Design And Development Of Hand-Glove Controlled Wheelchair Using Arduino And Xbee

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Abstract: Wheelchairs are great assistance for people with disabilities. Recent development in wheelchair technology includes smart ways of controlling the wheelchair and at the same time making it cost-effective and affordable to the user. In this paper,a new way of controlling a wheelchair by means of gyroscope and flex sensor has been proposed.With the help of these sensors, the control of the wheelchair will be implemented by simple hand gestures and finger bending. The control mechanism, transmission, and reception of the signals will be processed through the use of Arduino and Xbee.

Keywords :wheelchair, gyroscope, flex sensor, Arduino, Xbee, hand glove, gesture movement.

1. INTRODUCTION

Wheelchair with foot rest was first invented in 1565 by King Phillip II in Spain [1]. In 1783, John Dawson invented a tricycle wheelchair named the bath chair after the town of bath [1]. His invention dominated the market of 19th century. He used two large wheels and one small wheel. Between 1867 and 1875, new hollow rubber wheels were added on wheel's metal rims by the inventors. And they also added small front caster and rear push wheels. In 1881, the manual self-propelled wheelchairs were invented [1]. As time passed by, different types of wheelchairs were made for easier control such as attendant-propelled wheelchairs, motorized wheelchair, wheelchair, mobility scooters, single-arm drive wheelchair, reclining wheelchair, and so on [2]. The number of physically disabled people has been continuously increasing universally. Moving on a wheelchair is generally difficult and more difficult particularly for person with disability. This paper aims at a design to develop advanced wheelchair that is much easier to control for the disabled and as well as cost effective. The idea is to build a hand-glove controlled wheelchair with the hand-glove as the controller. The wheelchair will move according to the movement of user's hand or fingers. The controller sends signal to the receiver through a transceiver. The receiver circuit under the user's seat of the wheelchair receives the signal from the transmitter according to the motor's signal that changed the movement of the wheels. The controller section is consisted of two sensors – a flex sensor and a gyroscope. A flex sensor is attached underneath the index finger of the user, which will control the wheelchair to move forward and backward. The gyroscope is attached under the wrist of the user, which will control the wheels to move right or left. On the other hand, in the receiver section the circuit consists of a Xbee pro, which receives signal from another Xbee located in the controller. DC motor issued for the control of the speed of the wheelchair. The proposed design contemplates a very straightforward operation; the user can control the direction and speed of the wheelchair by simple hand gestures.

2. EXISTING METHODS TO CONTROL A WHEELCHAIR

Several methods have been suggested to control the movement of a wheelchair, namely: hand gesture using robotic car control, Manucon (aircraft control system), and voice radio controlled remote car. A brief description of these early methods isgiven below:

In the wheelchair using robotic car control method [3], a system is developed to deliver and perform laboratory tasks that require operation of physical components. Commands are generated through gesture and transmitted to a robot for required actions. The gesture movements are processed using an image processor. The method has limitations assessors at times may fail to detect the gestures correctly. In addition, image acquisition may result in errors if camera lenses not clean and/or clear enough, i.e., covered with finger prints, dust particles and/or any other opaque object. Another design used Manucon, a glove that is designed to control the aircraft system by hand gestures, was used as the controller of the wheelchair [4].When used for wheelchair, Manucon can accurately track the gesture of the driver's hand with the help of 6 axes IMU (Inertial Measurement Unit; three axes of orthogonal accelerometers and three axes of gyroscope) and flex sensors. The Manucon establishes a connection with the user, the radio system, the wheelchair and the computer for graphical data output. The method is originally designed to control the aircraft system; as such, components used in this design are complicated for normal wheelchairs and is expensive. In voice radio controlled remote car (RC) [5], a car is controlled through speech commands. The main theme is to drive a small toy car with two dc motors. The first motor is devoted to reverse and forward direction and the second one is mounted in the front for changing the direction of the toy car to right and left. The components used are Arduino microcontroller, Arduino motor shield, and an Easy Voice Recognition (VR) module. For the purpose of recording voice, a PC microphone with a small plastic stand and handle, connected to the soundcard, is used. Specific words are used as commands to control the car like 'go' for moving forward; 'left' for turning left; 'right' for turning right; 'back' for moving backward, and 'stop' for making the remote car stop. All in all, ten such commands are recorded via Windows Sound Recorder and stored as a .wav file, which is then analysed by MATLAB. For the speech coding schemes, the system uses the frequency domain representation of the speech signal. The short-time Fourier transform is especially necessary for this purpose. This transform is vital particularly in examining the features of the speech signal. Since the voice commands are triggered by sound, any sound that could trigger the designed threshold could be acknowledged by the computer as a command and it can send a wrong control data to the RC. The execution time for the complete operation is also not very fast.

3. REASONS FOR THE PROPOSED NEW DESIGN

The reason behind the new design implementation include both practical and ethical issues. In the practical consideration of the equipment, a simple and proven technology and corresponding precision control is incorporated. More reliable, easy to understand implementation makes the equipment easy to handle and work with. The method is also cost effective, user friendly, and easy to demonstrate to anyone with non-engineering background. Ethical reason arises from the fact that the developing countries in general lack advanced facilities for the disabled people. This design is planned to address that particular aspect and to develop a smart wheelchair that is different and unique to the disabled people, so that it can make them self-sufficient to move around the neighbourhood, work- and market-places and in doing so they don't feel any less significant than other people from their disability.

4. THE WORKING DESIGN

In this design, the hand glove, which is shown in Fig. 1, has three components: the bend sensing circuit or flex sensor, the gyroscope and a connection to the transmission circuit. A flex sensor that is attached to the index finger of the hand-glove initiates the command process by simply bending it. When the finger and thus also the flex-sensor are bent, a voltage is developed throughout the constructed flex-sensor circuit. The voltage is supplied into the Arduino Funnel I/O Board which has a build-in Xbee wireless transmitter socket and also a microcontroller.

Figure 1.*The picture of the hand glove.*

Transmitter Section:

The required calculations are carried out by using the microcontroller, which converts the data into serial data. The signals are sent serially to the Xbee transmitter. The block diagram of the transmitter section is shown in Fig. 2. The bend sensing circuit is a simple voltage divider circuit. Across the supply voltage, a resistor is connected parallel with the flex-sensor. The resistance of the flex sensor increases when the user bends his fingers; more the bending the more the resistance increases and at the same time the voltage across the sensor varies. The gyroscope tracks and calculates the hand gesture movement. When the user changes his or her hand gesture, the changed voltage drop transfers a corresponding signal in to the Arduino. By moving the hand just a little up and down, or left and right, gyroscope provides the microcontroller an instruction of the varying axis, which is also fed into the Arduino Funnel I/O Board and afterwards in parallel signal is also sent to the Xbee transmitter.

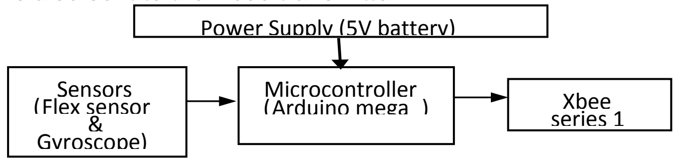

Figure 2. *Block diagram of the transmitter part.*

Receiver Section:

The receiver circuit is constructed and kept under the wheelchair as shown in Fig. 3. Another Xbee is used in the receiver circuit. The block diagram of the reception section is shown in Fig. 4. It should be mentioned here that this is the similar Xbee circuit that is used before in the transmitter section. However, the difference is that it is programmed to be a receiver here. The shield is the interfacing platform between the Xbee receiver and the microcontroller board.

Figure 3. *The receiver circuit under the wheelchair*

The received signal coming from the transmitter will be fed into the inbuilt microcontroller of the microcontroller board shown in Fig 5. The signal after that will be evaluated and analysed by the microcontroller based on the programmed instruction codes and will be sent to the PWM output and the 4-channel relay circuit. The relay will act according to the instructions and will control the motor's rotational speed as well as the direction. Here use of wind shield wiper motors is suggested and used as the speed of those motors is found to be adequate for the chair to move in an appropriate speed. With the reception unit in work as per the command signal that is transmitted, the wheelchair will move according to the hand gesture and finger bending.

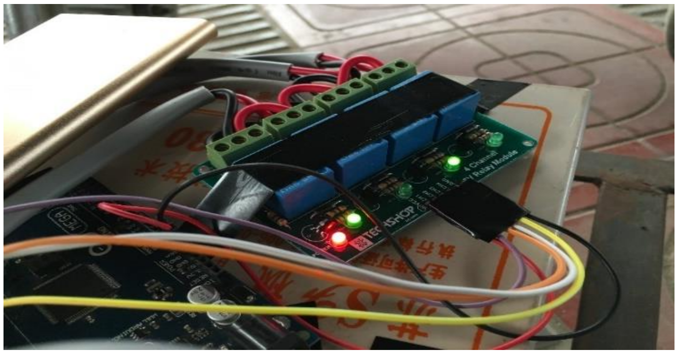

Figure 4*. The microcontroller board*

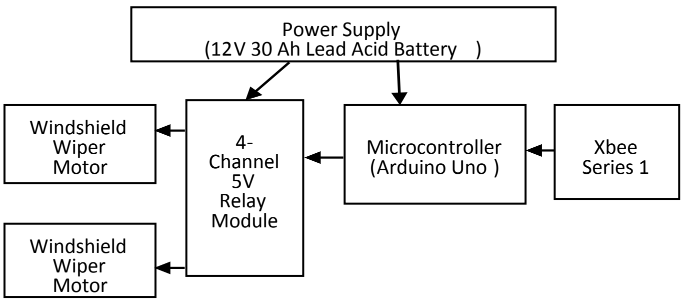

Figure 5*. Block diagram of the receiver part.*

The flex sensor and the gyroscope are the most significant components in this design, as to bend the flex sensors only a negligible force is required [7] and the gyroscope is sensitive enough to detect small movements [6]. These sensors, as initiators, are also primary to the motion of the wheel chair. Use of small force overcomes of the limitation of the joystick and makes it easier for people with severe disabilities in manoeuvring the wheelchair. The flex sensor and the gyroscope are embedded into the instrumented gloves, each sensor plays different function to control and guide the movement of the wheelchair. The wheelchair moves forward when the index finger, by extension the flex sensor, is straight, moves backward when the index finger, i.e., the flex sensor, is bend maximum, stops in the relax position. When the hand is moved left or right the wheelchair will move accordingly. The hand gesture controls the different turns of the movement – left or right – through the use of gyroscope. A tolerance is provided in the design to avoid the tendency of abnormal bending of the finger or turning of the hand.

5. DATA ANALYSIS

The reason of this effort is to check the efficiency of the motion of the finger and makes utilization of the accelerometer to change the course of the wheelchair relying upon its finger. During the experiment if the finger moves to the correct right side then the wheelchair moves right way or if the movement is to another side then the wheelchair moves left way. Wheelchair developments can be controlled in Forward, Reverse, Left and Right heading as appeared in the Table 1.

Table 1*. Algorithm setting for wheelchair direction*

Index Finger	Input From Arduino				Direction
	D1	D2	D3	D4	
Stable 0^0	0	0	0	0	No movement
Bend to Right 45^0	0	0	0	1	Right movement
Bend to Left 45^0	0	0	1	0	Left movement
Bend to Backward 45^0	1	0	0	0	Reverse movement
Bend to Forward 45^0	0	1	0	0	Forward movement

Table 1 shown how we control the motion of the wheel chair using certain algorithm, the system is quite simple as described previously a wheelchair whose motion is controlled with your index finger .The system has been performed using the same finger posture for further referencing to it as the stable movement or "neutral position" has been mentioned. The wheelchair is driven by the electric motors controlled using the hand gloves with the movement sensing device attached in it and put on start mode. The motors do not work and the wheelchair does not move when the index finger is in a neutral position. The wheelchair movement direction can be set by moving user's index finger away from the neutral position. To rotates the wheelchair to the right, the finger (wearing hand gloves) of the user need to move to the right. To rotate the wheelchair to the left, the index finger of the user need to move to the left. Move the finger (as much possible) to backward causes reverse wheelchair movement, while the moving to forward causes a forward movement. The wheelchair direction can be controlled easily by changing the position of the user's index finger. The wheelchair stops when the finger of user returns to the neutral position.

6. FUTURE PLAN FOR OUR PROJECT

We are very looking forward to take our work further and start manufacturing on a commercial basis. So here is a estimation that has been made on a commercial scale: • Estimated number of devices sold per year: According to 155,000 current possible consumers, if even 25% people buy this product in the upcoming year and they might need replacements in 5 years or so, then average sale per year should be about 6000 units. • Estimated manufacturing cost for each device: The cost of prototype is estimated to be $200 also can be reduced by a minimum of 20% by bulk ordering, per sets of wheel chair will cost as low as $160 • Estimated purchase price for each device: The average selling price of this product should be around $400, also including a cost of $140 for labour and manufacturing equipment, will allow minimum of $100 as a profit. Although this estimation is not fully confirmed just an educated conservative estimation, because some factors like product manufacturing costs and labour to assemble device is still undetermined. • Estimated profit per year: So the profit might reach to $600,000 based on previous estimations. • Estimated cost for user to use this device, in a specific time interval: This is to be around $20 per year to replace or recharge battery or motor also in the glove sensing part of the unit.

7. CONCLUSION

Wheelchair gives a disable person a new hope to live his or her own life fully. It gives them confidence to work on their own. Keeping this generally in mind, the plan undertook the design and development of the simple sensor-microcontroller based technology that has never been used in the wheelchair environment.

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