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Project Proposal - Tongue Control for Spinal Cord Injury Patients

Problem and Idea

In present day quadriplegics do not have a mobile, discreet method of finely controlling technology for independent living.

We envision a tongue interface capable of controlling technology to enable independent living. The tongue is one of the most sensitive and versatile muscles in the body. It is also hidden within the mouth.

Specifically for our project we wish to create a tongue interface for mouse control and juxtapose our interface with those of existing enabling technologies. If we can achieve a strong tongue interface, we may be able to extrapolate control to wheelchair control, exoskeletons to regain use of limbs, and telepresent control of robotic arms to aid in daily tasks.

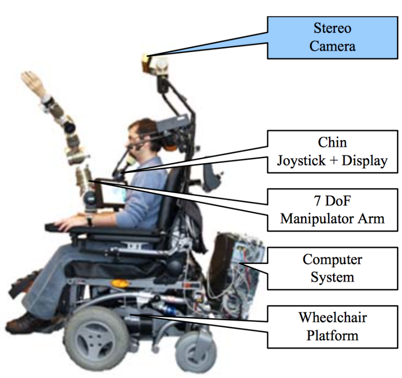
Analysis of Problem

Life as a tetraplegic or paraplegic can be very tough. These conditions are the result of a spinal cord injury which drastically changes the lives of people who suffer it. While the standard of living heavily depends on the severity of the injury - some patients have some limited movement while others have none at all - the truth is that independent living is in a wide range of cases not possible. This is exactly the problem that we want to address.

To provide a little bit of context, according to Spinal Cord Injury: Facts and Figures by the National Spinal Cord Injury Statistical Center, in the U.S alone there are approximately 11,000 new spinal cord injuries every year. The total number of people in the U.S with SCI is estimated to be around 280,000. Most of these injuries occur due to vehicular accidents, though many of them also occur due to sports. In terms of lifetime costs of living with SCI, for people injured at the age of 25 it can range from $1,500,000 in the mildest cases up to $4,500,000 in the cases of High Tetraplegia.

Fortunately, there has been a lot of progress in technology to help improve the quality of life of people with SCI, particularly in the area of robotics. Two areas of research are most prominent in this field. In the first, the use of external robot limbs to facilitate daily routines has acquired some popularity, though there is still a lot of progress to be made before it becomes common. In the second, robot layers added to the human body provide mechanical functionality to help move parts that would otherwise not be possible to move due to SCI. One of the main problems in these of areas of research is the human-computer interface that takes place. It is still not good enough to provide natural movement of the robot parts, making movements look artificial. This is also the case for prosthetics used by patients who have lost a limb.

We believe that a lot can still be done to improve the interface between the patient and the robot parts.



Left - Example of an external robot arm

Right - Example of exoskeleton

Suggested Solution

With the priorities of discreet (not easily noticed) and sensitive control, we propose a tongue-based control interface.

We envision an interface that stays inside the mouth, hidden either behind the teeth or in some not easily visible location. This interface interacts with the tongue and enables it to control a variety of technologies wirelessly. As an interface that stays within the mouth, we anticipate cleaning requirements; like contacts or retainers the interface may be removed or cleaned on a frequent basis.

Specifically for this proposal we suggest a tongue-controlled interface for a computer mouse pointer. We believe that designing for a tongue controlled mouse provides a basis for designing a generalizable interface for tongue-based exoskeleton or wheelchair control.

Experiment

Our experiment begins with the setup; we plan to first interview users of current quadriplegic/disabled control interfaces at Weill. After gathering initial information we will begin experiments on ourselves with the goal of rapidly prototype and iterating until we have an initial minimum viable product. This design which we settle on will be brought to our participants. We aim to test our design amongst various ages, genders, and degrees of familiarity with computers. We also plan to test amongst those that were born quadriplegic, those that transitioned into this state, those that were suddenly cast into this state and those that are not quadriplegics. These are the variety of participants we would like to incorporate within our study. With an understanding of who are participants are and what they need we would be begin testing our interface.

We plan to vary the interface related design choices in order to gauge the effectiveness of our design. These variations in the design are our independent variables. They include: choice of interaction element, interaction element placement within the apparatus, element sensitivity, and the types of casings (tongue mounted vs. retainer vs. additional configurations).

We expect that varying these independent variables will affect the speed and accuracy of interfacing, which we will quantifiably measure as dependent variables. Qualitatively, we also value the importance of comfort; we plan to monitor patient's oral comfort before, during, and after use as well as how much saliva they produce. We may also include timed tests to understand how much time it takes to become comfortable with our interface.

As modes of testing we plan to create a small series of games. The first, a navigation game where patients move through a maze, avoiding contact with the walls addressing interface sensitivity. The second, a button based whackamole game geared towards rapid movement. And lastly, a typing game that tests words per minute. From each test, as mentioned previously, we will record the speed and accuracy of the patient towards victory in the game, and use observations, questions, and interviews to record qualitative dependent variables. We will use our growing understanding to improve and iterate upon our design.

We predict that our first prototypes and tests will have a lot of issues to correct. We will spend the semester correcting these issues and refining our design with growing feedback from our users. It is our hope that the tongue interface will provide greater comfort and strong enough performance to be considered as a replacement technology for present enabling technology for patients with paralyzing spinal cord injury.