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AUTOMATION OF WHEEL CHAIR USING ULTRASONICS AND BODY KINEMATICS

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Abstract— Physically disabled persons find their movements very tough with the existing assistive devices. Though there are many robotics available in recent times to enable their motility they require fine and accurate control which is most of the times not possible in cases of higher disability. These robots are very efficient and enable the user to move around with ease. In recent times there have been various control systems developing specialized for people with various disorders and disabilities. This paper reports the preliminary work in developing a robotic wheelchair system that involves the movement of eyeball and shoulder kinematics in directing the wheel chair. The system enables the patient to have command over the robot, its direction of movement and will also sense and alarm the user about the obstacles in the path to avoid collision. This wheelchair helps the patient to move in environments with ramps and doorways of little space. This work is based on previous research in robot path planning and mobile robotics, generally a robot should be interactive, and robotic wheelchairs must be highly interactive to enable the system to work most efficiently.

Keywords: eyeball control, wheel chair automation, rehabilitation, IR sensing, shoulder control, capacitive sensing, Hemiplegic rehabilitation, ultrasonic intruder sensing.

1. INTRODUCTION

Assistive robotics is improving the lifestyle of the physically challenged people to a great extent. In recent times there have been a wide range of assistive and guidance systems available in robotics to make their life less complicated and motile. These robots in are very efficient and enable the user to move around with ease. In recent times there have been various control systems developing specialized for people with various disorders and disabilities. The systems that are developed are highly competitive in replacing the old traditional systems.

There are many assistive systems using visual aids like videooculography systems, infrared oculography, eyeball sensing using electrooculography and much more. There are even systems based on voice recognition too. The basic assisting using voice control is to detect basic commands using joystick or tactile screen. These applications are quite popular among people with limited upper body motility. There are certain drawbacks in these systems. They cannot be used by people of higher disability because they require fine and accurate control which is most of the time not possible. This paper reports the preliminary work in developing a robotic wheelchair system that involves the movement of eyeball and shoulder kinematics in directing the wheel chair.

The system enables the patient to have command over the robot its direction of movement and will also sense and alarm the user about the obstacles in the path to avoid collision.

This wheelchair helps the user to move in environments with ramps and doorways of little space. This work is based on previous research in robotics, generally a robot should be interactive, and robotic wheelchairs must be highly interactive to enable the system to work most efficiently.

The whole paper is divided into the following sections. Section 2 describes the principle behind the eye ball sensing, Section 3 about principle behind the shoulder movements, Section 4 shows the ultrasonic intruder sensing mechanism. In Section 5 the overall control system is commented with results.

2. PRINCIPLE OF EYEBALL SENSING

The basic principle of this direction sensing is the colour of the eyes. There are two main colour pigments in the human eyes. i.e., black and white. The colours show different wavelengths in the spectrum. White being the farthest colour in emits the lowest wavelength. So the wavelength of white light is chosen as the standard parameter. White light can be measured by infrared sensors. The wavelength of the white portion if the eye varies from 600nm to 640 nm.[2] The infrared light ray measures and reflects the wavelength emitted by the white portion and based on that the eyeball sensor is constructed.

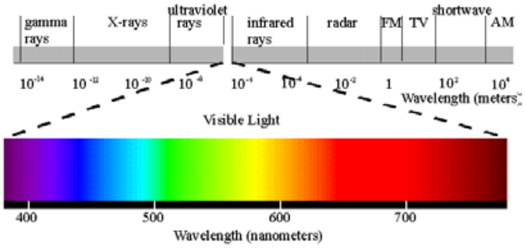


Figure 1: Electromagnetic Spectrum

The Infrared sensors are placed on either side of the eyes fixed in goggles. The whole circuitry is fitted inside a table-top instrument which is connected to the spectacles through a long flexible cable which performs the analysis, processing and amplification of the signals derived from the sensor's eye-ball movements. Both eyes are lit up by the energy from the Infrared Light-Emitting Diode (IRLED) sections. The silicon phototransistors and the IR sources are mounted in front of the eyes so that the obstruction of the field of view is minimized and the capability to accurately monitor the position of the eye is maintained

Figure 2: The Eyeball Sensor on goggles

SPECIFICATION:

- Supply 12v DC Ripple free
- Analog O/P 2-3v variation
- Repeatability 10%
- Switch O/P 100mA NPN switch
- LED indication for switch O/P

The Eye ball position is detected with reference to the Iris. Harmless 950nm wave length IR Transmitter and IR detectors are used to sense the position of the Eye ball. The Tx , Rx sensors are positioned in such a way to sense the position of Iris Up/Down, Left/Right

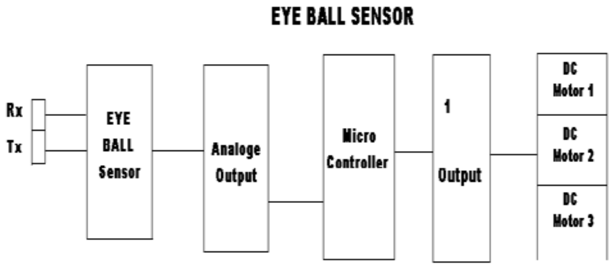


Figure 3: connectivity with wheel chair

3. PRINCIPLE OF SHOULDER SENSING

The overall block diagram of the project is

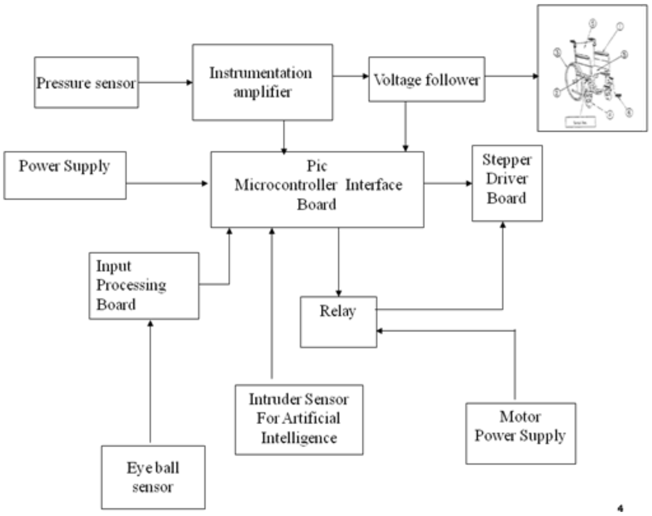


Figure 4: Overall block diagram of the intellichair.

This sensor is formed by two metallic electrodes wound on a non-metal tube with insulation between electrodes to form much like an open capacitor. These electrodes are placed in a feedback loop of a high frequency oscillator. When no material is present inside the tube, the sensor capacitance is low. Therefore, the oscillator amplitude is small. When any material is present, the capacitance value will increase resulting in increased amplitude of the oscillator. Depending on the dielectric constant of the material, the amplitude varies. The evaluating circuit will give the analog output proportional to the dielectric constant of the material.

The amplitude of oscillation is measured by an evaluating circuit that generates a signal to turn on or off the output.

SPECIFICATION

Supply voltage - 12v DC
O\P switching - 100mA
O\P analog - 6-12V DC
Hysterics - 10%
Dimension - 90*63*40mm

Capacitance is a function of the surface area of either electrode A or B, the distance between the electrodes (d) and the dielectric constant of the material (E) between the electrodes.

$$C = (E \times A)/d$$

Where C = capacitance of the sensor
A = surface area of either electrode
d = distance between two electrodes
E = dielectric constant of the material between the electrodes

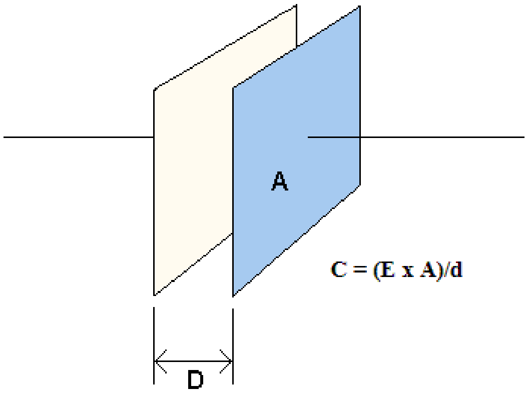


Figure 5: Capacitance principle

When the target approaches the sensor's field, it acts as an electrode to the face of the sensor, and decreases the distance between the electrodes (d), thereby it increases the average surface area of the electrodes.
The capacitance with a metal target is always greater than the capacitance of the circuit in the absence of the target. When a non conductive target enters the sensor's field, it acts as an electrical insulator between electrode A and B.
The dielectric constant of the material (E) is a measure of its insulation properties. All liquids and solids have a greater dielectric constant than air (E air =1). Therefore the capacitance with a nonmetallic target present is always greater than the capacitance of the circuit in the absence of the target.

Figure 6: Capacitance sensor (shoulder)

4. THE OVERALL CONTROL SYSTEM USING MOVEMENTS

The eyeball sensor is fitted on to the patient and the wavelength of white portion is recorded. Then when the patient wants to move right side, his left eye shows no variation in wavelength but in the left eye the black portion is sensed by the sensor which leads to decrease in the wavelength which automatically indicates to the wheel chair the direction it has to in. the same mechanism happens in the right eye too.

Figure 7: the overall view of the eyeball sensor

The wheel chair works in the mechanism of two input one output. Inputs from the eyeball sensor and the pressure sensor placed on the shoulder are taken and antagonistically and fed to the PIC microcontroller which is programmed to move across the direction required.

This intellichair is designed to help the paralyzed person who moves on a wheel chair, instead of the handicapped person moving the wheel chair by his hand, the chair will automatically move to a particular direction as the patient moves his eyes towards a direction, with the help of Eye ball movement detection sensor and lifts his shoulder by the shoulder sensor. The chair will also sense the obstacles in front of it and gives a beep sound and stop before it automatically. This is sensed by the ultrasonic sensor. The details regarding the construction of this chair includes the following

Model: A prototype model which symbolizes the wheel chair is constructed using the MS Sheet

Master Controller*:* A Micro controller will act as a master controller for the movement of the robot. It is responsible for all the decisions taken by the robot.

Eye ball Movement Sensor*:* This is used to sense the movement of the eye ball's direction and converts it into digital data and transfers it to the Master controller. (Straight Command, Left/Right Command, Stop Command)

Shoulder Movement Sensor*:* This is used to sense the movement of the shoulder. This is tuned to receive two commands i.e., up and down. This signal is transferred to the Master controller.

OptoCoupler with Stepper Driver Board. The need of Opt coupler is to isolate the Interface Board form the Stepper Motor to restrict any high voltage to the Interface board. And this board also contains stepper Driver circuit to amplify the Voltage and to withstand high current because the pulse coming out from the Interface is not tough enough to drive the Motor.

Stepper Power Supply. This board contains the power Supply for the stepper motor and relay driver.

Software Driver in Hitech C. This is a software tool used to control the angular position i.e., to send specified pulses with controlled timing to vary the speed as when and where require

Ultrasonic sensor*:* Ultrasonic sensor is another way to make non-contact distance measurements. It works by the principle of measuring the time a sound wave takes to propagate from the sensor, to an object and back to the sensor. They are generated by a transmitter and reflected by the target. The returning waves are detected by a receiver. The time delay is used to measure the distance to the object. The farther away an object is, the longer it takes the sound wave to propag

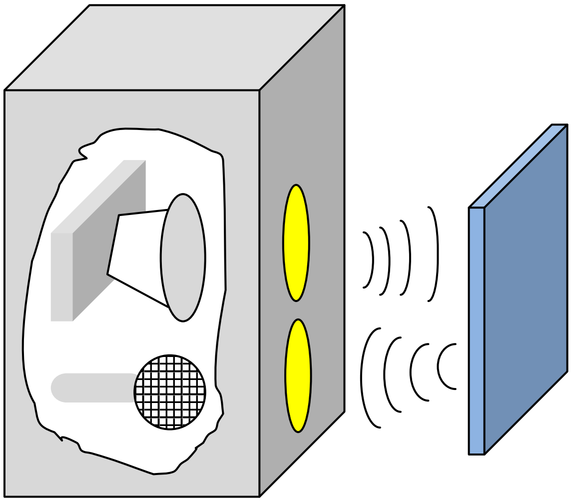


Figure8: Ultrasonic principle

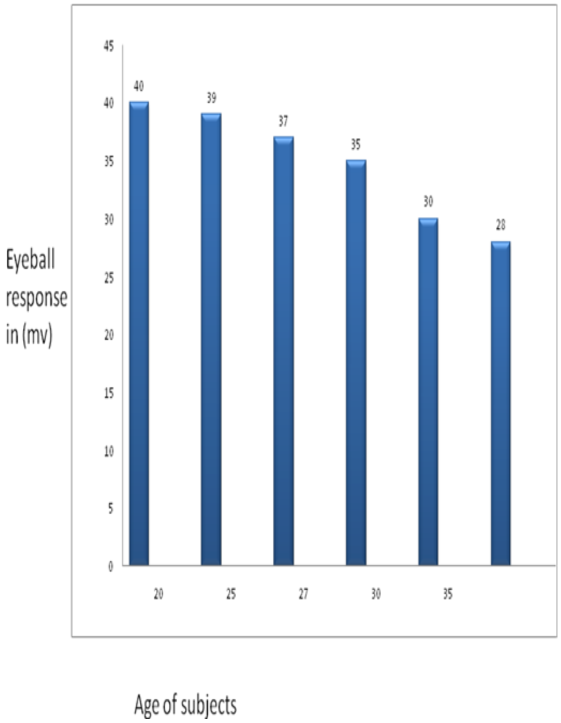
This sensor senses the obstacle in the way and stops 30 cm before it. So the wheel chair is fool proof against obstacles on the way of the wheel chair. This enables the disabled person to move freely around in the environment without any dangers. The patient can be left on their own to move freely in the limited area.

5 RESULTS:

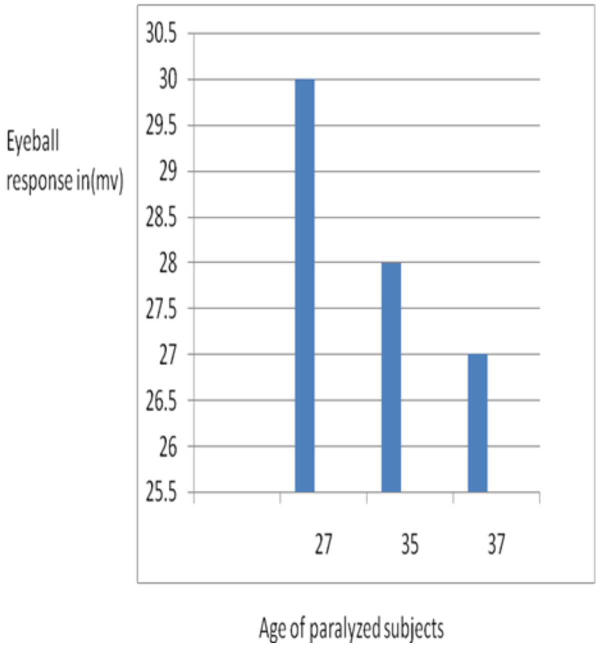
The eyeball sensor was tested with various samples against normal and hemiplegic patients. The following results were obtained, they were found to be almost stable and reliable.

Case 1:

Subjects of different age groups were subjected to the eye ball sensor and results are plotted.

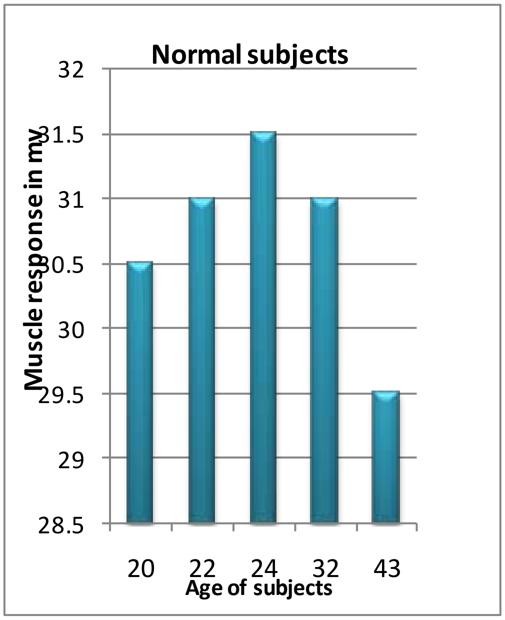


Case 2:
The eye ball sensor was tested on a hemiplegic patients and the results were plotted as

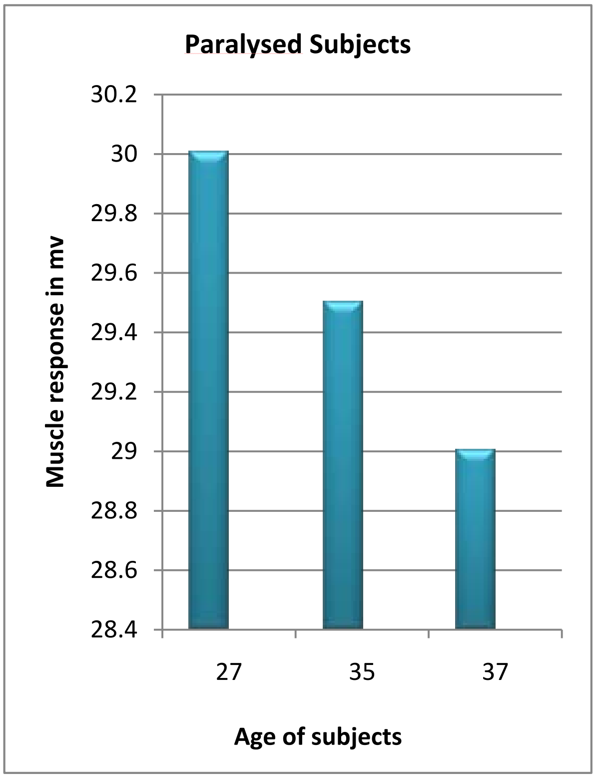


The shoulder sensor was tested with various samples against normal and hemiplegic patients. The following results were obtained, they were found to be almost stable and reliable.

Case 1(a):
Subjects of different age groups were subjected to the shoulder sensor and results are plotted.



Case 2: The shoulder sensor was tested on a hemiplegic patients and the results were plotted as



6.DISCUSSION

Based on the results obtained we conclude that the eyeball response and shoulder towards normal subjects and hemiplegic patients is very prominent and gives a wide range of movements. Thus the wheel chair moves in all required directions with good response.

- There is very slight variation in the responses of eye ball sensor in the case of normal subject to hemiplegic patient i.e., in the order of 0.5 mv
- There is no big difference in the shoulder sensor response when tested on normal subjects and patients i.e., the activity of the sensor depends on the muscle movement of the subject so the range can be narrowed according to the subject using the wheel chair.

7. CONCLUSION

This work forwards towards the development of a usable, low-cost assistive robotic wheelchair system for disabled people. This system can be used to control the handicapped, especially those with only eye-motor and shoulder coordination, to live more independent lives. Eye and shoulder movements and require minimal effort and allow direct selection techniques, this increase the response time and the rate of information flow. Some of the previous wheelchair robotics research are restricted a particular location and in many areas of robotics, environmental assumptions can be made that simplify the navigation problem. However, a person using a wheelchair and eyeball technique should not be limited by the device intended to assist them if the environment have accessible features.

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