International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 04 | April -2017 www.irjet.net p-ISSN: 2395-0072

Head Orientation Controlled Wheelchair

Rishi Prasad Sajeevan[1], Fasil Yousaf[2], Basil James[3], Jisha Kuruvilla P[4]

[123]*Students, Department of Electrical and Electronics Engineering, M.A. College of Engineering, Kothamangalam, Kerala, India*

[4]*Assistant Professor, Department of Electrical and Electronics Engineering, M.A. College of Engineering, Kothamangalam, Kerala, India*

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Abstract - *In this fast moving, avaricious world, people need to update and develop themselves. The world populace is increasing at a rapid rate and the people with disabilities are also increasing. Tetraplegia, also known as quadriplegia, is paralysis caused by illness or injury that results in the partial or total loss of use of all four limbs and torso; paraplegia is similar but does not affect the arms. The loss is usually sensory and motor, which means that both sensation and control are lost. This type of users suffering from quadriplegia requires special wheelchairs instead of using traditional ones that are controlled by joystick, since they are paralysed below their neck. In this paper, an innovative head orientation controlled wheelchair is proposed. The system use two head orientation detection units (Ultrasonic Sensors). Each unit includes ultrasonic transmitter and receiver which are combined together. The system uses a powerful microcontroller which detects the head position via the ultrasonic sensors and controls the motor rotation connected to the two wheels, thereby controlling the motion of wheelchair according to the movement of the head. An additional collision detection system is installed to improve the performance of the wheelchair system. This self-sufficient navigation ensures safety, suppleness, mobility and obstacle avoidance.*

Key Words: Head Movement, Navigation, Quadriplegia, Collision Detection, Orientation Detection, Ultrasonic.

1.INTRODUCTION

In this fast moving, avaricious world, people need to update and develop themselves. The world populace is increasing at a rapid rate and the people with disabilities are also increasing. They face many problems and need a support system for most of their activities. The most commonly available assistive system for people with disability in moving around, is a wheelchair. There are over 3.3 million people seeking the help of wheelchairs in the world. Quadriplegics however are not capable of using normal wheelchairs. The reasons quadriplegia can be different: stroke, arthritis, high blood pressure, degenerative diseases of bones and joints and cases of paralysis and birth defects. Also, quadriplegia can occur as a consequence of accidents or age. Quadriplegic patients are not able to perform their everyday actions, such as: feeding, toilet usage and movement. A quadriplegic patient cannot however use any of the existing wheelchair systems for moving around.

Rehabilitation engineering is the systematic application of engineering sciences to design, develop, adapt, test, evaluate, apply, and distribute technological solutions to problems confronted by individuals with disabilities. These individuals may have experienced brain trauma caused from things such as PTSD, shock, near death experiences, drug induced brain alteration, panic anxiety, or other chemical imbalances. Functional areas addressed through rehabilitation engineering may include mobility, communications, hearing, vision, and cognition, and activities associated with employment, independent living, education, and integration into the community. The wheelchair control is based on the movement of head.

Quadriplegic patients can move their head easily. So, a head orientation controlled wheelchair can be used to help quadriplegic patients use a wheelchair to move around. The main reason behind the implementation of this project is to give a helping hand for these physically challenged people. Powered wheelchairs play a crucial role in bringing freedom to the mobility impaired and allow people to get on with their activities of daily living. Many people who suffer from mobility impairments rely on powered wheelchairs to get out and about.

There are two types of medical devices that enable independent movement to a person suffering from paraplegia. Those are exoscelets and wheelchairs. Both of these contain electronic systems to enable and improve person's movement ability both in outdoor and indoor conditions. Electronic systems, such as sensors, actuators, communication modules and signal processing units, are used to recognize the activity that the patient is trying to perform and help him carry it out in coordination with the commands given. The application of the two mentioned devices are different. Wheelchair operation is based on navigation, which, in this case, is defined as safe transport from the starting point to a given destination. The wheelchair, comparing to the exoscelet, are a more general medical device and a much simpler one. Thus, the wheelchairs are used more often. Nevertheless, only patients with healthy upper extremities (paraplegics) can successfully operate standard electric wheelchairs. The patients who cannot use any of their extremities (quadriplegics) cannot operate these. In such cases, when the patient is not able to use the standard control interface, other approaches are used. In this project, a microcontroller system that enables standard electric wheelchair control by head motion is developed. A prototype of the system is implemented and experimentally tested. The prototype consists of the digital system (ultrasonic sensors and a microcontroller) and motors. The sensors are used to gather head motion data. To process the sensor data, a novel algorithm is implemented using a microcontroller. The output of the digital system is connected with the mechanical motors, which is used to drive the wheelchair in accordance with the user's command. Sensor data is processed by a novel algorithm, implemented within the microcontroller. Thus, user head motion is translated into mechanical movement of the motor.

2. METHODOLOGY

The Project uses ultrasonic sensors as the basic component for detecting the orientation of head of the user. The various components and their inter connections are shown in the block diagram.

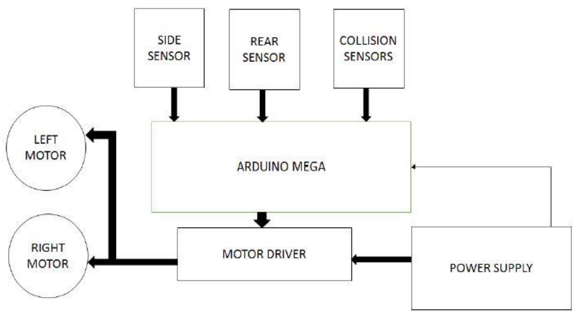

Fig-1: Block Diagram of Head Orientation Controlled Wheelchair

2.1 COMPONENTS USED

2.1.1 ARDUINO MEGA 2560

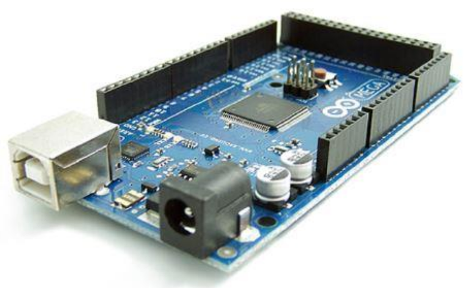

Fig-2: Arduino Mega 2560 Board

The Mega 2560(Figure 2) is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

2.1.2 ULTRASONIC SENSOR

Fig-3: HC-SR04 Ultrasonic Sensor

HC-SR04 ultrasonic ranging sensor is shown in Figure 3. This economical sensor provides 2cm to 400cm of non-contact measurement functionality with a ranging accuracy that can reach up to 3mm. Each HC-SR04 module includes an ultrasonic transmitter, a receiver and a control circuit.
There are only four pins that you need to worry about on the HC-SR04:
VCC (Power), Trig (Trigger), Echo (Receive), and GND (Ground).

The basic principle of work:
(1) Using IO trigger for at least 10us high level signal,
(2) The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
(3) If the signal is obtained back, through high level , time of high output IO duration is the time from sending ultrasonic to returning.

Test distance = (high level time velocity of sound (340M/S) /2)
You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion .You can calculate the range through the time interval between sending trigger signal and receiving echo signal. Formula:
uS / 58 = centimeters or uS / 148=inch; or:
the range = high level time * velocity (340M/S)/ 2;
suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal.

2.1.3 DRIVER CIRCUIT

Fig-4: RKI-1341 DRIVER IC

The driver circuit RKI-1341(Figure 4) 24V compatible 20A capable DC motor driver which can be used to drive two motors simultaneously. It is ideal for application where the motor requires up to 20 Amperes of current during start up and during normal operations. It is also compatible with motors that run at 24V. It has totally 10 pins. 5 pins for controlling one motor and the other 5 for the other motor.
GND: connect to GND on controlling board.
DIR: Pulled down to GND Forward by default and Backward when 5V (logic high)
PWM: Pulse Width Modulation input to control speed of motor (recommended freq 20Hz to 400Hz)
BRK: Breaking input to halt the motor in operations when 5V (logic high)
5V: Regulated 5V output from motor driver board(maximum 50mA supply)

2.1.4 DC MOTOR

Fig-5: A 12V DC Motor

DC motor used is shown in Figure 5. A 12V DC Motor is used here. A worm gear is connected to the dc motor. A worm gear controls the force that the motor delivers to the drive arm by slowing down the speed of the electric motor by 50 times while multiplying the torque by 50 times.

2.2 WORKING PRINCIPLE

The system consists of two motors and controlled by a motor driver circuit. By controlling the motors, we can control the movement of the wheelchair. This is facilitated by the motor driver circuit. The Arduino Mega 2560 is used to give appropriate input signals to the motor driver. It processes various inputs from the sensors and feeds the motor driver with appropriate signals. For turning the wheelchair, only one motor is to be driven. For turning the wheelchair towards the left side, only the right motor is to be driven. Similarly, for turning the wheelchair towards the right side only left motor is driven. For moving front, both the motors are to be driven and for moving back, both the motors are to be driven in the reverse direction. As shown in the flow chart, initially all the sensors read values and are given to the Arduino. That is, the Arduino will be receiving analog inputs from side, rear and collision sensors. Arduino can determine the position of the head using this input values from the side and rear sensors. If the head is tilted towards the right side, the Arduino will give the signal to drive the left motor only. Similarly if the head is tilted towards the left side, the Arduino will give the signal to drive the right motor only. For the front and back movement of the wheelchair the values from the collision sensors are also processed. If the head is tilted backwards, front movement will be detected and if the head is tilted towards front, backward movement will be detected. For the front movement, both the motors will be driven. Similarly, for backward movement, both the motors will be driven but in reverse direction. For both front and back movement, the Arduino first checks for any obstruction using the values from the front and back collision detection sensors and the motors will be driven only if there is no obstruction. If any obstruction is found, the motors will be stopped immediately there by providing a good collision detection and prevention system.

2.3 FLOWCHART

The basic flowchart of the program is given in figure 6. The program works by repeated checking of the sensor values. As soon as the program is initiated, sensor values are obtained. Using the obtained values of the head orientation, the program decides the direction of movement required. If the required action is to turn, the related motor is driven. If the action is the front or back movement, first the collision sensors are checked. The motor operation is carried out if and only if the collision sensor data is favourable. This process is repeated continuously.

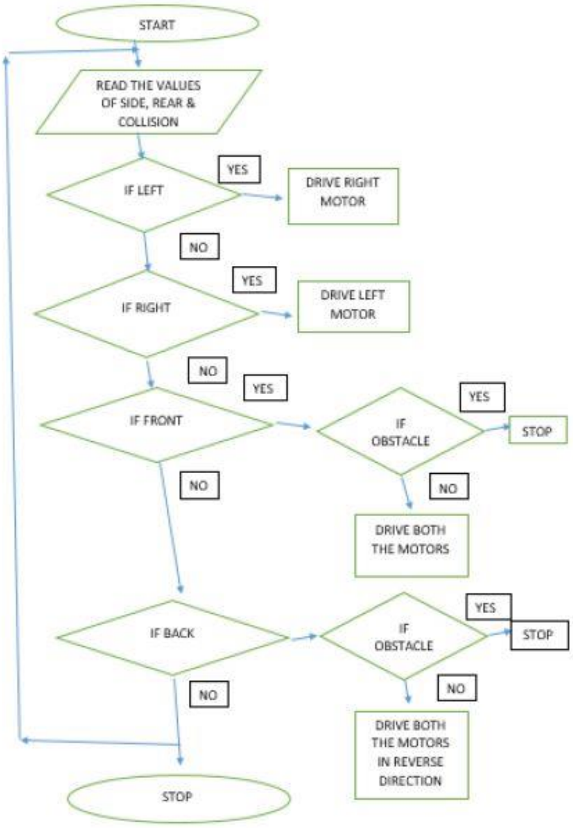

Fig-6: Flowchart

3. HARDWARE IMPLEMENTATION

Fig-7: Hardware Setup

The hardware is implemented as shown in Figure 7. A wheelchair was modified and two DC motors are attached to shaft of each of the back wheels. Ultrasonic sensors are positioned so that they will be at the backside and right side of the head when a person sits on the seat. The output from the sensors are taken to a microcontroller which decides the direction of movement of the wheelchair and that information is passed to the motors attached to the wheels through the motor driving circuit. The electronic part and power supply is provided in a small metal basket below the seat of the wheelchair.

Fig-8: Battery and Metal Basket

4. CONCLUSIONS

This project presents the model of an automated wheelchair with motion controlled by the movement of head. A working model of the head motion controlled wheelchair was designed and developed. The performed experiment showed very good results. The prototype consists of an electronic and a mechanical part. Movement of head was sensed through ultrasonic sensors and wheelchair movement was controlled accordingly. The technique is implemented as an algorithm of microcontroller system. As an added protection, two collision detectors was provided both on the front side and back side. The intelligent wheelchair helps the People with Disabilities (PWD) to lead their life in an uncomplicated way. An algorithm is implemented for the wheelchair movement. The disabled people can direct the wheelchair to the designation without any difficulty. With this intelligent wheelchair, people with disabilities can lead their life easily in any environment. The wheelchair can be further enhanced by using wireless charging techniques in future.

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BIOGRAPHIES

Basil James is a B.Tech student of Electrical and Electronics Engineering Department of M.A.College of Engineering, Kothamangalam, affiliated to Mahatma Gandhi University, Kottayam, Kerala, India.

Rishi Prasad Sajeevan is a B.Tech student of Electrical and Electronics Engineering Department of M.A.College of Engineering, Kothamangalam, affiliated to Mahatma Gandhi University, Kottayam, Kerala, India.

Fasil Yousaf is a B.Tech student of Electrical and Electronics Engineering Department of M.A.College of Engineering, Kothamangalam, affiliated to Mahatma Gandhi University, Kottayam, Kerala, India.

Prof. Jisha Kuruvilla P is an assistant professor of Electrical and Electronics Engineering Department of M.A.College of Engineering, Kothamangalam, affiliated to Mahatma Gandhi University, Kottayam, Kerala, India.