Physiological Cursor

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As computers become an integral part of human culture, people diagnosed with disabilities or specific diseases may find themselves physically incapable of performing standard computer operations. Due to physical restrains caused by these disabilities and diseases, a person may not be able to perform simple tasks with their arms and hands, such as moving a mouse or using a touch pad to manipulate the cursor on the screen.

The objective of this project is to develop a physiological cursor, which results in the manipulation of a cursor on a computer screen. A physiological cursor will be able to benefit all of the different populations whose disabilities or diseases affect hand and arm movement.

The Physiological Cursor project was designed to take the electrical signal from a contracting muscle and use that signal to manipulate the cursor on a computer screen. The Physiological Cursor research builds upon a previous senior design project, SEMGo, at Texas A&M University (Spring 2005), which implemented an EMG-controlled robot.

The Physiological Cursor project consisted of three parts:
1. Signal Acquisition and Muscle recognition
2. Analog to Digital Conversion and Signal Processing
3. Cursor Manipulation

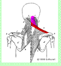
Muscles

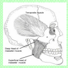
The Physiological Cursor was created to accommodate many different populations that would benefit from an alternative method for computer mouse movement.

It was assumed that if a person were to benefit from a physiological cursor they were physically unable to use their arms or hands to control a standard mouse or touch pad. From this assumption research concerning alternative muscles to perform the needed movements for cursor manipulation was conducted.

It was stipulated that muscles in the neck, face, and shoulder areas would provide the most natural movements.

Three factors were reviewed in determining if a muscle should be used for a generic system:
1. Signal strength
2. User friendliness – the contraction of the muscle was not difficult to perform
3. Cursor standard – the movement to contract the muscle could be associated with standard cursor movements


Trapezius [1]


Masseter [2]


Platysma [3]

Hardware Implementation

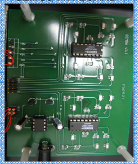
EMG Sensors → SEMGo Board → Notch Filter → TI Board

EMG: Four surface EMG sensors are used to control the mouse, three for direction and one for clicking.


EMG Sensors attached to the forearm

CALIBRATION: The system is calibrated to the user's unique physiological characteristics by having the user demonstrate a muscle flex pattern for the four cardinal directions and mouse click. The system is fully adaptable; it will accept any non-overlapping combination of muscle activation patterns for any direction. (The user can choose any pattern for any direction. As long as each direction has a unique pattern the system will function properly.) For every direction a mean response is calculated. The distance of the input to the means is what determines what action the system should take.

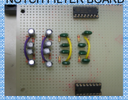
SEMGo v1.1 BOARD



SEMGo v1.1 BOARD: This board is comprised of four main parts, a pre-amp filter, an amplifier, a filter with voltage biasing, and power circuitry. The system was designed to be portable and therefore needed to be powered from batteries. The power circuitry on this board is to supply multiple voltages to multiple boards from a single 9V source. The EMG signal is first passed through a pre amp filter. This is a high pass filter with a frequency of 70Hz. The purpose of this filter is to help remove DC bias and reduce noise. The signal is then amplified with a gain of approximately 1000V/V. After amplification the signal is sent through another high pass filter to help stabilize the signal. Also, the signal is adjusted so that it is biased to 1.5V instead of 0V.

NOTCH FILTER BOARD: This is a four channel notch filter board. Its only purpose is to filter out noise at 60Hz caused by AC power. At the output of this board there is a 40dB attenuation of 60Hz in the EMG signal. This keeps the noise at 60Hz from dominating the signal, and increases the signal to noise ratio.

NOTCH FILTER BOARD



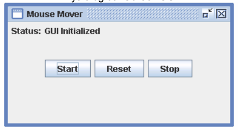
TI 56F800DEMO BOARD

TI 56F800DEMO BOARD: This board contains a Digital Signal Processor (DSP) made by Ti. The analog EMG signal is digitized and then analyzed by the DSP. A Fast Fourier Transform (FFT) is computed and compared to the data collected at calibration time. The DSP decides what action to take and sends the command to the PC over the serial port.

Software Implementation

When a user of the physiological cursor flexes one of the calibrated muscles, the computer screen cursor performs the specific action associated with that particular movement. These actions include move (up, down, right, left), click (left click, right click) and drag-drop. To manipulate the cursor according to the specific actions a Java interface was created.

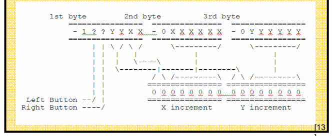
Physiological Cursor GUI



The Java interface was implemented with a GUI to allow the user to begin, stop, and restart the cursor movement. In the initiating of the physiological cursor the computer screen cursor is placed in the middle of the screen based on the screen dimensions. These dimensions are used to insure that the cursor is never moved off the screen in either the x or y direction.

After the muscle signal is processed a packet of bytes, serial packet, is sent to the Java interface through the serial port. This packet contains a series of bits that encode the x and y direction of the cursor movement and value for the left and right click functions.

Serial Mouse Bytes Packet



[13]

As each of the user's movements send the corresponding serial packet over the serial port, the Java interface receives each byte and individually checks if it is the first byte in a serial packet series. If this is the case then the bytes are manipulated to create values for the left click bit, right click bit, x-direction byte, and y-direction byte. These values are then used to move the cursor or instantiate a click through the Java Robot class. The Robot class uses the functions mousePress, mouseRelease, and mouseMove to manipulate the cursor on the screen.

Populations Benefited

Right-Hemisphere Stroke- Right-Hemisphere Strokes result in the paralysis of the left side of the body and can also impair the ability to guide the capable hand. EMG sensors would be placed upper body muscles, such as the shoulders, neck, and face [4]

Quadriplegia (150,000 people in America)- Quadriplegia is the paralysis of the upper and lower body. EMG sensors would be placed on the face, specifically the forehead and the jaw muscles. [5]

Muscular Dystrophy (over 50,000 Americans)- There are nine types of Muscular Dystrophy that can occur. The following five would directly benefit from a physiological mouse: - *Myotonic* affects the arms, legs, and face. The EMG sensors may be attached to the stomach, neck, shoulder, and back muscles. - *Limb-girdle* affects the shoulders. This may impair moving the arm to a position to interact with a cursor. The EMG sensors could be placed on the neck, face, and legs. - *Distal* affects the arms. The EMG sensors could be placed on the shoulders, neck, face, and legs. - *Facioscapulohumeral* affects the face, arms, and feet. The EMG sensors could be placed on the neck, shoulders, and legs. - *Emery* affects the shoulders and upper arms. The EMG sensors could be placed on the neck, face, and legs. [6]

Multiple Sclerosis (between 350,000 to 500,000 people currently diagnosed)- Multiple Sclerosis affects the brain and the spinal cord resulting in partial or mild paralysis, complete paralysis, loss of muscle tone causing stiffness (Spasticity, that restricts free movement of the affected limbs), slurred speech (Dysarthria), and muscle atrophy. When Multiple Sclerosis has affected the arms or shoulders the physiological cursor would benefit the person diagnosed. EMG sensors would be placed on the strongest muscles available in each different case of Multiple Sclerosis. [7]

Amyotrophic Lateral Sclerosis (over 20,000 Americans currently, 5,000 diagnosed each year)- Amyotrophic Lateral Sclerosis attacks the nerves responsible for controlling voluntary muscles. EMG sensors could be placed on the stronger muscles when the arms or shoulders are weakened. The EMG sensors may have to be repeatedly moved due to continued weakening of the muscles. [8]

Carpal Tunnel Syndrome (affects one out of every one hundred people)- Carpal Tunnel Syndrome affects mobility due to extreme pain in the wrist. EMG sensors would be placed on the shoulders, neck, face, or lower body. [9]

Cerebral palsy (500,000 Americans) – Cerebral palsy results from brain injury or abnormal brain development. [10] There are four types of cerebral palsy: Spastic, Nonspasic, Mixed, and Total body cerebral palsy. - *Spastic cerebral palsy* - EMG sensors would have to be placed on the forehead and neck. [11] - *Triplegia Spastic cerebral palsy*- EMG sensors would be placed on the face, legs (accordingly), neck, and shoulders. [12]

Results

After completing all of the different aspects of the physiological cursor project, the project was thoroughly tested to insure proper functionality. Each action to be performed by the cursor was successfully demonstrated on the computer screen. These actions included move (up, down, right, left), click (left click, right click) and drag-drop. Due to user control, the cursor was found to move faster then anticipated due to elongated muscle contraction time. With different calibration techniques the user may have found the specific muscle movements to be more precise and reliable for the computer screen cursor movements.

Physiological Cursor Serial Packets

	Binary	Hex
Left	01000011 00111110 00000000	43 3E 00
Right	01000000 00000010 00000000	40 02 00
Up	01000000 00000000 00000010	40 00 02
Down	01001100 00000000 00111110	4C 00 3E

Further testing was completed by implementing the physiological cursor with a standard Serial Mouse as input instead of the EMG sensors. The Serial Mouse sent the same serial packet protocol over the serial port to be read by the Java interface. When tested, all of the functionality was operational, including drag-drop, highlighting text and multiple objects, and double clicking. The actions performed by the Serial Mouse were more precise and controlled. This control was due to the fact that the Serial Mouse was able to send more unique serial packets in a shorter amount of time compared to the EMG sensors, so the cursors response on the screen was better.

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