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ORIGINAL RESEARCH

An Atypical Chauffeur: Tongue Driven Wheelchair

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Abstract

The human body is a machine that enables living and performing various task. Once the functional ability is lost a vital part of life will be compromised. The loss of function may be due to various causes and can be unilateral/bilateral which can be localized to a part or generalized.[5] Various wheelchairs currently available in the market uses electrically powered wheelchairs to allow individuals to complete daily tasks with greater independence and community environments. One of the newer concept in this area is a tongue driven wheelchair system. The tongue as an operating system can be beneficial because unlike the feet and hands, which are connected by brain through spinal cord, the tongue and brain has a direct connection through cranial nerve that generally escapes damage in severe spinal cord injuries or neuromuscular disease.[2] Tongue being a strong muscle provides faster and accurate movements that do not require much concentration or effort. Paralyzed patients can move around independently with the tongue driven wheelchairs creating a huge demand for this assistive technology in future. Further research in the field can make mobility far more accessible to people who are facing various challenges.

KEYWORDS
Chauffeur, Toung Wheelchair

1 | INTRODUCTION

The ability to move about freely, brings a sense of freedom to all. The loss of it can greatly impact a person's life. The loss of function of limb/limbs can be due to various causes. The most common causes leading to amputation are diabetes mellitus, peripheral vascular disease, neuropathy, and trauma.1

According to the World Health Organizations report on disability, currently about 15% of world population lives with some type of disability out of which 2-4 % of the population experience significant difficulties in their day-to-day activities. Wheelchair usage is not just limited to paralyzed people but also blind, physically handicapped and people having neuromuscular and spinal cord issues.2

Current modalities

There are currently multiple variants of wheelchairs available in the market. This includes the manual wheelchair.

1. Manual wheelchairs are great for people who can operate them independently. However, the downside is that users can quickly become fatigued especially if they travel long distances or move around for an extended period of time on their own.3
2. Powered wheelchairs have undergone an enormous change in the last decade. The development of micro processing capabilities allowed developers of powered mobility technology to include a wide range of functions in these devices.3 A motorized wheelchair like this resolves the issue of fatigue as well as disabilities that restrict the use of manually operated wheelchairs.

- Joystick controlled wheelchair is one of these modalities. A joystick mounted on the wheelchair helps maneuver it around.
- Another is the touchpad-controlled wheelchair. Touchpads feel similar to what you may find on a computer for controlling its mouse cursor. Touchpads can be configured for the user so that touching a specific part of the touchpad relative to the center will move in that direction. One drawback of both these technologies is that it is only accessible to those with coordinated motor functions.7
- Switch coordinated wheelchairs are also available in the market. Switches can be mechanical momentary contact switches or based on proximity where no physical contact is required. Multiple switches can be used, one for each direction, three switches as in a head array or a single switch that is used with some scanning display.
- Another alternative is the sip and puff mechanism wheelchair, which are operated by sucking and blowing on a mouthpiece. They require quite a bit of practice by the user to get good at driving.
- Eye movement activated and voice-controlled wheelchairs are also available. But the mechanism can be misled by rogue eye movements or voice commands.7

2 | MATERIALS AND METHODS

The alternative wheelchair system that will be discussed in this article is the tongue driven wheelchair system [TDS].6 It is controlled via a prosthesis incorporated with touch sensors placed on the palate, and operated by the tongue movements. The prosthesis can be customized according to the dentulous state of the patient, if the patient is completely edentulous then the controller can be adapted to the complete denture prosthesis

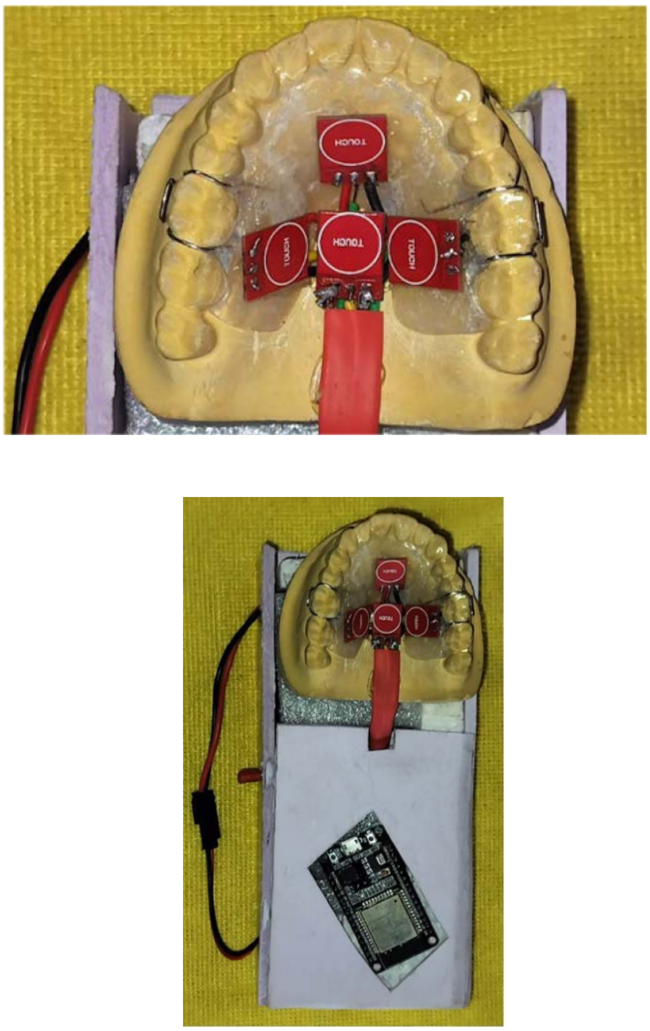
And if the patient is partially edentulous then the controller can be incorporated into the Removable partial denture via clasp mechanism. In case of completely dentulous patients, the controller can be adapted onto a prosthesis adapted to the palatal aspect of maxilla via clasp retention mechanism.

The patient is advised to wear the prosthesis during the operation of wheelchair.

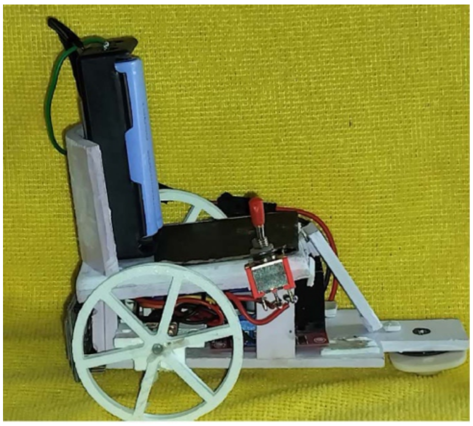
1. End-to-End Working Model of the prototype:

The end-to-end working model of the tongue-controlled wheelchair involves various components seamlessly working together. The user's tongue movements are captured by the touch sensors placed in the upper jaw (figure 1). These touch sensors detect the tongue's position and send signals to the microcontroller, specifically the ESP32. The microcontroller processes these signals and determines the desired direction or action for the wheelchair. It then controls the DC motors, which are connected to the 3D printed wheels of the wheelchair (figure 2), through the L293D motor driver. By adjusting the motor speed and direction, the wheelchair moves according to the user's tongue movements. The microcontroller also interacts with other parts of the wheelchair, such as the chassis and chair, to ensure a holistic functioning system.

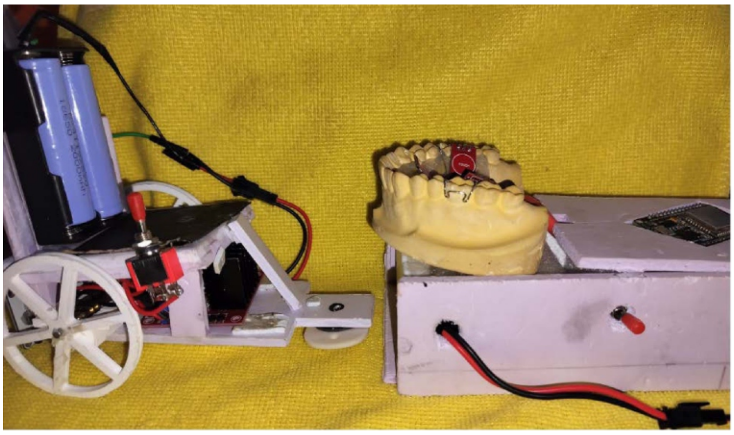
The complete setup of the prototype is depicted in figure 3



(Figure 1 – touch sensors placed on the palatal prosthesis)



(Figure 2 – 3D printer wheelchair with DC motor)



(Figure 3 – complete prototype set up)

2. Microcontroller Used in this prototype and its Significance:

The ESP32 microcontroller is selected for its suitability in IoT (Internet of Things) applications. It offers built-in Wi-Fi and Bluetooth connectivity, enabling wireless communication and control. The ESP32's ample processing power and memory make it capable of handling sensor inputs and effectively controlling the motors. Additionally, its abundant GPIO pins allow for seamless integration with various components of the wheelchair, including the touch sensors, motor driver, and other peripherals. By utilizing the ESP32 microcontroller, the tongue-controlled wheelchair can achieve efficient and reliable performance.

3. Sensors Used and their Significance:

In the development of tongue-controlled wheelchairs, the choice of sensors plays a crucial role in achieving a wire-free setup. While touch sensors typically require wires to come out of the mouth, alternative sensor methods offer the possibility of a non-intrusive and comfortable solution. This document explores various alternative sensor approaches that eliminate the need for wires inside the mouth. Additionally, it provides reasons for utilizing touch sensors in cases where wires are necessary.

External Mounting:

Rather than placing sensors inside the mouth, an external mounting approach can be adopted. Touch sensors can be integrated into a custom-designed mouthpiece or attached to a wearable device positioned on the palate. This allows for close proximity to the tongue while routing wires externally, providing a wire-free experience for the user.

Other type of sensors available

- Inductive Coupling:

Inductive coupling enables wireless power transfer. Touch sensors can be powered wirelessly using electromagnetic induction, with the power source located outside the mouth. Through a coil or magnetic field, the sensors receive power without the need for power wires. However, some form of wired communication may still be required for transmitting the touch data.

- Infrared (IR) Sensors:

Infrared sensors can detect tongue movements without physical contact. Placed outside the mouth, these sensors capture the reflection or emission of infrared light from the tongue. The detected signals can be translated into control commands for the wheelchair, offering a wire-free and non-intrusive solution.

- Optical Sensors:

Optical sensors, such as photodiodes or optical proximity sensors, analyze light changes to detect tongue movements. Positioned externally near the upper jaw, these sensors detect alterations in light when the tongue obstructs or reflects it. This wire-free method accurately captures tongue movements while maintaining user comfort.

- Magnetic Sensors:

By utilizing magnetic sensors like Hall Effect or magneto resistive sensors, tongue movements can be detected through variations in the magnetic field. A small magnet placed on the tongue interacts with the externally positioned sensors, translating the changes into control commands. This approach eliminates the need for wires inside the mouth.

- Ultrasonic Sensors:

Ultrasonic sensors measure the distance between the tongue and the sensor by emitting and analyzing reflected ultrasonic waves. These sensors, positioned externally, allow for wire-free implementation. By accurately determining tongue position and movement, they enable precise control of the wheelchair.

Reason for Using Touch Sensors:

The decision to use touch sensors, despite the wires required, can be justified based on cost-effectiveness, simplicity, and user-friendliness. Touch sensors are readily available, cost-efficient, and provide immediate response. These factors make them suitable for projects with limited resources or tight timeframes, where a wire-free setup is not a critical requirement.

In the quest for a wire-free setup in tongue-controlled wheelchair projects, alternative sensor methods offer viable solutions. Through external mounting, inductive coupling, infrared, optical, magnetic, or ultrasonic sensors, it is possible to eliminate the need for wires inside the mouth. However, touch sensors remain a practical choice in scenarios where wires are inevitable, considering their accessibility, affordability, and ease of implementation.

The touch sensors, placed in the upper jaw, play a crucial role in capturing tongue movements. These touch sensors are preferred due to their simplicity, affordability, and ease of implementation. They detect the presence or absence of tongue contact, providing reliable input for controlling the wheelchair.

Touch sensors are often cost-effective, readily available, and offer simplified implementation. This makes them an accessible option, particularly for projects with budget constraints or those requiring quick prototyping.

Additionally, the wheelchair may incorporate other sensors relevant to the specific requirements of the application, such as distance sensors or obstacle detection sensors. These additional sensors enhance the overall functionality and safety of the wheelchair.

4. Implementation in Real Scenario and User Enable/Disable:

In a real scenario, the tongue-controlled wheelchair would involve integrating the system into a commercially available wheelchair with a suitable chair for the user's comfort. The wheelchair's existing chassis provides the necessary structural support and maneuverability. The touch sensors would be strategically placed on the palate, allowing the user to control the wheelchair through tongue movements.

To enable or disable the tongue-controlled functionality, a user-friendly interface can be incorporated into the wheelchair design. This interface may include buttons, switches, or touch-sensitive controls conveniently located within reach of the user. By engaging or disengaging this control mechanism, the user can activate or deactivate the tongue-controlled feature of the wheelchair.

Proper safety measures should be implemented to ensure the user's well-being. For example, an emergency stop button or lever can be included to immediately halt the wheelchair's movement in case of any unforeseen circumstances or emergencies. Additionally, the wheelchair can have manual control options, such as traditional joystick controls, allowing the user to switch between different control modes based on their preference or specific situation.

By integrating the tongue-controlled system into a real wheelchair, it becomes a practical and functional solution for individuals with limited mobility. The user can easily enable or disable the tongue-controlled feature as needed, ensuring a personalized and adaptable wheelchair experience while maintaining safety and convenience.

3 | RESULTS

The prototype was adapted with four sensors denoting forward, backward, right and left movements. Several motion tests were done to check the efficiency of sensors in bringing about motion in the desired directions. The results obtained showed successful range of movements.

4 | DISCUSSION

The use of evolving technology to improve the quality of life of individuals is being done at an accelerated rate in recent times. The results we have obtained from using sensors adapted on a palatal prosthesis have been encouraging. The basic movements of forward, reverse and right and left movements were appropriately followed in the model. As the model uses Bluetooth connection between the sensor and the wheelchair there is no clunky connective components.

Additionally, the wheelchair may be incorporated with other type of sensors (distance sensors or obstacle detection sensors) relevant to the specific requirements of the application. These additional sensors enhance the overall functionality and safety of the wheelchair.

This signifies the potential that similar technology can be utilized to make a full-scale version adapted to a wheelchair that will successfully function in the intended manner. This could provide a new alternative version of a powered wheelchair.

5 | CONCLUSION

The tongue drive wheelchair can be utilized by all people with disabilities to achieve the freedom to move around independently. This system has the potential to be more versatile in its applicability and offer more comfort during its usage. It is a compact system with a slight learning curve involved in adapting to its usage.

Conflict of Interest

The Authors declare no conflicts of interest

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