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Tongue Controlled Mouse Pointer: An Assistive Technology For The Disabled

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Abstract

This paper aims at developing an unobtrusive and minimally invasive assistive technology for people with severe disabilities.Tongue controlled technology detects the user’s voluntary tongue movement and translates it into user defined commands. Since the tongue is connected to the hypoglossal cranial nerve, it escapes damage in most spinal cord injuries. Hence it can be used to drive the assistive technology. This technology uses Hall Effect sensors fixed on a head mounted device for detecting the proximity of a permanent magnet which is placed on the tongue. When the sensor senses the magnetic field generated by the magnet, it sends an output signal to the microcontroller which acts as an interface between the sensors and the PC. A Visual Basic code receives data from the microcontroller and moves the mouse pointer accordingly on the screen.

Keywords: Assistive technology, Hall Effect, head mounted device, permanent magnet, microcontroller, Visual Basic

Introduction

Statistics indicate that nearly 1 out of every 50 individuals is living with paralysis, which is approximately equal to 5.6 million people in the world [1]. In spite of this number accounting to 1.9% of the total population of the world, the opportunity and resources available to the paralyzed are limited. Hence assistive technologies need to be developed to ensure their independence.

Eye movements from corneal reflection [2] and pupil position can be used to operate assistive devices. Electro Oculographic Potentials (EOP) can be used to track eye movements [3], [4]. However the EOP signal is not deterministic even for the same person in a different environment. The fovea of the eye which gives clear vision, covers a visual angle of approximately 1^o arc of the retina leading to inaccuracy in measured gaze position Also, The eye gaze position cannot be consciously controlled. Therefore using eye movements to drive assistive technology can be inefficient.

Devices which employ tilt sensors [5] to track head movements and video camera to obtain information from facial features [6] have been built. The major limitation of these devices is that people with severe neuromuscular damage may not be able to use them.

A significant number of assistive technology devices that have been developed to help the paralyzed use tongue to drive the device. This is because the tongue is connected to the hypoglossal cranial nerve and escapes most of the spinal cord injuries. Magneto- inductive [7] and magneto-resistive [8] sensors can be used to detect the magnetic field generated by a permanent magnet placed on the tongue. However, the latter requires an additional Wheatstone bridge arrangement, which occupies more space and also makes the entire configuration heavy.

In another assistive technology device, inductive sensors [9] were used to locate position of the tongue. These sensors were arranged in series and placed inside the mouth in the palette using a dental retainer. Data acquisition was done using a DAQ module and the data was processed using a customizable MATLAB code. Here, the usage of a rectifier and a DAQ module increases the complexity of the system. Moreover MATLAB occupies more RAM space and its execution speed is less.

Another tongue drive system [10] developed used analog Hall Effect sensors to track tongue movements. Here Lab VIEW was used to create a Graphical User Interface (GUI). The analog Hall Effect sensors were placed on a mouth piece which is placed on the teeth. This arrangement is unsafe since there is a probability of a micro-shock. Since analog sensors were used, additional components such as the analog to digital converter (ADC), amplifiers were required. Further, Lab VIEW being proprietary software is expensive. It also occupies a lot of disk space. Complicated VIs need to be made for interfacing devices with Lab VIEW.

Devices such as Tongue Touch Keypad (TTK) [11] and tongue mouse [12] use piezoelectric ceramic sensors to detect the touch of the tongue. However, they are high impedance sensors and can pick up stray voltages from the connecting wires. Also, these devices have large protruding objects inside the mouth, which can cause disturbances during eating and speaking.

In contrast to the technologies mentioned above a Glossokinetic potential assistive technology [13] which taps the bioelectric potentials of the tongue to move the wheelchair has been developed.

Considering the amount of research that has been going on to develop assistive technologies, very few of them are commercially available in the market. For this reason, there is a pressing need for an assistive technology that is inexpensive, convenient and easy to use.

Importance of Tongue As A Manipulator For Assistive Devices

The tongue and the mouth occupy an amount of sensory and motor cortex that matches that of the fingers and the hand [14]. So it is capable of performing complex manipulation tasks. It is seldom affected in most neuromuscular degenerative disorders. The tongue has many degrees of freedom, and it can move very fast and accurately within the mouth cavity. The tongue muscle has a very low rate of perceived exertion. Hence, a tongue operated device can be used continuously over a long period of time. Therefore it is a suitable organ for manipulating assistive devices.

System Overview

In the tongue drive system for mouse pointer control, the motion of the tongue is traced by an array of digital Hall Effect sensors (AH34), which detects the proximity of a permanent magnet. The magnet is fixed on a plastic fixture placed on the tongue. The digital Hall Effect sensors are placed on a head mounted device. Fig. 1 shows six magnetic sensors. Four sensors control pointer movement in one of the directions RIGHT, LEFT, UP or DOWN. The remaining two sensors control RIGHT click and LEFT click operations. The output signals from these sensors are transmitted to a microcontroller which processes the data to determine the position of the permanent magnet and hence the position of the tongue. These are active low sensors and are powered by the microcontroller ATmega8 .The controller processes the output from the sensors and serially transmits the data to a personal computer. A program is written in Visual Basic to interpret the data received and to assign a certain control to the tongue position for moving the mouse pointer.

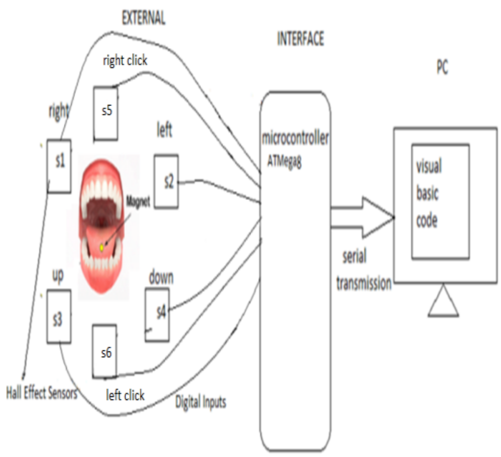

Figure 1: Block Diagram of Tongue Control Mouse Pointer

Advantages of Tongue Controlled Mouse Pointer

The Neodynium permanent magnet which generates the magnetic field is small and weighs less, thus ensuring user’s comfort. The magnet is also passive and hence provides power saving unlike an electromagnet. It is placed on a non-magnetic fixture at the tip of the tongue, avoiding a piercing on the tongue. The use of digital magnetic sensors, further reduces errors due to digitization and amplification. An output signal is generated when the distance between the sensor and the magnet is 1cm or less. A minimum distance between the sensors and the magnet is ensured to prevent noise. The head mounted device is removable and not specific for a particular user. The entire device is placed outside the oral cavity and hence is expedient for the user. Since the magnetic sensors sense proximity, the tongue drive system is more robust against noise, external magnetic interference and involuntary movements. Many aspects of the system can be customized and fine tuned through software for an individual's requirement.

Prototype

A. Hardware

The magnetic sensors, also called Hall Effect sensors, produce voltage difference across an electrical conductor in response to a magnetic field strength. The AH34 digital Hall Effect sensor has high speed operation over 100kHz and broad temperature range (-40 to +150 ^{o}C) [15]. In comparison to analog Hall Effect sensors it has long life time and high repeatability. It provides temperature compensation and is unaffected by external interference.

Six AH34 Hall Effect sensors were appropriately positioned and soldered on the dot boards. These dot boards were fixed on the head mounted device. Fig. 2 shows a diagrammatic representation of the position of the sensors. In a Tongue Drive System [10], analog Hall Effect sensors were placed on a dental retainer attached to the lower jaw on the outside of the teeth which can cause irritation to the cheek tissues. Hence we have placed the sensors outside the mouth on a head mounted device, which can be removed when not in use.

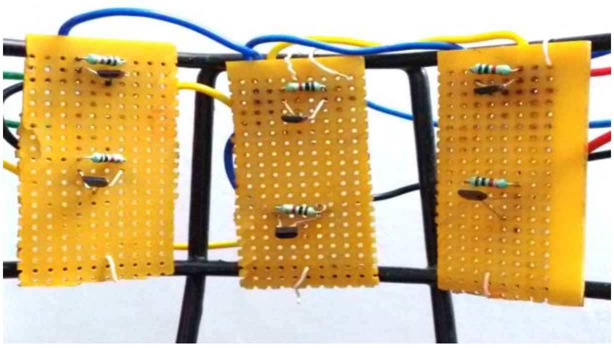

Figure 2: Arrangement of the six AH34 Hall Effect sensors on the dot boards

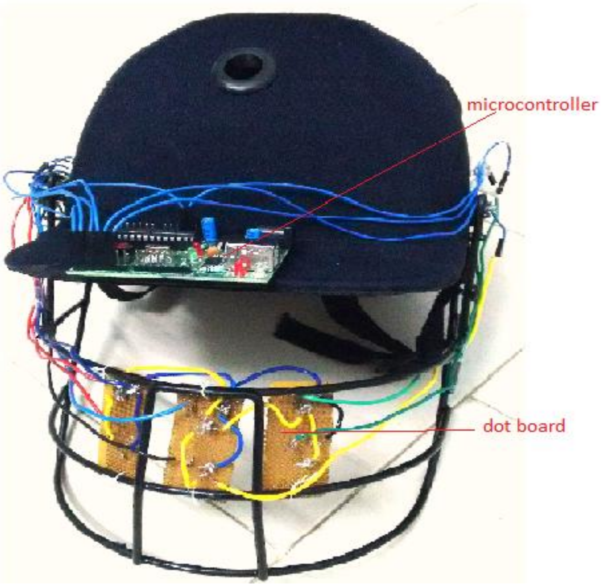

Figure 3: The head mounted device with sensors and microcontroller in place

B. Software

The softwares used in our project are Arduino and Visual Basic. Arduino provides a number of libraries to make programming simple. In our prototype, the controller AtMega8 is programmed in Arduino. A program in Arduino designates an integer value for each sensor. As a sensor is activated, the integer corresponding to that sensor gets transmitted serially.

The code for the user interface is developed on Visual Basic (VB). VB provides an integrated, interactive development environment (IDE) and it is an ideal platform to create graphical user interfaces (GUI). Through a Component Object Model (COM), data is received serially. VB has in-built mouse pointer control functions which are used in the code to move the mouse pointer in the directions RIGHT, LEFT, UP, DOWN and also to perform RIGHT CLICK and LEFT CLICK operations. The mouse pointer will continue to move in a particular direction as long as the permanent magnet is in close proximity to the sensor. The speed of the mouse pointer movement can be assigned in VB. The top left corner of the computer screen is set as the initial position of the mouse pointer.

Result

The Hall Effect sensors were accurately positioned in such a way that the magnet on the tongue is detected by the sensor and interference between sensors is avoided. Any further interference is prevented by bringing the magnet to the null position (inside the mouth), between a transition from one sensor to another. Fig.4 proves that our set-up is minimally strenuous for the tongue.

Fig.5 shows the VB form which when executed moves the mouse pointer according to the position of the tongue.

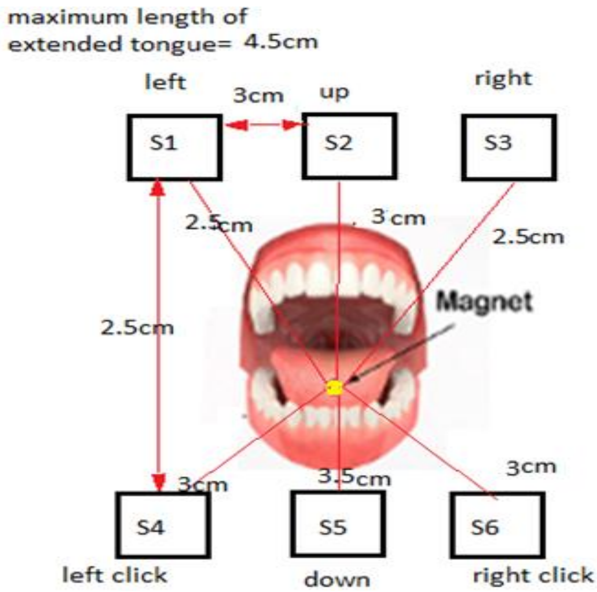

Figure 4: Schematic representation of the distance between sensors and their positions with respect to the tongue.

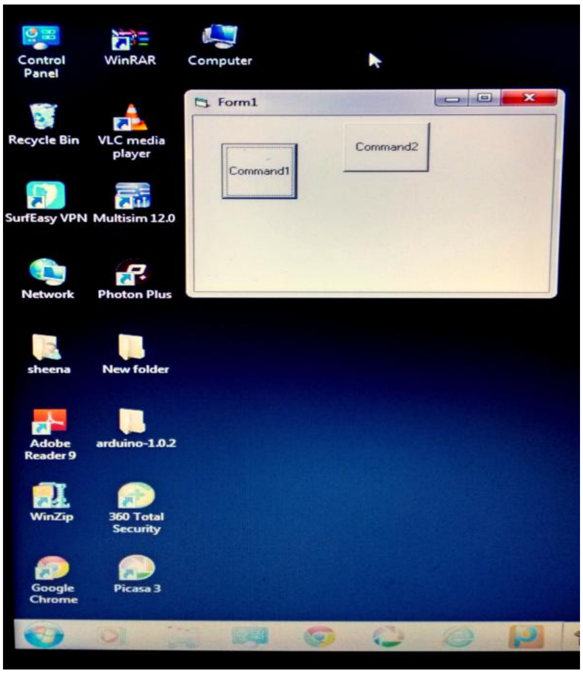

Figure 2: A screenshot of the desktop when executing the VB code. On clicking command1 button the system is made ready for serial communication .On clicking the command 2 button the mouse pointer is brought to its initial position .The user can now begin using the system.

Future Scope
Our design can be improvised by adding double click and scroll operations. An alternative sensing technology which rules out the need of a magnet and detects just the presence of the tongue can be employed. A wireless technology which enables the user to operate the mouse pointer at a significant distance from the PC can also be designed. Furthermore, the usage of this technology to control a phone would prove to be beneficial for the disabled.

Conclusion
People with severe disabilities from Traumatic Brain and Spinal Cord Injuries (TBI/SCI), Amyotrophic Lateral Sclerosis (ALS) and stroke [16] generally find it extremely difficult to carry out daily tasks without receiving continuous help. 10% of the global population, i.e., about 650 million persons, have disabilities. Nearly 1 in 50 persons are living with paralysis. This paper has aimed at making those people to overlook their disabilities. The tongue controlled mouse pointer will help them to lead an independent, self-supportive life and connect them to the external world.

This technology provides people with severe disabilities to access computer and even to control external environment. It translates users' intentions into control commands by detecting and classifying their voluntary tongue motion. This is achieved by placing a small permanent magnet on the tongue and an array of magnetic sensors mounted on a head mounted device outside the mouth. Six control strategies are developed for the mouse pointer. The user is facilitated to control and operate computer, browse Internet, playing games, etc.

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