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HUMAN TO COMPUTER INTERFACE CONTROLLED FOR USING TETRAPLEGIA BY THE LIP

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Abstract: Lip control system is an innovative human–computer interface specially designed for people with tetraplegia. This paper presents an evaluation of the lower lip potential to control an input device, according to Fitts' law (ISO/TS 9241-411:2012 standard). The results show that the lower lip throughput is comparable with the thumb throughput using the same input device under the same conditions. These results establish the baseline for future research studies about the lower lip capacity to operate a computer input device. Lip muscles are controlled by the facial nerve that is directly connected to the brain. This is an important characteristic for people with SCI in the neck region. An innovative human– computer interface using the lips, such as the one proposed in this paper, indicates an excellent potential. The major contributions of this paper are the analysis, under the rigor of Fitts' law of using the lips to control a pointing device; and the comparison of the results with a common way to control the same

Index Terms—Assistive technologies (ATs), Fitts' law, human–computer interaction, pointing devices, severe disabilitiesvice.

I. INTRODUCTION

Lip muscles are controlled by the facial nerve that is directly connected to the brain. This is an important characteristic for people with SCI in the neck region. An innovative human computer interface using the lips, such as the one proposed in this paper, indicates an excellent potential. This system is designed with the X, Y joystick device which is fixed in lower lip. When it is moved upwards, downwards or sideward's the same movement will be controlled in the mouse input device. It totally meant that cursor movement will be based on our lower lip movement. Selecting the particulates files or folders will be based on the joystick centre clicks.

A. NEED OF JOYSTICK

This joystick device is interfaced with the PIC microcontroller through the interfacing circuit signal conditioning unit. Signal conditioning unit (SCU) is nothing but the communication device to pass the signal from inputs to the controller. Here PIC microcontroller is used to do the controlling actions where programming is done according to the project needs with the specific tasks. Status of the cursor as well as joy stick movements will be displayed in the LCD display which is interfaced with the microcontroller. Lots of robotic projects need a joystick.

Fig.1. Joy stick

B.TRANSMITTING PROCESS

Transmitting the data's from LIP movement with the joystick device to the PC will be done through the Bluetooth wireless modules. Whatever the lip is doing with the joystick, the movement of cursor will react according to tit in the PC.

II. RELATED WORK

The components to be used are:

- Microcontroller (any compatible arduino)
- Joystick module
- 1 Pin M-M connectors
- Breadboard
- USB cable

1. Connect the components based on the figure shown in the wiring diagram using a M-M pin connector. +5V pin is connected to the 5V power supply, GND pin is connected to the GND, the VRx and VRy pins are connected to the analog input pins and the SW pin is connected to the digital I/O pin. Pin number will be based on the actual program code.
2. After hardware connection, insert the sample sketch into the Arduino IDE.
3. Using a USB cable, connect the ports from the microcontroller to the computer.
4. Upload the program.
5. See the results in the serial monitor.

III. PROPOSED TECHNIQUE

The Concept of a Lip Controlled System are explained in following section

The lip control system (LCS) is a human–computer interface with a headset and a joystick positioned in front of the lower lip. The studies to develop the prototype showed that the lip control must be head mounted in order to capture the lower lip muscles movements. The joystick, as interaction method ,was chosen because it is easy to use, provides an intuitive control, is compatible with the lips movement and is widely known and adopted in assistive technologies (ATs). Some other important characteristics of the LCS are as follows:

1) It is controlled by the lower lip (dry area), an external body part, less hygienic issues;
2) It allows soft free movement in any direction as it is based on a joystick;
3) It is a personal system that can stay with the user in the wheelchair, chair, bed, etc; and
4) It avoids false commands deriving from wheelchair vibration or body spasms because it is head mounted.

An efficient human–computer interface is very important to improve the autonomy of people with tetraplegia allowing the control of power wheelchairs, computers, smart phones or other
Computerized appliances.

To evaluate LCS as a computer input device, it was configured as a Bluetooth standard mouse (compatible with computers and smart phones), but with the purpose of controlling power wheelchairs as well. Computer input devices have been deeply studied [30]–[32] and there are effective methods to evaluate their interface efficiency, such as Fitts' law [28] (standards in ISO/TS 9241- 411:2012 [29] that revises ISO9241-9:2000) that is widely used.

The main measure for comparing computer input devices is the throughput *TP* in bits/s [30] from a human to a computer, and it is calculated as:

$TP = (IDe/MT)$

(where *IDe* is the task effective index of difficulty [23], [30], [32] and *MT* is the average movement time to execute it. *IDe* is based on Shannon formulation [33]:

$IDe = \log z\ (De/We+1))$

where *De* is the average of effective distance between the point where the participant selects one target and the point where he selects the next target. *We* is the effective width and is defined as: where *De* is the average of effective distance between the point where the participant selects one target and the point where he selects the next target. *We* is the effective width and is defined as:

$We = 4.133 \,\square\, SD$

Where *SD* is the standard deviation of the distance between the target center and the point at which the participant selects the target, 4.133 is a constant. More detailed information can be found in . The LCS throughput, controlled by the lip, was measured to establish the lower lip capacity baseline to control a human– computer interface, but it is also important to understand if this throughput is limited by the device. The LCS throughput, controlled by the thumb (as a gamepad) was measured, because this can be considered one of the best use conditions, near the device limit throughput. This two- throughput comparison shows how good the lower lip could be considered if compared with the thumb to control the LCS. This is the reason why all the participants chosen to the tests are able-bodied.

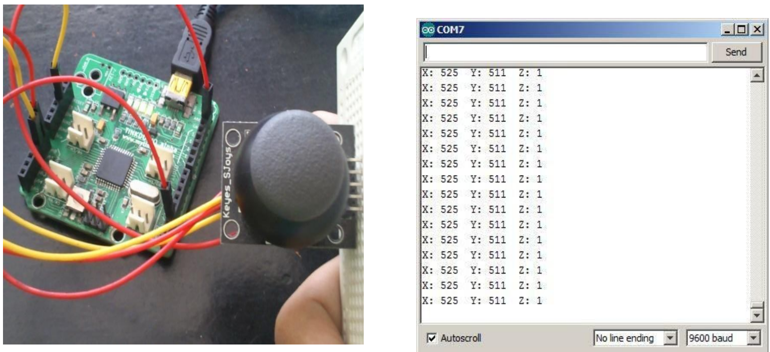
IV. LCS ARCHITECTURE AND IMPLEMENTATION

The LCS hardware consists of a development board Arduino Mega ADK, a Bluetooth module (Roving RN42-HID) and a thumb joystick, The system was configured as a standard Bluetooth mouse with a human interface device (HID) profile.
All the communications occur as with a standard Bluetooth mouse.

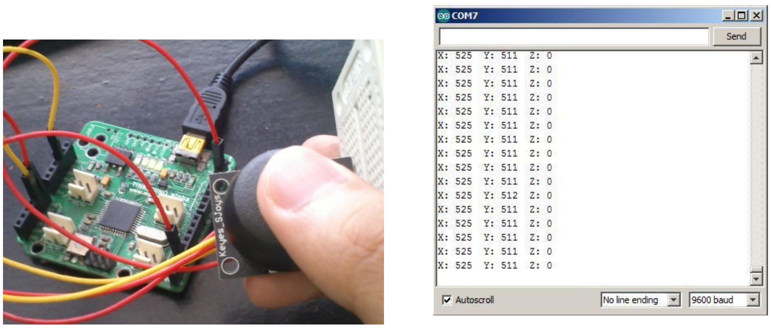
The LCS was designed specifically to be controlled by the lower lip; the current version is the ninth. The head support, evolved to provide the necessary stability during the operation; the joystick support, , evolved to be double and to provide calibration of length and angle in order to set the joystick in the correct operation position (just touching the skin). Fitts' law multidirectional tests were done to choose the joystick response with better throughput response.

The full headset prototype has 158.8 g of mass, including the joystick and the cable used to connect the joystick. A USB cable was connected to the computer just to provide power during the tests (this prototype does not have batteries).

V. RESULTS AND DISCUSSION



When the middle button was pressed



When the stick was moved downward

The lip-controlled LCS achieved throughput comparable with other assistive technology research studies. The TDS presented in achieved for one-directional horizontal task results from 2.1 to 2.5 bits/s, vertical task from 2.2 to 2.7 bits/s and multidirectional task from 0.4 to 1.0 bits/s. An important objective of this work is to understand how the lower lip can be a good option to control an input device. That is the reason for controlling the LCS with the thumb and the lip under the same conditions. The lip-controlled LCS reaches 1.06 bits/s throughput for the multidirectional task, while the thumb-controlled LCS had 1.80 bits/s throughput (this can be considered near the device limit) also for the multidirectional task. We can conclude that the lower lip achieved 59.2% of the thumb-controlled LCS throughput for multidirectional task. Fig. 6 shows the percentages for each task. Fig. 6 shows a consistent percentage tendency for the three tasks, with mean 62.2% and standard deviation 3.2%. In short, the lower lip was able to control a human–computer interface reaching 62.2% of the thumb throughput.

VI. CONCLUSIONS AND FUTURE WORK

This paper presented an evaluation of the LCS according to Fitts' law (ISO/TS 9241-411:2012 standard). The tests showed the lower lip potential to control an input device, and the results **showed** viable throughputs (2.6 bits/s for one-direction tasks and 1.06 bits/s for multidirectional task) and the most important, the lower lip achieves 62.2% of the thumb throughput, showing its potential to control human–computer interfaces. These results encourage us to expand the use of LCS to other applications (for instance controlling a power wheelchair), researching the use of other input devices that has better throughput than the joystick (to be lip-controlled) or to develop a new input device specially designed to be controlled by the lower lip. We have two new ongoing works.

1) Development and test of a new version of LCS with a mini trackball instead of a thumb joystick.
2) Evaluating the LCS to control power wheelchairs

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