DESIGN AND FABRICATION OF AUTOMATED WHEEL CHAIR FOR QUADRIPLEGIC PATIENTS: A REVIEW

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Abstract: The aim of this project is to design a wheelchair that is to be used by Quadriplegics (handicaps unable to use their four limbs). The wheelchair is based on the concept of the head tilt movement which enables the user to move from place to place easily. There are various sensors used in the entire wheelchair to reduce the errors and malfunctions which could take place. This wheelchair stress on level of comfort, easy mobility, maintenance of gradual and balanced speed based on head tilt movement. The above work studies and focuses on different technologies which are applied for the wheelchair based on different motions associated.

Key Words: Electric power wheelchair, quadriplegic, Head Movement navigation, Microcontroller, Hub Motor.

I. INTRODUCTION

Today, in the 21st century, movement or motion from one place to another is the easiest way of transportation and the most comfortable as well. Some people are not granted this easy feature of functioning within their own bodies which could be due to several reasons, such as, paralysis, arthritis, accidents, etc. The part where the field of engineering and medical science can collaborate in and bring out a result, by the power of which it makes it easier for such people to get chances at life, is what this project is all about. The wheelchair that has been designed here is purely for the sole use of quadriplegic patients so that they could carry on with their day to day lives. Quadriplegia or Tetraplegia is where the patient loses the ability of functioning through the four limbs due to various reasons, such as, an injury or an illness [2]. In cases like these powered wheelchair play an important role for building up the confidence, independence as well as the mobility and comfort of the person [1]. The fact that the wheelchair is only operated by the head movement of the person makes it even easier to handle. This systems an automatic head tilt movement system which can also be used by the people who are not physically challenged. It is mobile in all the directions, that is, forward, backward, right and left directions. It stops when the person does not tilt his head in any direction. It also has safety features indulged into it such as in cases where the user falls asleep, there are pressure reliefs sensors that are fixed at the back which would automatically stop the wheelchair motion no matter if the person is to be moving in the forward direction. Also, the feature that there are two hub motors attached to the two separate wheels of the chair in order to give a better speed and a better tilt angle or a pitch mechanism ratio. There are tilt sensors as well as accelerometers that have been attached to the head set where ever necessary. The main reason to design this and work on this project was to keep in mind the safety of the patient, maximum mobility, easy functioning system to operate, and also the cost [6]. This wheelchair has all the required features that are not so easily available in the market for all the patients at this level of comfort as well as the main issue of cost has also been considered and cut down to a much lower cost than the other available wheelchair.

II. RELATED STUDY

Satish Kumar et al. [1] Explained the importance of mobility and also designed the wheelchair based on both mechanical and electronic combinations to make it easier for the users to operate it. They also designed a remote controller for the wheelchair explaining that it can be used by the people near the patient for controlling it any case of emergency, etc. After testing the entire wheelchair it was concluded that the wheelchair had passed all the tests and the main aim was kept the cost estimation. The author also describes the various sensors and parts that were used, such as, tilt sensors, wireless control systems; gesture based controlled systems, etc. in the designing of the wheelchair which were cost effective and user friendly. The weight bearing capacity of the wheelchair in this case was up to 100 kg which makes it even more flexible to the weight range of the person.
Vignesh S.N et.al. [2] designed a wheelchair in such a way that it includes an accelerometer (sensor) which detects the movement of head and the controller will process the signal and transmit to the wheelchair for its navigation. It also explained that the wheelchair does not look as complex as the ones that is usually sold in the market. There are various parts and sensors used in the design of this wheelchair which have been very well explained separately, such as, accelerometer, motor, obstacle sensor, eye blink sensor, motor driver, etc. The eye blink sensor locates the voluntary and non-voluntary motion can be identified by just the simple eye blink movements. Here, the eye blink sensor senses if the eye is open or closed and works by illuminating the eye or eye lid area with an infrared light and then monitoring the changes in the reflected light using a photo transistor and differentiator circuit. On the other hand, we also have an obstacle sensor which detects any obstacle in front of the wheelchair and stops the motion of the wheelchair. This is placed at the bottom of the wheelchair and has the flexibility of being reset again. The main objective of this project is to control the wheelchair using accelerometer.

Mr. Vijendra P. Meshram et.al. [3] Used the accelerometer device called the ADXL535 based transmitter. This device is placed on the person's head which detects the head gestures in various directions. The ADXL535 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs, all on a single monolithic IC. The wheelchair can be driven in any of the four directions i.e. left, right, forward, and back. The automated wheelchair is based on simple electronic control system and the mechanical arrangement that is controlled by an PIC microcontroller. This automatic wheelchair can be used for people who have various other disabilities to sit on the chair and just hold the accelerometer and move it over to control the vehicle movements. It also contains obstacles detection system such as an IR sensor to detect various kind of obstacle comes in the path of chair. This is a modern version of the wheelchairs used in the above two cases and has a rather more complex design. The automated wheelchair can be developed by using the voice recognition system also and by using brain sensors. In the transmitter, an accelerometer based on head movements generates command signals. Microcontroller gets the hex data from the accelerometer and converted into ASCII code for LCD display. LCD displays the X—Y—Z values on the screen. The accelerometer is placed at the head set n order to determine the movement of the head accurately and to reduce and redeem the cost of implementation. The whole system is widely and orderly explained by the working of the entire system. MPLAB IDE software has been used from the electronics point of view. This project was mainly based on making a wheelchair based on electronic circuits, the hardware designing & software knowledge.

Colleen Nelson et.al. [4] Worked on a robotic wheelchair using eye blink sensors and accelerometer provided with home appliance control. In this case, an RF transmitter and receiver were also used in order to control the various devices or objects in close vicinity of the user of the wheelchair. This feature is in addition to the eye blink sensor and head tilt sensor for more accurate movement of the wheelchair. The author has also given examples of many other related studies based on the same concept and has briefly explained their work and their conclusions. He also explained that various commands and algorithms are used and can also be used in conjuring the mechanism and working of a wheelchair. In this case the wheelchair can be operated based on two modes, that is, the wheelchair control mode and the home appliance control mode. The switching between the two modes is done by the use of a toggle switch provided at the back of the head. Here the Keil C Complier software was used to control the microprocessor with the application of C codes. The paper was concluded stating that the wheelchair finally produced was user friendly and without a doubt made it easy to move for the users. Other devices like Bluetooth, Zigbee can also be used to communicate with the various devices in the room.

Narender Kumar et.al. [5] Wrote a research paper which introduces the design and implementation of a novel hands free control system for intelligent wheelchair. This is achievement for those whose limbs are not working and who are blind because it works with the movement of head. Novel hands-free control system follow by wireless & 2D wheelchair and it works on real time basis. Here, the robotic wheelchair is divided into two categories these are Automatic and semiautomatic. In automatic the wheelchair work for command and gets its position itself by checking initial and final position. It will till the command performed. In semiautomatic the person can interrupt while wheelchair is working. The person can move the wheelchair to the required route. Software used are also of three types. Local for the detection of indoor obstacles and global for the outdoor obstacles, control of movement and way planning. This paper introduces an automated wheel chair for physically handicapped
persons for their independent movement. It will able to navigate in indoor and outdoor environment. It is a reactive system and does not require mapping or planning. Interaction between user and wheelchair is investigated. Implementation of 2 dimension head movement for good control has been done. This shows a novel hands-free control system for intelligent wheelchair based on visual recognition of head gestures. So, this is an extremely useful system for users having restricted limb movement caused by some diseases such as Parkinson’s diseases and quadriplegics. We can use this wheelchair for the person whose only one sense is working that is their mind and their body does not respond to any machine which may be due to any reason.

Monika Jain et.al. [6] Worked on the wheelchair based on the eyeball motion controlled wheelchair using IR sensors. There are three 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 (PIC18F452) to control the motors of the wheelchair. The potential and efficiency of previously developed rehabilitation systems that use head motion control, sip-n-puff control, voice recognition, and EEG signals variededly have also been explored in detail. They were found to be inconvenient as they served either limited usability or non-affordability. After multiple regression analyses, the proposed design was developed as a cost-effective, flexible and stream-lined alternative for people who have trouble adopting conventional technologies. Thus, they produced 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.

Snehalata Yadav et.al. [7] Explains the various methods that are used or have been used or incorporated in the making and functioning of the wheelchairs made so far for the disabled. The author also explains the various techniques used in the wheelchair control system, such as, HCI (Human Computer Interface) and HMI (Human Machine Interface) which are the latest and most effective techniques. Methods such as Electroencephalography (EEG) has also been mentioned which records electrical brain signals from the scalp, where the brain signal originates from post-synaptic potentials, aggregates at the cortex, and transfers through the skull to the scalp. Also, another technique of the EMG measures electrical currents that are generated in muscles during its contraction. A muscle fiber contracts when it receives an action potential. EOG based technique are very useful for persons who born with any congenital brain disorder or for those who are suffer from severe brain trauma. EOG signals records the potential difference between the retina and cornea of the eye.

Sandeep et.al. [8] Gives a briefing of gesture controlled wheelchair. The purpose of this study was to present the reliable means of human-computer interfacing based on hand gestures made in three dimensions. In this paper we present a hand gesture recognition system which is of general use and can be used for different applications. The system is based on a MEMS accelerometer and it is able to recognize several gestures. The system can be divided in two parts: a gesture recognition module with MEMS sensor and a wheel-Chair controlled by the microcontroller. Also the author proposed a low cost, minimal invasive, low power consuming and easy to learn assistive technology using MEMS which provide smooth controls to wheelchair in associated with microcontroller.

Gowthaman A et.al. [9] Explains In his paper, the accelerations of a hand in motion in three perpendicular directions are detected by a MEMS accelerometer and transmitted to a PC via Bluetooth wireless protocol. An automatic gesture segmentation algorithm is developed to identify individual gestures in a sequence and the Hidden Markov Model (HMM) is used for the hand gesture model training. After this, the trained gesture model and Bayes method are combined to recognize the gestures from the sensing data sequences. When the gesture information is transferred into the corresponding wheelchair motion, S-Curve function is adopted to connect the velocities of the neighboring motions. This would insure the wheelchair's motion to be smoothed. Simulations showed the effectiveness of recognition method and smoothed motion of intelligent wheelchair under control. On the algorithm of hand gesture recognition, the author proposed a real-time gesture segmentation method based on the distance principle which could segment the gesture sequences out of the sensing data automatically. And then the author utilized the trained HMM and Bayes method to judge the gestures online. On the motion control method of wheel chair, to avoid the unsmoothed velocities between two consecutive motions, the S-curve functions to realize the continuous curvature of the velocities. Simulation showed the effectiveness of the recognition method and the realization of the wheelchair's smoothed motion under control. While
there still exists a lot of work to do, such as adaptive parameter determination during the gesture segmentation, real wheelchair control under gesture recognition. 

Rahul CM et al. [10] Explains that the main aim of this paper is assist paralyzed (quadriplegic and paraplegic) people and physically challenged people. The prototype developed consists of user dependent voice recognition system and accelerometer interfaced, which is being further extended for real time implementation. Intended users control the chair by wearing a glove fitted with accelerometer for controlling the movement and direction of the wheelchair. The wheel chair is also assisted with a Voice recognition kit, with the help of which the user can guide the wheelchair through voice commands. Ultrasonic sensors are used for real-time obstacle detection, the author has provided a design that is efficient in helping the quadriplegic and paraplegic people without putting their strengths and efforts to pull the wheelchair, by commanding it on their voice. the author has also shown that it can be controlled even in the uneven case of events by providing a manual control of the wheelchair.

III. PROPOSED STRUCTURE

The work is being conducted with the aim of understanding how to develop a system for making it easier for the quadriplegic patients to move and be independent. The wheel chair being designed should be tested after being constructed for measuring its precision.

Figure 1: Side View of the wheel chair

The proposed wheel chair which is shown in figure 1 is adjusted with two hub-motors on both the wheels to give the wheel chair a better accelerating and twisting power and ability. It also consists of sensors such as pressure sensor in order to limit the chance of an error in case if the patient falls asleep or sneezes. It also has the sensors to detect the head gestures, that is, the motion sensors. Overall the wheel chair automation is done by using head gesture based on the accelerometer and the motion sensors. Microcontroller (program) is mainly used to control the direction of wheel chair. The lightest material is used in order for a better regulation of the speed.

Figure 2: Back profile of the wheel chair

IV. CONCLUSION

From the above literatures it is been found that head tilt motions controlled automated wheel chair proves to be an effective solution for quadriplegic patients with more than 45 % disability or for the patients with spinal cord injury who could not move their hands and legs for driving a manual or automatic wheelchair. This system proves better than automatic joystick powered wheelchairs in terms of ease of operation and head tilt control. Also, the project comes out to be economical as compared to other available wheelchairs in the market. Another paper infers that the model of a wheelchair that is controlled using accelerometer. The accelerometer is controlled by the head tilt motion and is used to steer the wheelchair. The head gesture project explains that automated wheelchair can be used to help handicapped people, especially those who are not able to move. This project was the complete addition of the electronic circuits, the hardware designing & software knowledge. The system was successfully implemented to move the wheelchair left, Right, Forward, Backward or Stay in...
same position. Another project worked on the control of the wheelchair on the basis of eye ball control sensor. The IR sensor based eye-motion tracking system can be used as basic infrastructure in future technologies such as home automation. The system can be used for wireless automation by using radio frequency modification in the circuitry. This interface can be used to include an explicit input from the user by detecting intentional blinks and eye motions to create unique signatures. These signatures can then be used to generate control functions for individual home appliances. With various modifications, the proposed method can also be successfully implemented in vehicle automation. Another design shows that the motion and voice controlled wheelchair can guide the paraplegic to head towards their will and wish with the help of the voice command wheelchair. Thus, conclusion is that a design that is efficient in helping the quadriplegic and paraplegic people without putting their strengths and efforts to pull the wheel chair, by commanding it on their voice has been provided. It has also been shown that it can be controlled even in the uneven case of events by providing a manual control of the wheelchair. In one paper they have utilized the acceleration data to recognize the hand gestures and then transfer the gesture information which indicates certain motion commands into the wheelchair's smooth motions. It's a try to realize the natural interaction for the older and handicapped with the wheelchair through hand gestures. On the algorithm of hand gesture recognition, a real-time gesture segmentation method based on the distance principle which could segment the gesture sequences out of the sensing data automatically has been proposed. And then they utilized the trained HMM and Bayes method to judge the gestures online. On the motion control method of wheel chair, to avoid the unsmoothed velocities between two consecutive motions, we adopted the S-curve function to realize the continuous curvature of the velocities. Simulation showed the effectiveness of the recognition method and the realization of the wheelchair's smoothed motion under control. While there still exists a lot of work to do.

This wheelchair is specifically designed for the cream purpose of making it more comfortable for the patients and for making it very easily available. This happens so due to its lower cost within the market compared to the ones which are already available. There will be more ideas and modifications made into this wheel chair once the entire wheel chair has been constructed, tested and validated. This will enable a new generation and idea in the world of technology to the advancement of such an important process and a wanted piece of machinery as this for the quadriplegic patients. This wheel chair will also be helpful for the patients who undergo with the problem namely cerebral palsy which another paralysis problem in patients caused by brain injury which could have taken place due to an accident or naturally. In this problem the balance, reflex, body movement, muscle coordination of the body, muscle control of the body and posture get highly affected. Looking at the amount of safety features that we are incorporating within this wheel chair, it is easily evident that it will with no doubt be extremely helpful and easily affordable for these patients as well. Highly sensitive or in other words highly accurate equipment such as the ultrasonic sensor, which is perfect in itself to detect the distance between the wheel chair and the object to which the wheel chair has to go near. Also, pressure sensors have been used for safety purpose in order to detect if the patient is sitting on the wheel chair. If not, then the wheel chair will stop automatically for safety purpose of the patient. These features which have been installed and will be tested repeatedly to avoid any error at all, since it will be a matter of safety of the patient, are very densely looked into. Hence, making this wheel chair good enough for the using. This will also make it more economical and more in demand. From all the other mechanisms used to control the wheel chair, head controlled wheel chair seem to be more precise, less complex, sturdy and economical.

REFERENCES

