Assistive Technology for Physically Challenged or Paralyzed Person Using Voluntary Tongue Movement

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***Abstract*— The "Tongue Drive System" (TDS) is a wireless assistive technology (AT) which is operated by using tongue motion has minimum invasion & also has no obstruction to daily activities. This system can enable those people who have high spinal cord injuries such as the tetraplegia patient to move around with quite ease even giving them some ability to control their surrounding environment. The TDS transforms the movement of the tongue into user's command i.e. the intention to move in a specific direction. In our work used the TDS technology to control the direction of a powered wheelchair's propulsion. The wheelchair was initially a manual one but by using two high torque gear motor in each of its wheel it's been turned into a powered one. A small permanent magnet secured in the tongue was used as a tracer for the tongue movement. These tongue movement was then detected by five magnetic sensors on an orthodontic base inside or in a headset outside the mouth. We used Hall Effect sensors as the magnetic sensors. The Five sensors carry five different commands: Forward, Reverse, Right, Left & Stop. The output of the sensors then sent wirelessly to the Motor driver connected with the DC motors. The driver later controls the DC motors according to the received signal. Finally the testing of the project was done with a healthy subject who was able to maneuver the wheelchair in obstacle course with quite ease.**

Keywords—tounge drive system; wheelchair; hall effect sensors;

I. INTRODUCTION

Assistive Technology (AT) is essential to lead a quite self supportive & independent life for people with severe disabilities. Disabilities resulting from various reasons such as traumatic injuries, spinal cord injuries as well as road accidents make its victim to find that daily life is quite difficult without continuous help from others. For the purpose of improving their daily life the AT's are necessary. Among the different kinds of AT's, the most important AT's are considered those that provide mobility [1] as it can improve the users lifestyle quite drastically.

There are many deferent types of AT's available for the purpose of mobility. There are some AT's that uses Sip-n-puff technology. This types of AT's are quite simple and easy to use. The user has to blow or suck air through a straw to control the movement of the AT. Though the cost of this types of AT is quite low and they are easy to use, they have a very limited number of instructions. Also the command process is quite slow which makes this type of AT unsuitable for day to day activity.

There is also other type of AT that uses the head pointer technology. This AT's measure the head level of the user to do different types of pre programmed functions. But for the use of longer period of time this technology is not sufficient as maintain the head in certain level for quite some time is tiresome.

Another type of AT that is available that uses the bioelectric signal such as Electromyogram (EMG) muscle twitches signal, Electroencephalograms (ECG) [2] brain signal to control the movement. But these types are still in development phase and costly.

There even some AT's that are voice controlled [3]. This type gives the user a wide range of control. But these need to be used in quite place as noise could make the device unable to understand the command and thus limiting the AT's performance.

Among all the AT's that available the AT's that uses Tongue Drive System (TDS) are the most effective as this type gives the user a good range of command ability. It has minimum invasion for the AT to integrate it command circuitry with the user. The only other organ in human body that rivals the fingers and hand in motor cortex ability is the tongue & mouth. The movement of the tongue is controlled by a completely another cranial nerve known as Hypoglossal nerve which can remain functional even in most severe spinal cord injuries. The muscle of the tongue does not fatigue easily & the tongue can move freely inside the mouth. Also the movement of the tongue does not depend on the user's body position which gives the user maximum comfort in using this type of AT.

II. DESIGN & CONSTRUCTION

The whole construction of the project can be divided into two parts as there are both mechanical and electrical portion in the project.

A. Mechanical portion

As both the availability and price of powered wheelchair is quite high in Bangladesh a manual wheelchair was used instead

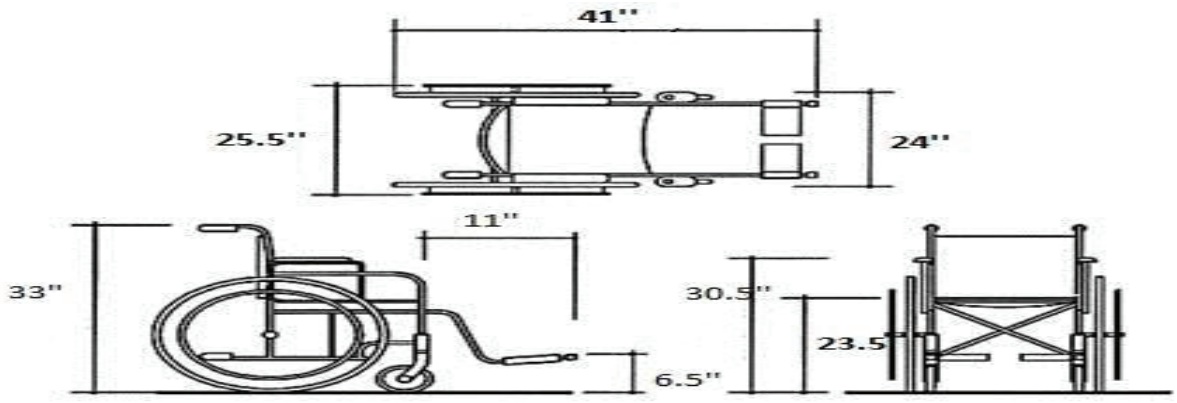


Fig1: Dimensions of the Manual Chair

of a powered one. Necessary propulsion was given with the help of two high torque gear motor mechanically coupled in each wheel. In Fig.1 the actual dimension of the wheel chair is shown.

The motor that was purchased from the nearby flee market for the purpose of minimizing the cost. The motor rating was selected as trial and error method to carry suitable loads.

From the Fig: 2 it can be seen that the mechanical couplings of the motors were done using pinions & chains. The pinions are bi-directional same as the gear motor which allows the chair to have a propulsion in the reverse direction.

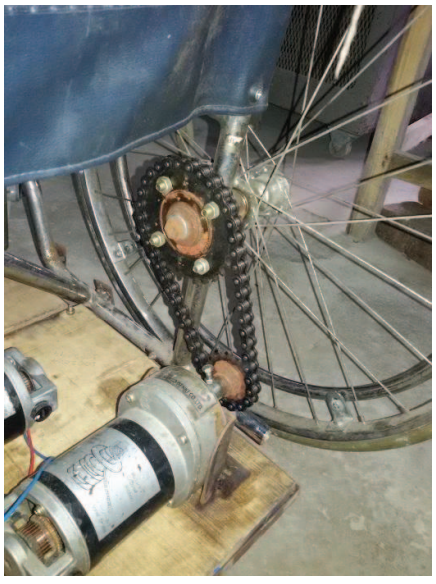


Fig2: Motor Coupled with Wheel

B. Electrical portion

The electrical part of the construction is mainly consists of controlling the chair with voluntary tongue movement. This controlling part is also divided into two segments: capturing the tongue movement & controlling the motor movement.

In order to capture the motion of the tongue, we used a neodymium magnet as a tracer. The magnet can be secured in the tongue with piercing or tongue adhesives.

In our work due to lack of volunteer we kept the oral device outside.

The magnet in the tongue is used as a tracer for the tongue movement. Five Hall Effect sensors were used to make the tongue movement into electrical signals. These five sensors defined user's five commands: Forward, Reverse, Right, Left & Stop. These could be placed in an orthodontic brace inside the mouth or in a head gear outside of the mouth. An Arduino Uno device which is powered through a 9v DC battery was used for the processing of the electric signal gained from the sensors. The signals then wirelessly transmitted via a RF transmitter for the controlling of the motor.

The controlling of the gear motor connected with the wheel was done with a motor driver. The motor was controlled with a L298N Dual H-Bridge motor controller. This controller is a compact device with a L298N IC, heat sink, voltage regulator etc. which even enables to control the motor speed using Pulse-Width Modulation(PWM) system. A single L298N Dual H-Bridge motor controller can effectively control two high torque gear motor but for giving the motor necessary power to propel a human being we used one controller for controlling a single gear motor instead of controlling both with one controller. This allows the motor to carry more loads without burning the L298N IC.

The transmitted signal from the RF transmitter was used for the signal to control the motor controller input. This received signal is then processed with an Arduino MEGA device which than later sent the signal to the controller for controlling the motor. For controlling the motor speeds the PWM unit of the Arduino MEGA was used.

III. METHODOLOGY

The working principle of this project is rather simple. It can also be divided into two segments: tracing the tongue movement and controlling the chair accordance with the tongue movement.

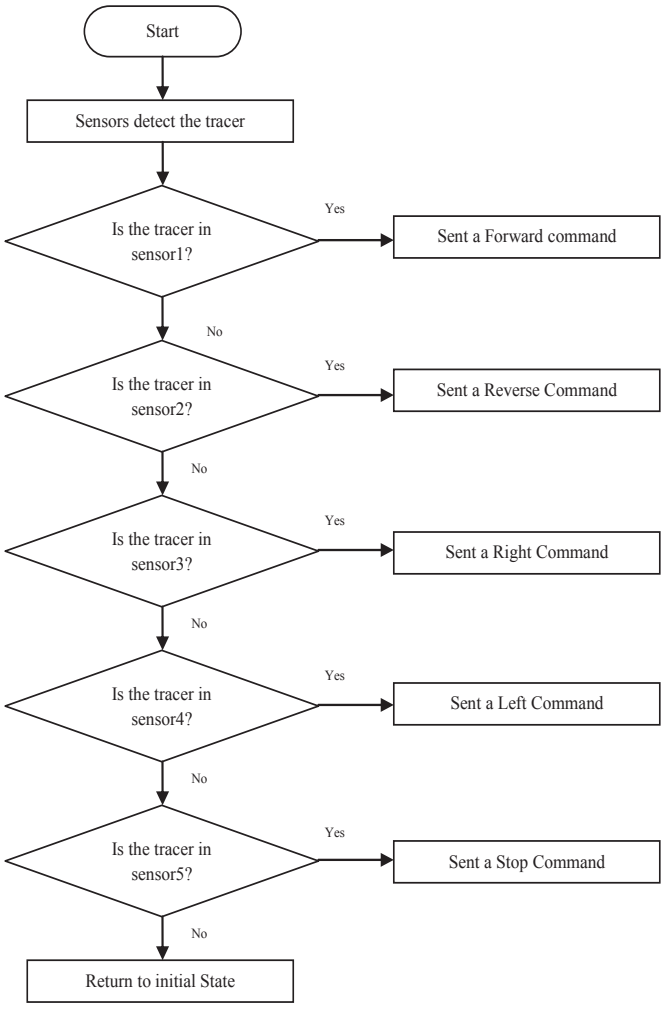
The magnet in the tongue acts as the tracer for the tongue movement. Whenever the magnet comes close with Hall Effect sensors it generates an electric pulse. The sensors are latch type. Therefore when the magnet moves away from the sensors the pulse ceases to exist and the sensors returns to its initial state. The generated signal is processed with the help of Arduino UNO device which is later transmitted through the RF transmitter.

Transmitted signal is received with a RF receiver. The receive signal is then processed by the Arduino MEGA and sent to the L298N Dual H-Bridge motor controller to control the motor movement. In the MEGA unit it is also possible to control the motor speed. But the motor speed can only be controlled by pre-programming as PWM controlling is done in the MEGA. So the user has no ability to control the motor speed. The output of the controller is done as the following table.

TABLE 1: MOTOR CONTROLLER OUTPUT

Controller 1		Controller 2		Direction
IN1	IN2	IN3	IN4	
HIGH	LOW	HIGH	LOW	FORWARD
LOW	HIGH	LOW	HIGH	REVERSE
HIGH	LOW	LOW	HIGH	RIGHT
LOW	HIGH	HIGH	LOW	LEFT
LOW	LOW	LOW	LOW	STOP

A flow chart of the total procedure is shown below:



IV. RESULT AND DISCUSSION

The completed device was tested with a healthy human subject weighing around 55 kg. In the test the subject was able to control the chair with quite ease. He was able to maneuver the chair through an obstacle course.

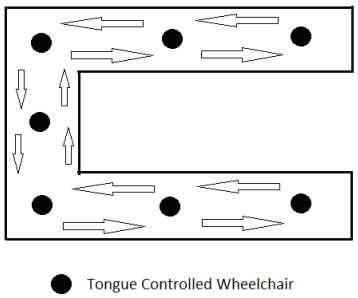


Fig3: Obstacle course

Table 2: Test Data

Distance	Time taken to complete the course (sec)	Total number of collision
20 feet (6.1m)	23	3
	21	3
	24	2
	22	2
	22	2

The chair was able to move at a average velocity of 1 km/h with the subject. Through the course there were a number of collisions with the obstacles almost 3 collisions per test run. With subject each DC motor takes almost 2.4A current which results in having the chair a battery backup capability of 17 hours.

There was certain limitation in our TDS system. As the Chair was made into a powered one through mechanical coupling, there was some error due to the imperfections of the work. The weight distribution of the chair was not equal on both sides as a result the chair had a tendency to go in the right direction in the starting & the end of the propulsion. Also the motor driver used i.e. the L298 cannot supply more than 2.4A current to the DC motor which results in having the capability of taking a user no more than 55 kg for effective movement.

V. CONCLUSION

The TDS system is quite new system for Bangladesh's perspective. This system utilizes the tongue movement to effectively control the movement of a powered wheel chair. As the TDS system is unobtrusive & has minimum invasion it gives the user quite an ease in use. The results from the trial make it a viable option for effective control of wheelchair for the disabled people in our country.

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