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Head & Eye Based Electrical Wheelchair Tracking & Control System

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Abstract - The market for a wheelchair is very wide as more than 600 million people who are suffering from some kind of disability or elderly people are in need of a wheelchair. Many from these people who are suffering from a disability have restricted body movements due to which they cannot use the traditional wheelchair. For people with moderate physical disabilities or long-term diseases as well as the elderly an alternative to a traditional wheelchair is a powered wheelchair, a mobility aided device. In order to tackle different disabilities, there are many different ideas that have been developed for powered wheelchair control like head control, joystick control and sip-puff control. Electric wheelchairs are designed to aid paraplegics. Unfortunately, these cannot be used by persons with higher degree of impairment, such as quadriplegics, i.e. persons that, due to age or illness, cannot move any of the body parts, except of the head. Medical devices designed to help them are very complicated, rare and expensive. In this paper a microcontroller system that enables standard electric wheelchair control by head motion is presented. The system comprises electronic and mechanic components. A novel head motion recognition technique based on accelerometer data processing is designed. The wheelchair joystick is controlled by the system's mechanical actuator. The system can be used with several different types of standard electric wheelchairs.

Key Words: Electric Wheelchair, Head Motion, Eye blink Monitoring, Automation System.

1. INTRODUCTION

Technology People suffering from disabilities are separated and do not get the same opportunities as the others from their own communities when their needs are not met due to their disability. There is a vast opportunity, by providing the wheelchairs for the purpose of their mobility it also helps them with a new perspective towards life and open up to a whole new world and opportunities. To follow on this the new steps to be taken are- the development of the national policies, expand training opportunities in the design field, production and supply of wheelchairs. Every single person to move freely is highly valued. So, to tackle this issue a suitable wheelchair which completely focuses on manual use and complete comfort of the user's choice? Due to any accident or disease which affects the nervous system often results in the loss of the ability to move their voluntary muscle. Locomotor organs like arms and legs, their movements can be risked if the suffer from paralysis, as the voluntary muscle is the main controller that enables to move the body. Electric wheelchairs are available for the use if any such incident occurs, they are controlled via a joystick but still there are many who can't use it due to their restricted hand movements. Designing a electric wheelchair which can function and be controlled by the movement (blinking) of eyes. Infrared sensor mounted on transparent glasses which is used to monitor the eye blinking so the person can control the movements of the wheelchair according his will. The aim of the project is to design this electric wheelchair to make live simpler. A computer mounted on the electric chair will receive the data from IR-sensor and then processes captured data, of detecting and tracking movements (blink) of the user's eye and then it will send a command to DC motors accordingly and turning the electric wheelchair in the desired direction which was indicated by the user's eye. In India out of the 1381.57 million population, 26.8 million persons are 'disabled which is 1.58% of the total population. 18.7 million people in rural areas and 8.1 million in urban areas. In the case of total population also, 69% are from rural areas while the remaining 31% lives in urban areas.

Head Motion Recognition Algorithm –

Since a set of possible motions in this case is very small, the number of available commands is also very limited. Thus, the control system that we propose allows the user to give only four different commands: "forward", "backward", "left" and "right". This means that the set of motions to be recognized has only four members. The implemented algorithm relies greatly on this fact. The meaning of each of the commands is relative and depends on the present wheelchair state, Fig. 2. Namely, we define six different wheelchair states: "state of still", "moving forward – 1st gear", "moving forward – 2nd gear", "moving backward", "rotating left" and "rotating right". If the wheelchair is in the "state of still", the command "forward" will put it in the state "moving forward – 1st gear", and the command "backward" will put it in the state "moving backward". On the other hand, if the wheelchair is in the state "moving forward – 1st gear", the command "forward" will put it in the state "moving forward – 2nd gear", and the command "backward" will put it in the state "state of still", i.e. stop the wheelchair. Analogously, if the wheelchair are in the state "moving backward", the command "forward" will stop it. Head motion recognition is based on the force measurements yielded by an accelerometer attached to the head. As mentioned, there are only four members of the motion set, which represent head leaned in four possible directions. This means that the algorithm needs to estimate when the head is leaned in one of the four directions. In other words, it is sufficient to read only the accelerometer data of two axes: in this case, x and y. The position of the accelerometer and the axes are defined in Fig. 3. The thresholds are accelerometer output values that the user defined at system startup. These represent the angles in all four directions by which the head needs to be leaned in order to issue a command to the system. These thresholds define borders of a region in three-dimensional space (Fig. 4) and the algorithm operation is based on estimating the head position relative to this region.

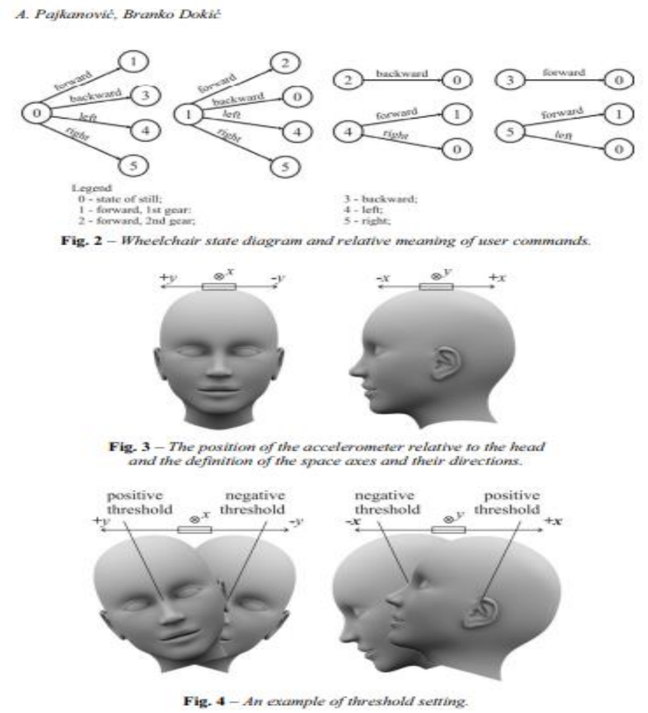

Fig -1: MEMS working method

1.2. LITERATURE REVIEW

1. Federal University of Esp´ırito Santo, Av. Fernando Ferrari, 514, Vitoria 29075-910, Brazil, "Wheelchair prototype controlled by position, speed and orientation using head movement", march 2021.
A prototype that simulates a wheelchair was built using electronic commercial devices and software implementation with the aim to operate the prototype using head movement and analyzing the system response. The controllers were simulated using MATLAB toolbox and PythonTM libraries. The mean time response of the system with manual control was 37,8 s. The mean orientation control response with constant speed was 36,5 s and the mean orientation control response with variable speed was 44,2 s in a specific route. The variable speed response is slower than constant speed due to head motion error. The system was rated such as" very good" by 10 participants using a System Usability Scale (SUS) [1].

2.Aleksandar Pajkanovic University of Banja Luka. "Wheelchair Control by Head Motion" feb 2013.
Electric wheelchairs are designed to aid paraplegics. Unfortunately, these can not be used by persons with higher degree of impairment, such as quadriplegics, i.e. persons that, due to age or illness, can not move any of the body parts, except of the head. Medical devices designed to help them are very complicated, rare and expensive. In this paper a microcontroller system that enables standard electric wheelchair control by head motion is presented. The system comprises electronic and mechanic components. A novel head motion recognition technique based on accelerometer data processing is designed. The wheelchair joystick is controlled by the system's mechanical actuator. The system can be used with several different types of standard electric wheelchairs. It is tested and verified through an experiment performed within this paper [2].

3.Sandeep Kumar Anna University, Chennai. "Design and development of head motion controlled wheelchair". May 2017.In the project is to design a wheelchair tilt communicator system that could operate the wheelchair of the handicapped person with the help of tilt of head movements. This system could be used by physically disable persons who cannot move their hands or legs but make head and eye motions.This wheelchair could be operated in any direction using head tilt movements by the handicapped person. Design and development of Head motion controlled wheelchair has been achieved using tilt sensors and wireless modules. The system is implemented practically and works well with a person sitting on it and has a weight bearing capacity of upto 100 kg. This wheelchairis aimed to be designed at a lower cost as compared to the other versions available in the market. The head motion controlled wheelchair designed using tilt communicator system turns out to be a great use for quadriplegic patients and disabled people having more than 45% or more disability as this could be operated easily through head gestures [3].
4.N Wanluk, S Visitsattapongse, A Juhong (2016). Smart wheelchair based on eye tracking. 2016 9th Biomedical Engineering International Conference (BMEiCON). doi: 10.1109/BMEiCON.2016.7859594 .

Smart wheelchair purely based on eye tracking is designed especially for people with locomotory disabled with additional remote control for simple electrical device to turn ON and OFF and to communicate via message with care taker or any other family persons. Here motion of the eye pupil is used as the control cursor on the raspberry PI where the image captured by webcam is processed using open CV customised image processing to drive in the direction of eyeball movement and also control module controls the manual control of the wheelchair for equipped appliance like small electrical switch and messages is being sent via smartphone to the caretaker [4].

5.MA Eid, N Giakoumidis, A El Saddik(2016). A novel eye-gaze-controlled wheelchair system for navigating unknown environments: case study with a person with ALS. IEEE Access (Volume: 4). doi: 10.1109/ACCESS.2016.2520093
In this paper for a person with propeller debilitated due to diseases like ALS (Amyotrophic Lateral Sclerosis). a Novel system is being proposed where the wheelchair is controlled through eye-gaze and in an unknown environment it provides

a continuous, real time navigation or target identification, path planning and navigation based on novel algorithm. A novel N-cell grid-based graphical user interface to input and output specification and a calibrating method to minimise the calibration overhead which is caused in eye tracking system. This proposed system is not only beneficial for only Amyotrophic Lateral Sclerosis (ALS) population but also for many paralysed population [5].

2. PROPOSED SYSTEM

The prototype of the microcontroller system comprises: sensor board with an accelerometer ADXL330 [21], development board EasyAVR4 with Atmega16 microcontroller [22] and a mechanical actuator. This accelerometer measures linear acceleration in all three axes within the ±3g range. The integrated circuit contains polysilicium sensor and the circuits required to shape the signal. The output signal voltages are proportional to the acceleration. However, different BATTERY CONTROL UNIT ATMEGA /ARM CORTEX Head Sensor Button (Snooze) LCD DISPLAY BUZZER GSM/WIFI MODULE Eye Sensor Motor Driver Motor Driver Left side motor Right side motor GPS SMS Ultrasonic Sensor manufacturers use different communication protocols or different messages within the same protocol. Often, these protocols are proprietary and, thus, unavailable to the public. So, in order to perform direct control of the wheelchair motors, the protocol and the messages need to be decoded. Such operation is highly time consuming and it does not offer modularity, since different wheelchair types use different protocols. Otto Bock Bx00 wheelchair family is taken into account during the design and production of the mechanical actuator. The dimensions of interest were measured on different types and then, the actuator is produced so that it fits to all of them. Also, it can be easily modified for more wheelchair types.

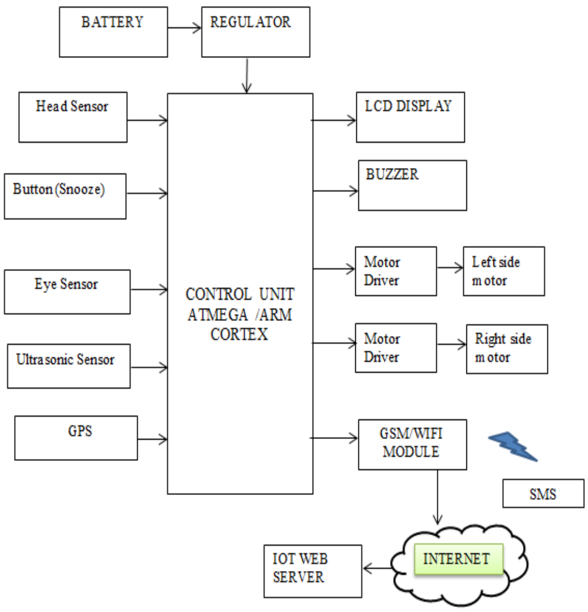

Fig -2: Block Diagram

2.1 ATmega2560 MICROCONTROLLER:

The Atmega 2560 microcontroller is a popular choice for many embedded systems projects. It is a high-performance, low-power microcontroller that is based on the 8-bit AVR RISC architecture. The Atmega 2560 has 256 KB of flash memory, 8 KB of SRAM, and 4 KB of EEPROM. It also has 86 GPIO pins, 32 general-purpose working registers, a real-time counter, six timer/counters with compare modes, PWM, four USARTs, a byte-oriented Two-Wire serial interface, a 16-channel 10-bit A/D converter, and a JTAG interface for on-chip debugging. The Atmega 2560 is also popular among hobbyists and makers, due to its low cost, ease of use, and wide range of available libraries and resources.

Fig -3: ATmega2560

2.2 Ultrasonic Sensor

Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing. The transducer of the sensor acts as a microphone to receive and send the ultrasonic sound. Our ultrasonic sensors, like many others, use a single transducer to send a pulse and to receive the echo. Typically, a microcontroller is used for communication with an ultrasonic sensor. To begin measuring the distance, the microcontroller sends a trigger signal to the ultrasonic sensor. The duty cycle of this trigger signal is 10µS for the HC-SR04 ultrasonic sensor.

Fig -4: Ultrasonic Sensor

2.3 MEMS SENSOR:

The term MEMS stands for micro-electro-mechanical systems. Whenever the tilt is applied to the MEMS sensor, then a balanced mass makes a difference within the electric potential. This can be measured like a change within capacitance. Then that signal can be changed to create a stable output signal in digital, 4-20mA or VDC.

Fig -5: MEMS Sensor

2.4. Eye Blink Sensor:

An eye blink sensor relies on infrared technology to detect if a person's eye is closed. The sensor is made up of two components: an infrared transmitter and an infrared receiver. The transmitter emits infrared waves onto the eye, while the receiver searches for changes in the reflected waves, indicating that the eye has blinked. To create an eye blink sensor with an Arduino, one requires an eye blink sensor, an Arduino board, and a switch between the power supply and the Arduino. The sensor has three pins: GND (ground), 5V, and OP (output). The sensor's output is transmitted to the Arduino board, which can be programmed to execute various tasks based on the output.

Fig -6: Eye Blink Sensor

2.5. LCD display:

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD.

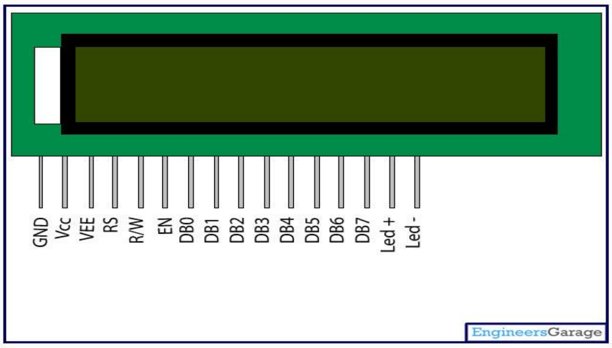

Fig -7: LCD Display

2.6. DC Motor:

"A DC motor is an electrical machine which converts electrical energy into mechanical energy. The basic working principle of the DC motor is that whenever a current carrying conductor places in the magnetic field, it experiences a mechanical force**.**

Fig -9: DC Motor

3. Result:

Here we successfully implemented "Head & eye Based Wheelchair control system with IOT". Photographs of actual hardware shown in fig 10.

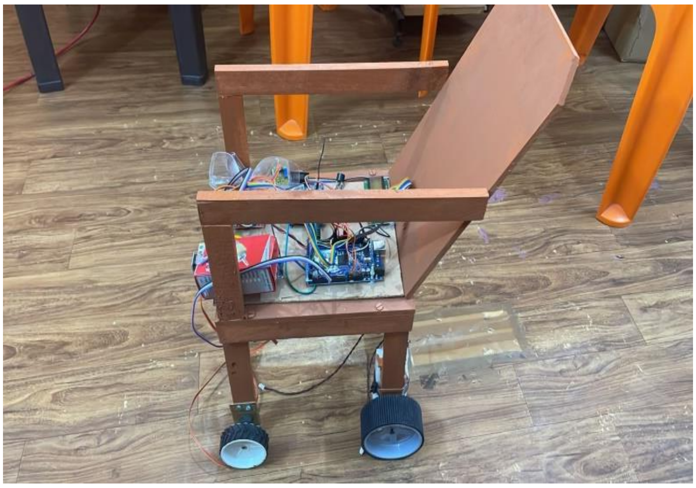

Fig -10: photograph of Project

4. CONCLUSIONS

The Head and Eye-Based Electrical Wheelchair Control System with IoT is a transformative innovation aimed at enhancing the quality of life for individuals with mobility impairments. This project successfully demonstrates the integration of cutting-edge technologies such as head and eye tracking sensors and IoT connectivity to create an intuitive and responsive control system for electric wheelchairs. By leveraging these technologies, users can navigate their wheelchairs with remarkable precision and minimal physical effort, promoting greater autonomy and social inclusion.

This project showcases the potential of emerging technologies to empower individuals with physical disabilities and improve their overall quality of life. It represents a promising step forward in assistive technology, providing a foundation for further research and development in the field. By combining innovative hardware and software solutions, the Head and Eye-Based Electrical Wheelchair Control System with IoT brings us closer to a more inclusive and accessible world for all.

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