A Framework for Mouse Emulation that Uses a Minimally Invasive Tongue Palate Control Device utilizing Resistopalatography

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***Abstract*—The ability to interface fluently with a robust Human Input Device is a major challenge facing patients with severe levels of disability. This paper describes a new method of computer interaction utilizing Force Sensitive Resistor Array Technology, embedded into an Intra-Oral device (Resistopalatography), to emulate a USB Human Interface Device using standard Drivers. The system is based around the patient using their tongue to manipulate these sensors in order to give a position and force measurement; these can then be analyzed to generate the necessary metrics to control a mouse for computer input.**

Keywords—Resistopalatography (RPG); mouse; HID; USB; Force Sensitive Resistor;

I. Introduction

Quality of life for patients with severe levels of neuro-disability could be dramatically improved if technology was developed focusing around a subset of muscles which are least likely to be affected by their disability (i.e. those controlling the tongue).

Many technological advances have been made in the field of providing computer interfacing to patients with varying levels of disability. Although these technologies on their own can provide levels of mobility to some patients, it is often seen that certain niches do not provide adequate control [1]. Whilst there are sensors that can be used to generate inputs from the patient such as sip and puff, chin control and head movement detection, these systems rely on the user having the ability to move neck muscles or have a reasonable level of vascular strength [2]. Other systems such as head Movement Detection[3], Brain Wave Analysis[4], Eye Based Tracking[5], Vocal Commands[6] are available but can be complex and provide additional challenges in regards to calibration and interfacing to computers which have not been setup for use by the device.

A Resistopalatography device, utilizing five force sensitive resistance sensors measuring the force exerted on them by the users tongue at specific locations on the hard palate, has been designed at the University of Kent. The use of five sensors allows for simple multi axis travel by combining sensor data, and a central mouse click.

The primary aim of this project is to deliver a system, which can be utilized by patients with the complex neuro-disability, to give them computer interaction without the worry and constraints of driver installation or complex hardware deployment.

This paper presents a framework which provides tongue pressure control of a mouse with any device that implements standard HID drivers. This is implemented over USB requiring no additional software or driver installation allowing for broad compatibility.

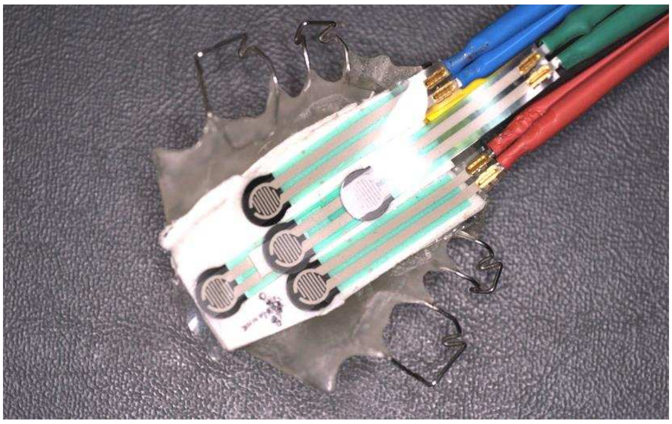


Fig. 1. Resistopalatography Prototype design without fluid cover.

II. Tongue Palate Control

The Resistopalatography (RPG) system is based on an intra-oral device with force sensitive resistor sensors that capture the pressure of the tongue at pre-defined areas of the patient’s hard palate, Fig. 1. All of the data generated by the sensors is captured by the analogue to digital converter function on a micro controller, which remaps the data into a format suitable for mouse emulation. The micro controller then acts as a USB HID mouse with the computer, and allows for user control of the mouse, Fig. 2.

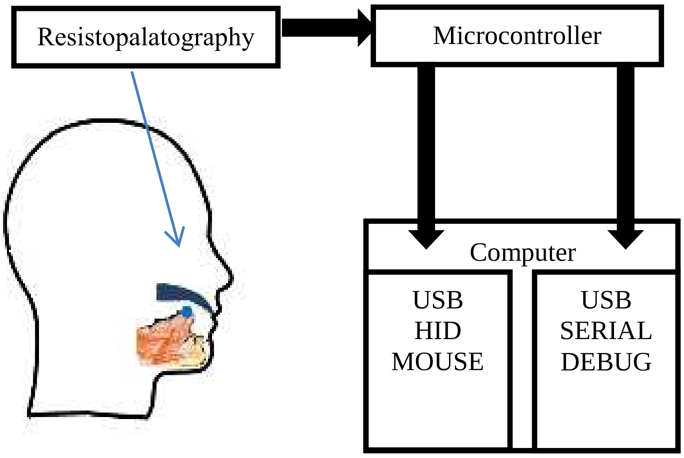


Fig. 2. Overview of the Resistopalatography system.

A. *Force Sensitive Resistance Sensors*

Force sensitive resistance sensor technology was chosen to capture tongue pressure against the hard palate due to its size, actuation force range and device response time. The sensor used was a FSR 400 manufactured by Interlink Electronics [7]. These are encapsulated into a dental retainer custom made for the project using a removable acrylic appliance with Adams cribs for retention. The sensors are connected to the micro controller's analogue to digital converter via a calibration voltage divider. At this stage of the project only five sensors are implemented, with two being paired to each axis and the final sensor acting as the mouse click detection.

B. *Micro Controller*

The micro controller used for this project is the Atmel ATSAM3XBE [8]; this was chosen due to its computational performance, connectivity and compatibility with the Arduino IDE. Furthermore this micro controller provides additional UARTS for live serial debugging whilst the primary USB is engaged in Mouse communications. The micro controller samples the sensor readings every 10ms (100 Hz) to provide smooth input to the computer.

III. System Framework

The micro controller captures the raw data from the FSR sensors which are analyzed for any drift or oscillation at idle. After this filtering, the first four sensor readings are mapped into a set of x and y axes to generate the mouse co-ordinates for transmission. The fifth sensor data is isolated at this point and only sets a flag for mouse click detection if it exceeds a certain threshold value to indicate the user is pressing the sensor with more than minimal pressure. Once the mouse metrics have been generated the data is then mapped into mouse movement data using Arduino mouse libraries [9] Fig. 3. The micro controller's primary USB interface is setup to emulate a USB Mouse, so that when a USB connection is made the operating system sees the device as a Mouse and loads the default USB Mouse drivers[10].

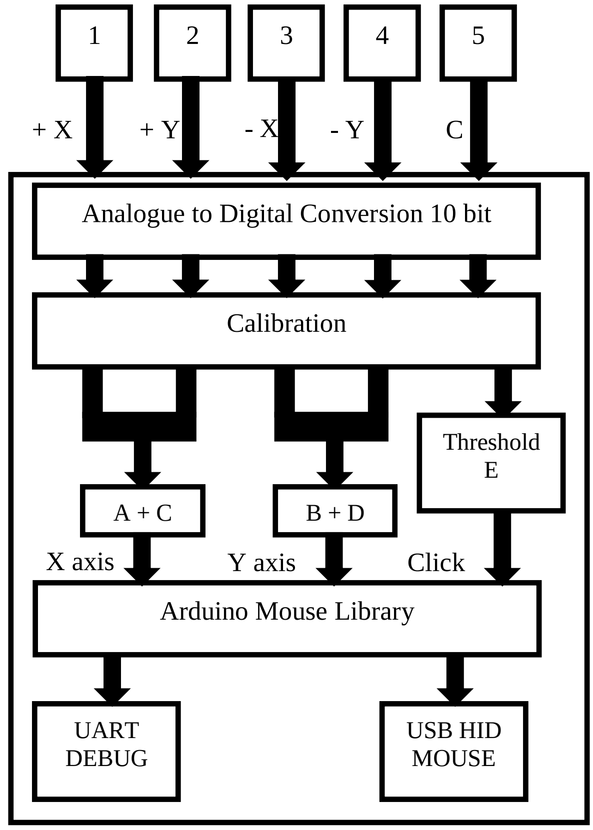


Fig. 3. Overview of the microcontroller routine.

IV. Prototype Results

To validate that the framework was adequate for basic use of a computer, a system test was devised utilizing the mouse feature along with the Mac OSX on screen keyboard. The test was to input the string "device testing". The anticipated projected path for the user was generated before the test to act as a reference, and then subsequent tests were performed on a mouse/track pad/Resistopalatography plate.

To provide a baseline comparison, an anticipated on screen keyboard trace can be seen in Fig.4, whilst Fig.5 demonstrates the real trace from using a standard mouse. The keyboard trace from the mouse can be seen as being very rapid in its movement around the keyboard; this is most likely due to the level of training with a mouse that the user has. The next test in Fig.6 demonstrates the same test scenario using a track pad on a laptop. The results from this show a slower navigation of the keyboard, however remaining relatively smooth between key pushes.

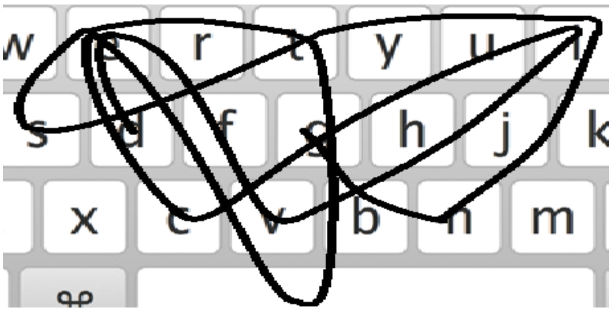


Fig. 4. Anticipated pointer trace route

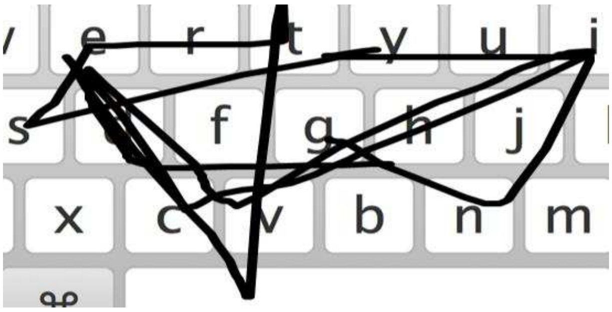


Fig. 5. Recorded Mouse Trace Route

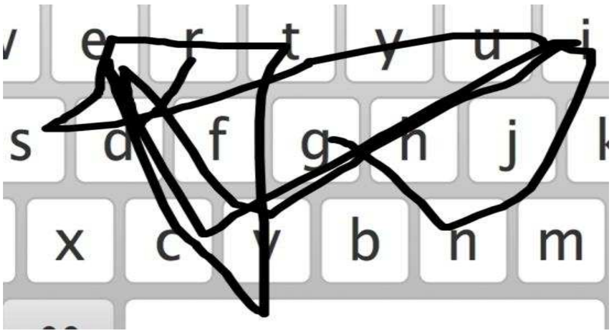


Fig. 6. Recorded Track pad Trace Route

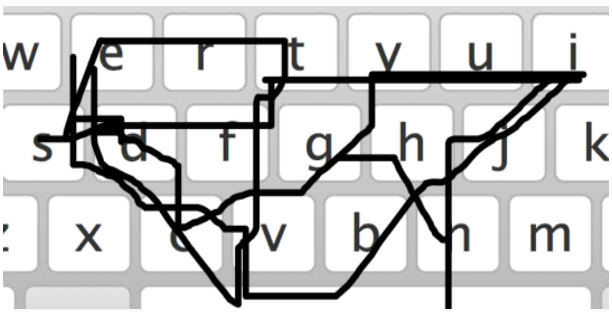
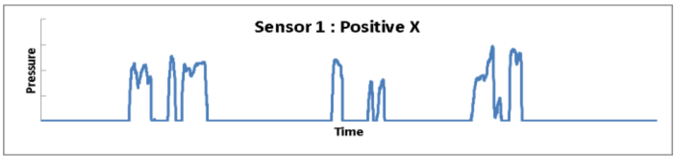
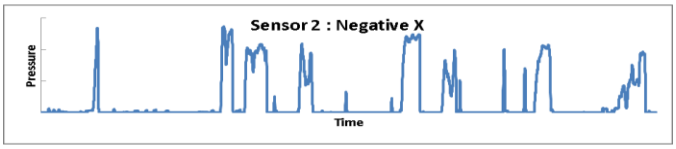


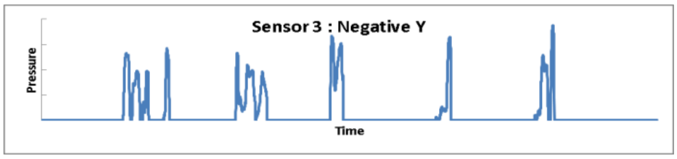
Fig. 7. RPG Trace Route



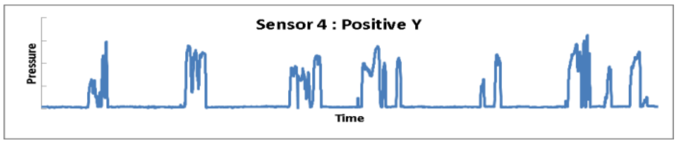
a. Positive X Axis RPG Sensor Data



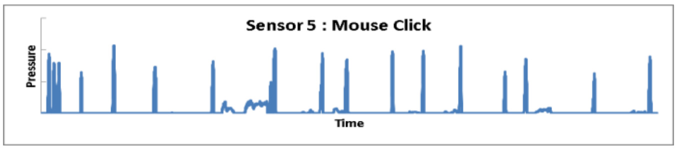
b. Negative X Axis RPG Sensor Data



c. Negative Y Axis RPG Sensor Data



d. Positive Y Axis RPG Sensor Data



e. Mouse Click RPG Sensor Data

Fig. 8. Sensor Data

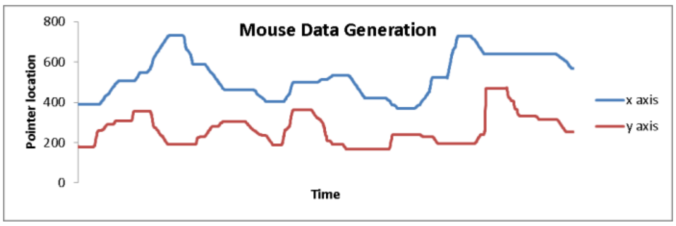


Fig. 9. Captured Mouse coordinates within computer derived from RPG

TABLE 1

Device Timing	
Device	***Time(s)***
Mouse	3
Track pad	9
Resistopalatography plate	55.4

Data collected from the sensors before any manipulation into mouse metrics, are shown in Figs 8a, b, c, d and e. Each of the sensor axis sample data provide clean signals to generate mouse co-ordinates and pronounced mouse clicks. All minor fluctuations on sensor 5 did not manage to cause false positive mouse click events. Sensor 2 had a minor level of offset due to issues with the mounting of the sensor, causing it to register a very small pressure being applied; however this was not enough to register as the first level of movement of a mouse and thus did not affect the device in anyway during the test.

The keyboard trace from the Resistopalatography device in Fig.7 has a minor error due to overshoot going from ‘I’ to ‘N’ during the test however this is to be expected due to the nature of the system and the fact that the test involved used a person who had low levels of experience operating the device. A notable feature of the results are the vertical and horizontal lines generated, this is due to only one sensor being used at one time, for most of the test. More than one sensor has to be used to generate movements in both axes. The results in Table.1 show the clear range of times it takes to complete the test with the different technologies

V. DISCUSSION

The framework presented in this paper provides user control of a mouse along with the ability to use an on screen keyboard for additional user interaction. As a proof of concept, this framework has been devised using off the shelf components for sensing and data acquisition. Whilst these provide adequate levels of functionality, they also have future potential if their key technologies are extracted to form a new system specific to this method of user input.

It is felt that with more sensors a more fluid user experience can be achieved; this can be supported by the fact that single sensors were used for some of the pointer navigation. Work is currently being carried out to increase the physical quantity of sensors from the five in this prototype to at least nine. With more sensors comes better axis control and perhaps different user actions can be performed. However it is felt with more training the time taken using Resistopalatography could be reduced.

Whilst research into human interface devices is currently a hot topic, another use for this type of technology could be in the identification of swallowing characteristics regarding the tongue’s pressure against the hard palate. Furthermore this technology could be used in regards to other input devices for disabled patients such as the input control for powered wheelchairs. We are currently developing joystick interface for use in the control of powered wheelchairs.

Experimental work is being undertaken in an attempt to implement a fully oral version of this technology, which will need to deal with the issues of wireless transmission and power deployment.

Nevertheless the functionality delivered within this paper can be seen as a step forward in the development of minimally invasive tongue palate control for severely disabled patients.

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REFERENCES

[1] A. Craig, Y. Tran, P. McIsaac and P Boord, “The efficacy and benefits of environmental control systems for the severely disabled,” Med.Sci.Monit, vol. 11, pp. RA32-9, Jan. 2005.

[2] P. Donald, M.W.L. Gear and S.P. Wilkinson “A life-threatening respiratory complication of gastro-oesophageal reflux in a patient with tetraplegia”,Postgraduate Medical Journal, 1987, Vol 63

[3] A. Pajkanovic, B.Dokic “Wheelchair control by head motion” Serbian Journal of electrical engineering. Vol. 10, no.1

[4] M. Kawate “Thought Controlled Wheelchair” July 2013 ; http://illumin.usc.edu/printer/240/thought-controlled-wheelchair/

[5] A. Al-Haddad, R. Sudirman, C.Omar, K. Hui, M. Jimin “Wheelchair motion control guide using eye gaze and blinks based on pointbug algorithm” Intelligent Systems modeling and simulation 2012.

[6] K.Komiya, K.Morita, K.Kagekawa, K.Kurosu “Guidance of a wheelchair by voice”. IECON, 2000, vol. 1.

[7] Interlink Electronics. “ FSR 400 Product Detail,” June 2013 ; http://www.interlinkelectronics.com/FSR400.php#

[8] ATMEL. “SAM3X/SAM3A Series Summary,” June 2013 ; http://www.atmel.com/Images/doc11057s.pdf

[9] Arduino. “Arduino Mouse/Keyboard Libraries,” June 2013 http://arduino.cc/en/Reference/MouseKeyboard

[10] USB Implementers' Forum, "Device Class Definition for Human Interface Devices (HID)," usb.org., Tech. Rep. Version 1.11, 2001.