Eyeball Motion and Joystick Controlled Wheelchair with Obstacle Detection

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***Abstract*- This project presents the 'eyeball Motion Controlled Wheelchair using IR Sensors for the elderly and differently abled people. In this eye tracking-based technology, two Proximity Infrared (IR) sensor modules are mounted on an eye frame to trace the movement of the iris. Since, IR sensors detect only white objects; a unique sequence of digital bits is generated corresponding to each eye movement. These signals are then processed via a micro controller IC (AVR328) to control the motors of the wheelchair. The potential and efficiency of previously developed rehabilitation systems that use head motion, voice recognition variedly have also been explored in detail. They were found to be inconvenient as they served either limited usability or non-affordability. This design consists of very minimal numbers of instruments used in order to make it cost-effective and it is also assisted with accelerometer sensor for handling properly.**

***Keywords*- Eye tracking technology, intelligent wheelchair, IR module, Accelerometer sensor, IR proximity sensor (Obstacle detection sensor).**

I. INTRODUCTION

Certain human senses are extremely useful in perspective of human coordination with externally attached supportive mechanisms and also use this senses in technology. So, use of eyes is one of the major section. For the paralyzed people who are unable to move most parts of their body, there should be a technology to make them independent. This project model is the locomotive guided by pupil movements, which makes even the severely handicapped person to locomote independently.

The ability to exercise freedom of mobility affects an individual's sense of dignity. If Census 2001 is to be believed, of the 2.1 percent of India's disabled, 0.6 percent is suffering from movement disability [1]. From last decade developments in medical aid for the people with any disability have been increased, which include either pharmaceutical aid or mechanical aid, which also include use of wheelchairs and other assisting equipment. Considering the average population its almost very difficult for much handicapped people to access or buy the modern equipment due to social and economic conditions. Since the patients have various disabilities ranging from severe to average, single design can't account for every patient, so a universal design with various features needs to be created.

Since most people use their assistive devices as the extension of themselves, its utmost important to create the device more comfortable to use. A large variety of electric powered wheelchairs that use different human machine interfaces (HMI) such as head motion, chin control, voice recognition and EEG signals, are available. Chin control technology uses a force-sensing joystick shaft that doesn't require very accurate head movements [3]. A little different direction of force each time suffices in moving the wheelchair in different directions. The force required is generally in the range of 0.2 to 0.8 pounds (0.09 to 0.3 kilograms) [3]. This technology can only be adopted by people possessing substantial strength in their neck muscles. Sip-n-puff devices are controlled by commands given by sipping (inhaling) and puffing (exhaling) on a pneumatic tube [4]. Sharp sips and puffs can be used to change the direction of the wheelchair while the steering can be accomplished by lower/softer levels of sips and puffs [4]. These devices are mainly equipped for speed maintaining and require a considerable accuracy in the sips and puffs each time. They are also limited by the fact that they require an external switch to start. The TTK (tongue touch keypad) is the only commercially available tongue controller system, it consists

of 9 switches built into the dental mouthpiece and fits in the roof of the mouth [5]. Users can adjust the wheelchair speed by touching the front and back pads variedly [5]. A major limitation of such a controller is that they have to be constantly removed before eating and even drinking water. It can prove to be a

discomfort to be constantly worn inside the mouth. EOG (electrooculography) technology measures the electric potential difference between the cornea and the pupil, with respect to a reference electrode placed on the forehead [6]. 5 more electrodes are placed near the eye to detect eyeball rotation [6]. A change of 20 microvolts is measured for each degree of eye movement [7]. Changing light conditions have negligent effect on EOG signals but they are prone to signal noise and drifting [8]. The variability of the electrooculogram reading depends on many difficult-to- measure factors such as perturbations caused by other biopotentials like EEG, ECG, EMG (electromyogram) [11]. plus, those caused due to the positioning of electrodes, skin- electrode contacts, lighting conditions, head movements, blinking, etc. [7], [10]. The major limitations are the barely deterministic variables measured in the human body as well as the persistent problem of the Midas's Touch the human eye is always ON [7]. As a result, everywhere the user looks, a command is activated. EOG control systems require a high degree of supervision [4]. VOG (video oculography) is another eye tracking system that uses head mounted cameras to analyse the gaze data and record the user's point of view [7]. The video images are the basis for estimating the working distance and gaze quality [9]. There are a number of issues that affect the quality of VOG tracking, such as droopy eyelids, squinting while smiling, varying light conditions, sweat and even make-up [3]. Since the eyes are connected to the balance organs in the inner ear it is necessary to observe the fine eye movements in various head positions, in order to make a correct diagnosis [7]. For accurate calculation of the gaze vector the user must be very still which can become quite uncomfortable [12]. The most advanced rehabilitation technology is perhaps the EEG (electro-encephalogram) controlled system that uses brain signals to calibrate the movement of the wheelchair [5]. Brain patterns are generated by attaching electrodes to the user's brains that map the signals such as if the user is thinking left motion, the wheelchair will move left [6]. A very advanced model based on EEG signals is the Intel connected wheelchair designed for the physicist Stephen Hawking. It can not only control mobility by thoughts but can also translate them into computer generated words. This Brain Computer Interface (BCI) acquires and analyses brain signals to calibrate the computer to the specific electrical signals generated by different thoughts [13], [14]. Though all these technologies are extremely advanced and useful but they aren't cost-effective, which remain a dream for poor population, so we have come up with cheap solution compared all these technologies.

II. WORKING AND EXPLANATION OF PROJECT COMPONENTS

Model consists of an Eye gear which has a pair of photosensors and infrared LEDs to detect the position of pupil, along with that the model has accelerometer sensor for another way to handle the system and has IR proximity sensor which works as obstacle detection. Infrared LED setup is interfaced with microcontroller, which then give the digital signals of pupil's position to the motor drivers of the wheelchair and the signals from accelerometer are also given to the microcontroller which get activated when the accelerometer mode is selected. Algorithms in the microcontroller guide the motor drivers respective of the pupil movement or accelerometer. Along with this, the wheelchair is accompanied with the obstacle sensor which ensured the safety of the wheelchair.

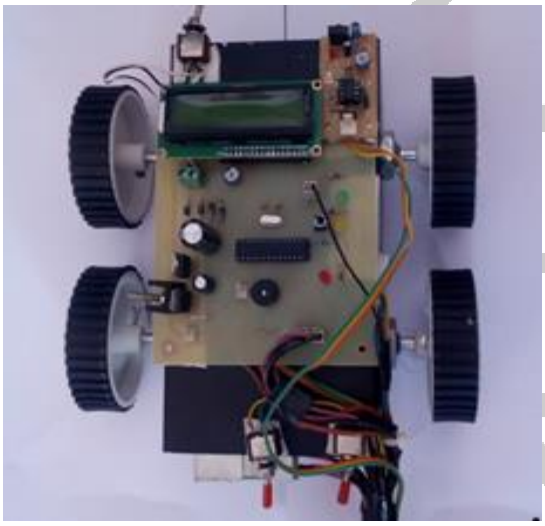


Fig. 1 Proposed Model

i. EYE MOUNTED FRAME

Eye-tracking involves the tracking of eye movements. It is a method to scan path of a person's gaze, while looking in a particular direction, is traced and recorded [6]. In other words, the angle of person's gaze is being measured. Eye tracking has been perceived to be a very accurate platform for the building of rehabilitation technologies due to the real-time actions taken by controller depending on eye movements. Eye records precisely what people percept and what not [7]. Most eye-trackers (headgear) are designed to detect saccades and fixations. Other types of eye movements that are a frequent occurrence are the smooth-pursuit (for tracking slow-moving visual targets), the vestibulocochlear reflex (for compensating head movements) and the vergence (for obtaining binocular vision) [7]. Tracking the eye movements is difficult in many systems, due to the minor and critical changes in the eye position, which makes tracking eye movement much more complicated. So, IR sensors remain a good option considering the accuracy and the cost. Though being appropriate choice compared to other devices, the IR sensors should be slowly handled for greater accuracy and proper functioning. The use of infrared technology in eye tracking helps in measuring and then simultaneously changing the vehicles directions guided by the person's gaze. In this proposed design, an eye mounted frame consisting of IR sensors has been developed that is worn like spectacles.

Two pairs of IR sensors have been drilled into the spectacle which is wore on eyes. Even single eye can give required signals but for proper accuracy the infrared sensors are mounted in front of both the eyes which in return assures exact command. IR sensor (transmitter) transmits the beam of rays into the eyes which is reflected back (from white iris of eye) is captured by photosensors which is accommodated on the spectacle itself. When beams bombard on black object (sclera of eye) the IR rays are absorbed by the eye and cannot be reflected resulting in null output. It was found that the accurate detection of the eyeball movements can be achieved by using two proximity IR sensor modules. For turning the wheelchair in right direction, the user has to look in extreme right and for left turn the user has to look in extreme left direction. When the gaze of the user is straight, the motion of the wheelchair is forward. To avoid the confusion between the blinking of eyes and the closed eyes, the system has been a given a delay of few microseconds (delay is slightly greater than the duration of the blink of eye). The signals after being received by the IR sensors are then fed to the AVR 328 micro-controller. AVR 328 microcontroller is preferred because the presence of an inbuilt ADC and several other features in the IC helps in less usage of peripherals. Along with this AVR 328 has inbuilt media storage. The proposed system is extremely cost-effective as well as efficient.

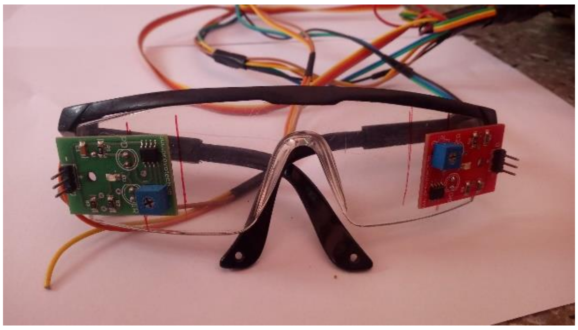
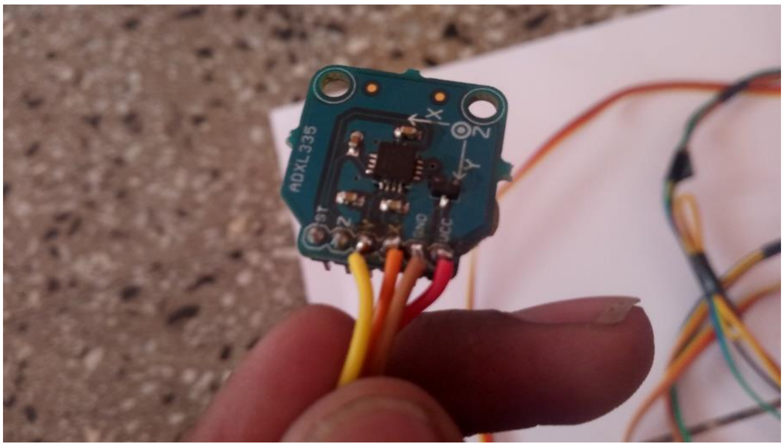


Fig. 2 Eye Mounted Frame

ii. ACCELEROMETER

For the patients who are less bed prone or less paralytic, another system has been added to the system. Accelerometer sensor has been added which can be converted into joystick or handheld device controller which is also a good alternative to IR based system. The proposed system has been put into two modes viz. headgear based and accelerometer-based system. After the selection of accelerometer mode, the controls of wheelchair totally get sent to the joystick. The accelerometer sensor is ADXL, which is excellent gravity sensed movement reacting sensor, which performs in two axes viz. x and y. The accelerometer is connected to hand and the wheelchair moves as per the movements of the hand.



Fig, 3 Accelerometer Sensor

iii. OBSTACLE DETECTION SENSOR

To assist both the eye-controlled and accelerometer-controlled inputs, there needs to be a supervisory system which would avoid any damage to the system as well as the user. though the inputs are given by the user (keeping in mind that the user is physically challenged) we have to provide the wheelchair with an obstacle detection sensor (IR proximity) which keeps an eye on any obstacle which would possibly become hurdle for the system. obstacle sensor makes the system to stop in case of any obstacle, which after some rounds of checking, resumes the working of wheelchair (after ensuring that there is no obstacle).

III. IC'S AND MODULES

1. MICROCONTROLLER (AVR328)

The Atmel 8-bit AVR RISC-based microcontroller combines 32 kB ISP flash memory with read-while-write capabilities, 1 kB EEPROM, 2 kB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. The device achieves throughput approaching 1 MIPS per MHz [2].

2. MOTOR DRIVER IC

Since motors require more current than the micro-controller. we use motor drivers as current amplifiers. L293D is a 16 pin micro-controller which allows DC motors to rotate in either direction. The maximum voltage supply is 36 volts. The raw signals are picked by three IR sensor modules, S1, S2 and S3, connected to the eyepiece, shown in Fig. 2. These signals are amplified and then sent to the ADC channels of PIC where they get converted to digital form.

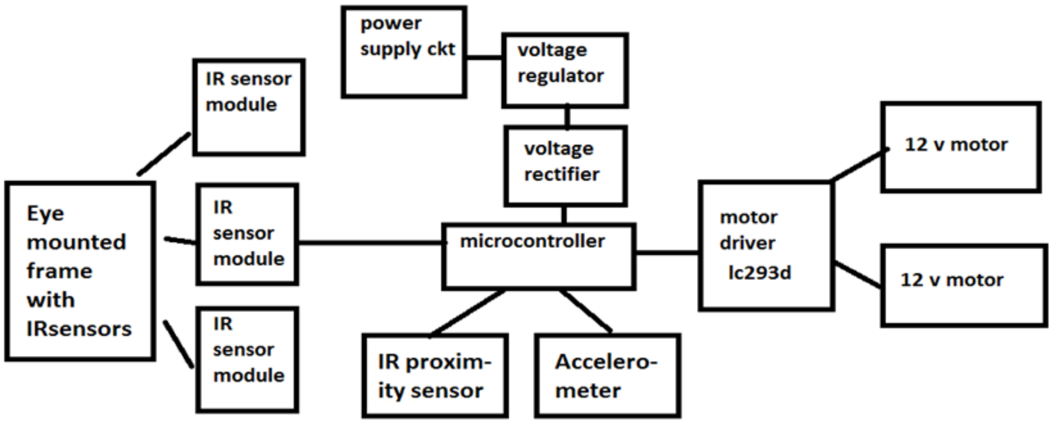
3. ADC MODULE

Built-in ADC (10 bit) of AVR is used for a precise estimation of an analog signal into a digital signal readily operational by the software burned into PIC.

IV. METHODOLOGY

When the gaze of the person is straight, sensor modules S1 and S2 give their outputs as 1, 1 because sclera is placed in front of them. As long as the micro-controller receives this signal the prototype moves forward. If S1 (right), S2 (left), are producing the output 1, 0 respectively which means that user is looking extreme right and thus the wheelchair will turn right. Until next command the device will move in same direction, when the command to turn left is initiated i.e. user looks to extreme left (S1=0, S2=1) the algorithm is followed and the wheelchair turns to its left. The flowchart for the control scheme is shown in Fig. 4. These transmitted signals when receive by the ADXL are used to activate and work the corresponding control algorithms.

V. BLOCK DIAGRAM



VI. CONCLUSION AND FUTURE SCOPE

The IR sensor based and accelerometer-based eye-motion tracking system can be used as basic infrastructure in future technologies such as home automation and medical essentials. The system can be used for wireless automation by using radio frequency modification in the circuitry. These signatures can then be used to generate control functions for individual home appliances. With various modifications and with help of future technology, the proposed method can also be successfully implemented in vehicle automation.

The steering of a vehicle can be controlled by motion of a person's eyeball. Thus, we have made a platform for demonstrating and testing eye-based interfaces at a very low cost and high efficiency which can be used on a large scale in various fields with accompanying accelerometer sensor.

Voice commands and future techniques like ATM iris-based security scanners can be added to the project with the help of Google API. Mobile operation can also be added to the functions list, so that surveillance can be kept on patient remotely. This system can also be used in unmanned vehicles, for remote access of the vehicles.

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