheelchair kinematics S (q) is defined by:

$$S(q) =$$

$$\begin{bmatrix} c(b \cos \Phi - d \sin \Phi) & c(b \cos \Phi + d \sin \Phi) \\ c(b \sin \Phi + d \cos \Phi) & c(b \sin \Phi - d \cos \Phi) \\ c & -c \\ 1 & 0 \\ 0 & 1 \end{bmatrix} \quad (7)$$

Satisfies the equation

$$A(q) S(q) = 0 \quad (8)$$

Where the constant  $c = r / (2b)$ . The kinematic model, is given by

$$\dot{q} = S(q) v(t) \quad (9)$$

## III. WHEELCHAIR DC MOTOR MODEL

To control a DC motor must have the mathematical model of the motor [13]. The mathematical model must be able to determine a relationship between the angular velocity of the rotor and its applied voltage. To get the input/output model of wheel DC motor, having as input the armature voltage and as output angular speed, we can write the steady-state mechanical and electrical variables:

$$\omega(t) = \frac{d\theta}{dt} \quad (11)$$

$$e_b(t) = K_b \frac{d\theta}{dt} \quad (12)$$

$$e_b(t) = R_a i_a(t) + L_a \frac{di_a}{dt} + e_b(t) \quad (13)$$

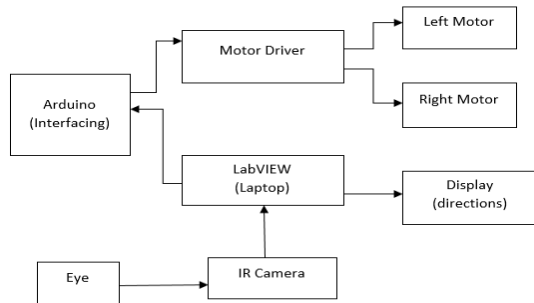
$$T_m(t) = K_t i_a(t) \quad (14)$$

$$T_m(t) = J \frac{d\omega}{dt} \quad (15)$$

Where, R<sub>a</sub> is armature resistance, L<sub>a</sub> is inductance armature T<sub>m</sub> is active torque, i<sub>a</sub> is current through the armature circuit; e<sub>a</sub> is input electromotive voltage, e<sub>b</sub> is counter electromotive voltage, ω is angular speed, J is moment of inertia of the motor shaft and K<sub>b</sub>, K<sub>t</sub> are motor

constants. It is used to drive DC motors rotating in either direction. And works on the concept of typical H-bridge, a circuit which allows the high voltage to be flown in either direction.

**IV. BLOCK DIAGRAM**



**A. IR Camera**

An IR camera attached head gear is used to take the image of the eye to detect the iris and track its movement. The IR light cannot be seen with our eye as it has a longer wavelength and a lower frequency than regular light. IR picks up how much heat an object or person has, since all life forms on earth puts on some form of IR light depending on its temperature. IR do not rely on reflected ambient light therefore thermal imagers are entirely ambient light-level independent. In addition, they also are able to penetrate obscurants such as smoke, fog and haze.

In all commercially available webcam there's the IR blocking filter to make the resulting images appeared as is seen by naked eye. by removing the IR blocking filter, the sensor becomes sensitive to IR light. Then you can see a mixture of visible and infrared light in the images. This enables the perfect distinguish between the pupil and the iris.



Figure 2: The image of eye in IR camera

**B. Motor driver**

It is used to drive DC motors rotating in either direction. And works on the concept of typical H-bridge, a circuit which allows the high voltage to be flown in either direction. Motor driver the L298 motor driver is used in this model to drive the motors .it is capable of driving two DC motors directionally.



Figure 3: L298 driver IC board

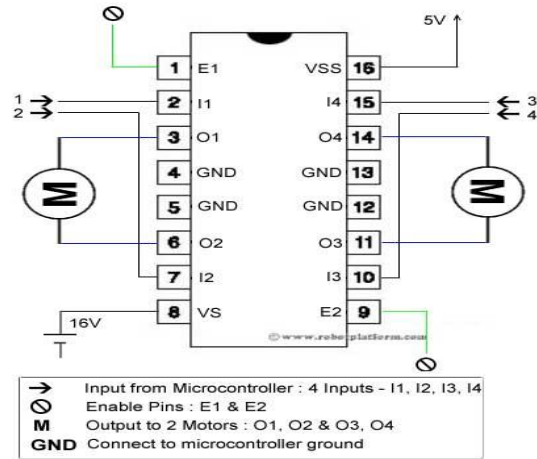


Figure 4: pin diagram of L293d

**C. DC Motors:**

DC Motors are used to create a movement in wheel of the wheelchair. Since the wheel chair requires to carry weight of the patient we need to use a high torque motor with a low rpm for safety reasons. The dc motor used have a torque of 10kgcm each so a total of 40kgcm can be attained. Since high speed application is not favoured in this application an rpm of 10 is used.

**V. SOFTWARE TOOL DESCRIPTION**

LabVIEW is a graphical programming language that uses icons instead of lines of text to create application. LabVIEW 2014 is the version used for this model. LabVIEW make use of G Programming Language. It is a Flowchart-like dataflow programming model, using which, you can quickly tie together data acquisition, analysis, and logical operations and understand how data is being modified. From a technical standpoint, G is a graphical dataflow language in which nodes (operations or functions) operate on data as soon as it becomes available. The “flow” of data through the application graphically with wires connecting the output of one node to the input of another. Hardware Support for thousands of hardware devices, including:

- Data acquisition devices
- Cameras
- Motors and actuators

For this project we have made use the NI Vision LabVIEW version 2014.the vision acquisition module of LabVIEW is used to capture the real time image of eye and to process it. The Arduino interfacing block is used to interface the LabVIEW to the motor driver and motor. The signal given to the motor is digital with the 0 indicating 0V and 1 indicating 12V

The input image from the IR camera is opened in LabVIEW. The area of interest, that is, the pupil is snapped from the image and saved as a template. Template matching is done with the real time image of eye to determine the direction of glaze.

The coordinates of the centre of the image is taken as the reference. The change in the position of pupil from this

reference is used to determine the direction. Upper limit and lower limit coordinates are set for the right and left directions and whenever the pupil template comes within this limit corresponding left and right direction is determined

**A. Snap Frame**

The major purpose of this section is to snap a region of interest (ROI) from the camera image and save it in a buffer.

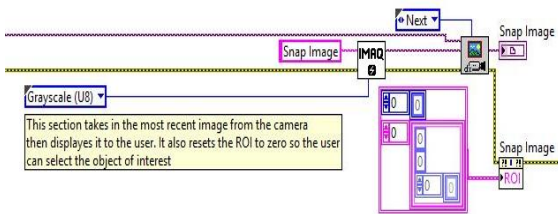
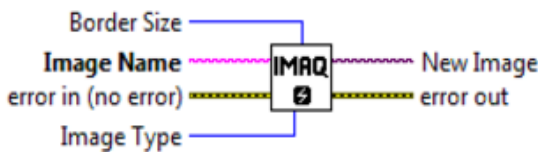


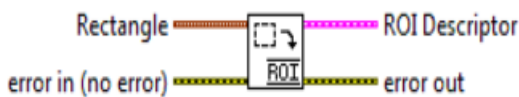
Figure 5:snapping the image

The blocks made use are:

i) IMAQ: Creates a temporary memory location for an image. Image Name is the name associated with the created image. Each image created must have a unique name referred by Image name. Image Type specifies the image type. We have chosen grayscale image as input image type



ii) ROI CONVERSION: Rectangle specifies a rectangular region. The Left, Top, Right, and Bottom coordinates describe a non-rotated rectangle. The Rotation parameter specifies the rotation angle of the rectangle around its center. The descriptor outputs the ROI. The x and y axis of the rectangle can be specified in the block.



After snapping the ROI is selected and the image is stored in a buffer as template.

**B. Learn template**

This section copies the snapped image and creates a template image. then gray scales the image and extract the user defined ROI. Learns the pattern of the template image.

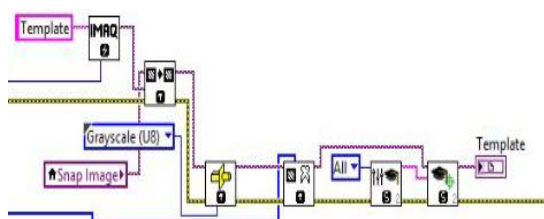
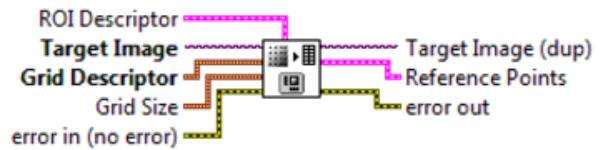


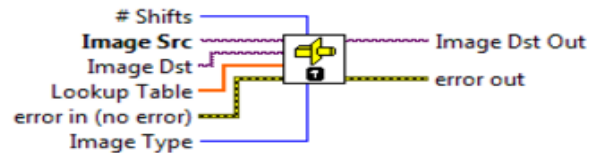
Figure 6:learning the template

The blocks utilized are:

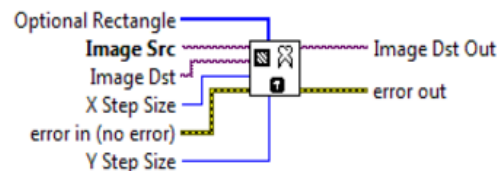
i) Calibration block:This creates a copy of the target image.



ii) Cast Image: Converts the current image type to the image type specified by Image Type. If a lookup table is specified, the IMAQ Cast Image VI converts the image using a lookup table. If converting from a 16-bit image to an 8-bit image, the VI executes this conversion by shifting the 16-bit pixel values to the right by the specified number of shift operations and then truncating to get an 8-bit value. Image Src is a reference to the source image. Image Type specifies the image type into which the input image is converted, here we used grayscale



iii) Extract: Extracts (reduces) an image or part of an image with adjustment of the horizontal and vertical resolution. Optional Rectangle defines a four-element array that contains the left, top, right, and bottom coordinates of the region to process. The right and bottom values are exclusive and lie outside the region



iv) IMAQ Setup Learn Pattern: Sets parameters used during the learning phase of pattern matching. Execute this block before the IMAQ Learn Pattern 2 block. Learn Mode specifies the invariance mode to use when learning the template pattern. All (0) Extracts template information for shift- and rotation-invariant matching. Learn Pattern Setup Data is a string that contains information about the setup parameters selected for the learning phase.



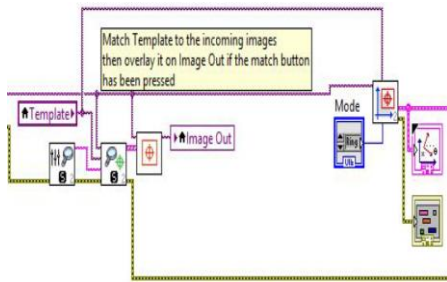
v) IMAQ Learn Pattern: Creates a description of the template image for which you want to search during the matching phase of pattern matching. This description data is appended to the input template image. During the matching phase, the template descriptor is extracted from the template image and used to search for the template in the inspection image. Image input is a reference to the template image for which

you want to search in the inspection image. Learn Pattern Setup Data is a string that contains information obtained from the IMAQ Setup Learn Pattern. If this input is not connected, the VI uses default parameters during the learning phase.

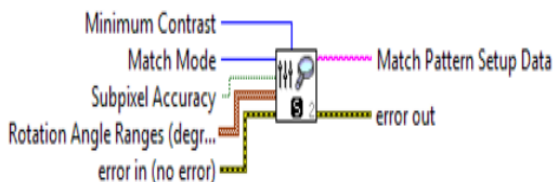


C. Match Template

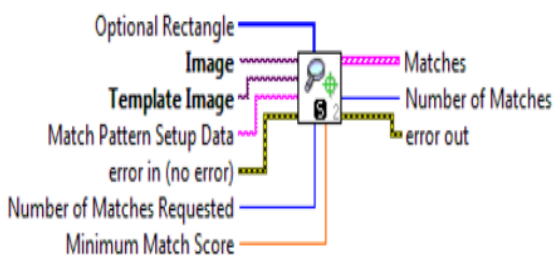
The template is matched with the incoming image and a rectangle box is overlay on the image if matched



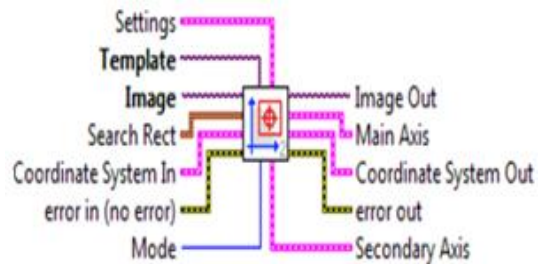
i) Match Setup Pattern: Sets parameters that are used during the matching phase of pattern matching. Execute this block before the IMAQ Match Pattern. Match Pattern Setup Data is a string that contains information about the setup parameters for the matching phase.



ii) Match Pattern: Searches for a pattern, or template image, in an inspection image. Run the IMAQ Learn Pattern before this block to configure the template image for the matching phase. Image is a reference to the inspection image in which you want to search for the template image. Template Image is a reference to the template for which you want to search during the matching phase. The template image is an output of the IMAQ Learn Pattern. Match Pattern Setup Data is a string that contains information from the IMAQ Setup Match Pattern. If this input is not connected, the VI uses default parameters.

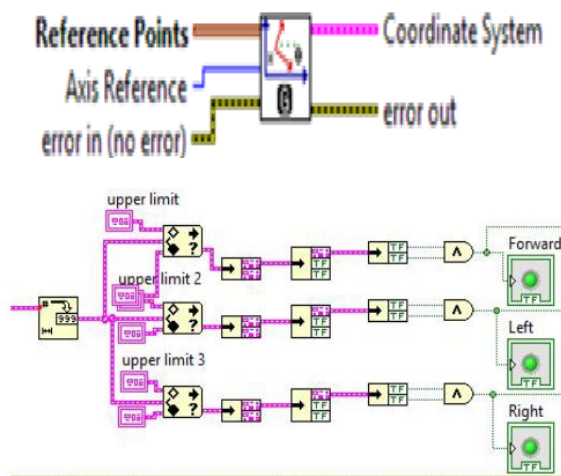


iii) Find Coordsys: Searches for a template image in a rectangular search area of the input Image. The VI uses the location and orientation of the template found to create the reference position of a coordinate system or to update the current location and orientation of an existing coordinate system. The VI has the capability to overlay on the returned image the position of the search area and the location and orientation of the coordinate system found. Match Mode specifies the technique to use when looking for the template pattern in the image. Template is a reference to the image to locate during the match process. The template image is the image obtained from the output of the IMAQ Learn Pattern 2 VI. If the template has not been learned, this VI first goes through the learning process. Image is a reference to the source image.



iv) Built Coordsys: Builds a reference for any arbitrary coordinate system with respect to the image plane. The reference of the coordinate system is specified as the position of the origin of the coordinate system, the orientation of its x-axis with respect to that of the image plane, and the direction of the axis.

Reference Points is an array of point clusters that define the coordinate system. If two points are specified, these points are assumed to lie along the x-axis of the coordinate system and the first point is used as the origin of the coordinate axis. Coordinate System specifies the coordinate system defined by Reference Points and the Axis Reference



The coordinate obtained is unbundled and the upper and lower limits for the different direction is set. When the template fall under the range set a Boolean signal is send to led which turns it corresponding led

## VI. SIMULATION AND RESULTS

A. The position of iris and pupil detected will be highlighted with the help of a circle as show below. And the position of the image is detected and the decision for the given below input image will be produced as Right.



Figure 7: Output when looking to right

B. The position of iris and pupil detected will be highlighted with the help of a circle as show below. And the position of the image is detected and the decision for the given below input image will be produced as Left.

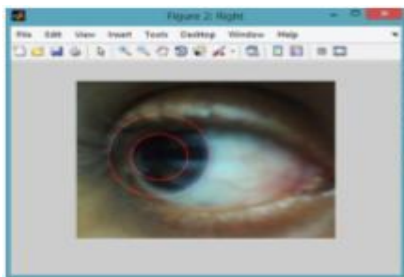


Figure 8: Output when looking to left

C. The position of iris and pupil detected will be highlighted with the help of a rectangle as show below. And the position of the image is detected and the decision for the given below input image will be produced as Forward

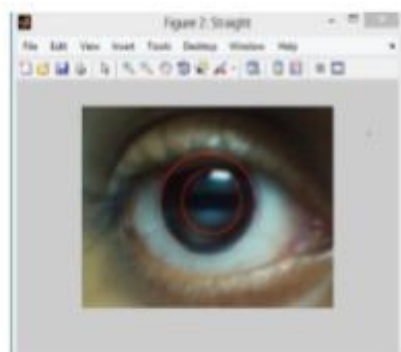


Figure 9: Output when looking forward

## VII. CONCLUSION AND FUTURE SCOPE

This paper has presented a wheelchair system using eye movements to help the differently abled people to move around freely on their own. The model make use of LabVIEW to track the eye and determine the direction of the glaze. This signal is then used to drive the motor in the desired direction. An ultrasonic sensor and alarm can be

incorporated into the powered wheelchair to detect obstacles in the path of the user and warn the user by ringing an alarm. to help the user to move in environments with ramps and doorways of little space an accelerometer can also be used to determine the inclination [10]. This project enables the disabled patients to move their wheelchair on their own without the help of any other person. However, the only drawback with this project is as the wheel chair requires eye-ball movement as input to the controller for its working, a lot of strain is created to the eyes.

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