
Tongue-Computer Interface Technology - Mid-fi Prototype

1. PROBLEM AND SOLUTION OVERVIEW

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. 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.

2. TASKS

In our previous prototypes, we were trying to address the following tasks: 1) being able to locate buttons with the tongue, 2) being able to perform operations by pressing those buttons with the tongue, and 3) fitting a well sized artifact inside the mouth comfortably. In those versions, we were able to gain an understanding of how easy it may be for users to interact with a device hidden within their mouths and what felt comfortable for them. However, when it comes to performing operations with it, we were limited to wizard of Oz techniques or to the calculator's display to show some output performed by the user. The problem with this is that the buttons shape and the calculations performed did not really represent the final vision we had for our product.

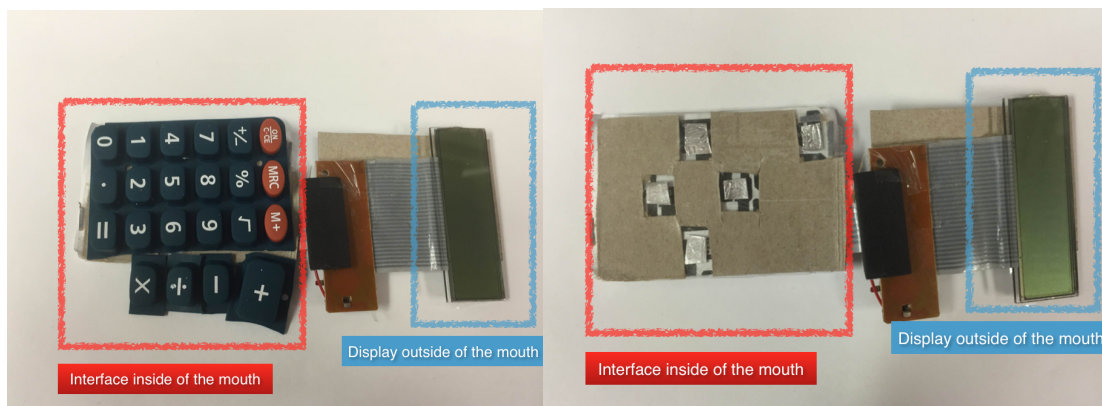


FIGURE 1 - PREVIOUS CALCULATOR PROTOTYPE

In that sense, we have now developed a new prototype that aims to address the following tasks: 1) Locating buttons inside the mouth with the tongue (*Medium*), 2) Using those buttons to perform operations easily done with just the tap of a button or two (*Complex*), and 3) Keeping an external device inside the user's mouth for longer periods of time. (*Simple*)

3. REVISED INTERFACE DESIGN

Based on the users' feedback during the previous prototype versions, we kept testing different materials to get a better understanding of what might be comfortable for the user. In that sense, we tried materials that varied from chocolate and cheese to plastic and foam. This helped us understand different textures that might be familiar for the user when using our product.

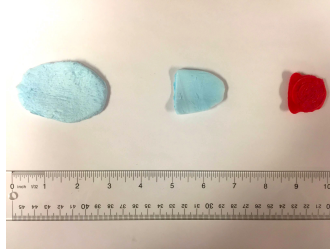


FIGURE 2 - PREVIOUS STUFFS PROTOTYPES

We then proceeded to address the problem of operating with our previous prototype that used a calculator screen to indicate success of operations. This time around we built a more robust prototype that: a) had a shape that allowed for easy insertion in the mouth, and b) was able to perform the operations of turning lights on and off with 2 different buttons. The scenarios of interaction with our prototype are the following:

Scenario 1 - Locating buttons inside the tongue

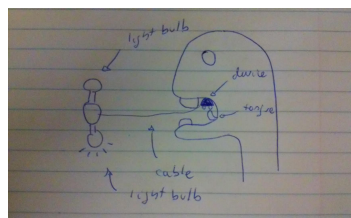
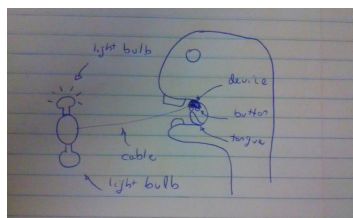


As it can be seen in the picture, the idea is for the buttons to be easily identifiable by the user that is using the interface. With his tongue, he will proceed to touch the device and sense the buttons, identify each one of them, and then perform operations of his choosing.

For this prototype, locating the buttons consisted on identifying a small gap between them. However we also found useful for future possibilities having their texture be different.

FIGURE 3 - SCENARIO 1: LOCATING BUTTONS

Scenario 2 - Performing operations to turn lights on and off



In this case, the idea is for users to activate and deactivate certain functions based on the buttons pushed. For testing purposes, we decided for that operation to be turning lights on and off.

FIGURE 4 - SCENARIO 2: TURNING LIGHTS ON AND OFF

Please note that we do not offer a scenario of keeping the device in the mouth for longer periods of time because we felt it didn't really provide any useful insight.

4. PROTOTYPE OVERVIEW

Tools

The tools used for building our prototype consisted of: *Arduino* (to make all the connections to the buttons and the lights and program it so that on a button push the lights would turn on), *LED* lights, *Pushable buttons* (that would activate the LED lights), and *Plastic* which would cover the buttons and work as our device to be put inside the mouth. The shape of this plastic cover was modified through heat. *Tape* was used to keep everything together, *cables* were used to connect the buttons to LEDs, and *plastic bags* were used to allow for multiple uses of our prototypes by different people.

We also tried using chocolate and cheese to see how important the texture of the device was and how easy it would be to identify buttons. This was very helpful to gain insights into how users feel when touching the device and will be explored in the next iteration of our prototype.

What was left out and why

Previous versions of the material used in our prototype included stuffs, which were helpful to address what the shape of the device should be, but the feeling was not very much liked during the heuristic evaluation. because of this, we decided to then go with plastic, which has so far been very successful.

This prototype represents the first working version of a tongue interface that allows the user to do something. However, only using buttons to perform discrete actions is not enough and continuous movement should be addressed eventually. At the same time, the buttons are connected to the LED lights through cables, and in that sense, we will need to come up with a way of performing actions wirelessly with the device. These were all functionalities that were left out due to time constraints and because what we were testing with the prototype did not demand it. In next versions of our prototype we shall explore this options.

Wizard of Oz techniques

So far the only action that can be performed with our prototype is turning lights on and off. In our final version we intend to be able to connect to a computer and have our device act as a mouse. In that sense we already have the 2 buttons, so users can actually pretend they are clicking the buttons of a mouse and using a wizard of Oz technique we can act as if the computer was receiving their input!

Hand coded features and why they are required

The hand coded features we had to implement were the turning of lights on and off. We wanted to get a feeling of what it would be to achieve this through our interface and since we had the tools at our disposal to do so, we felt that trying to do a Wizard of Oz for this was not going to give us the insights we needed for this version.

5. PROTOTYPE SCREENSHOTS

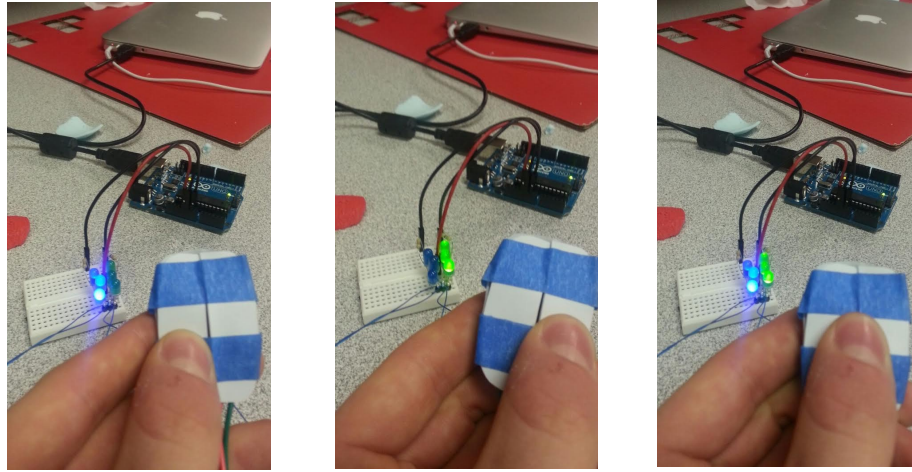


FIGURE 5 - BUTTON PRESSING AND LEDS TURNING ON. SYSTEM OVERVIEW

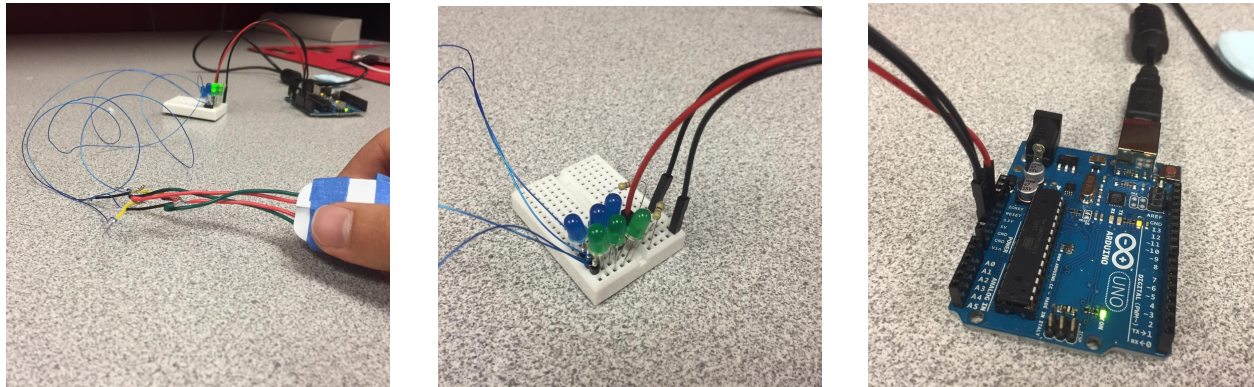


FIGURE 6 - A CLOSED LOOK AT THE MATERIALS USED