Hand Sensory Rehabilitation Device
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Abstract
One of many outcomes of a stroke is diminished body sensation, normally in the hands. Thus, this device will integrate into a next generation system built to rehabilitate patients with hand sensory deficiencies. First, the device will apply force, at a one-to-two point resolution, to positions along the thumb or forefinger. Data will then be processed via a push button and user interface. The user presses the button after he or she feels a stimulus. The nurse/physical assistant will then input the position(s) at which the patient felt the stimulus and whether one or two forces were felt. This information will be exported to provide quantifiable data for rehabilitation.

Background
Following stroke, spinal cord / brain injury, etc., patients can lose sensation in their hands due to damaged nerves and sensory pathways.
- Loss of sensation following stroke is common, occurring in up to 65% of patients.
- Poor sensation can negatively affect personal safety, self-care, and the ability to perform everyday activities.

Problem Statement
Diminished hand sensory capabilities in patients subject to stroke, spinal cord / brain injury, etc. increases difficulty in motor skills and overall function. Currently, there is not an existing system that can empirically quantify or effectively rehabilitate loss of sensory function.

Final Design

Mechanics:
- Force application is achieved using a captive linear stepper at the tips of the index finger and thumb and at any point along the index finger and thumb.
  - The distance between points is varied using a non-captive NEMA 17 linear stepper motor

Hardware:
- An Arduino Mega and three stacked Adafruit motor shields drive the motors using the 5V power supply from the USB-computer connection.
- Force detection is achieved using surface mount FSRs embedded beneath the force pin.
- Push button is used by patient to communicate to software when stimulus is perceived.
- Snap switches are used to "zero" all motors

Software:
- Motors are controlled with Matlab to Arduino Mega communication, including a Matlab GUI.
- User chooses test type in GUI, then Matlab performs a cycle of tests, and randomizes the location of the stimulus for each testing iteration.
- Patient selects perceived location of stimulus, then all testing data is sent to an excel file.

Device Specifications:
- Must apply a force at two points on the index finger and thumb
- Magnitude of force must be variable
- Distance between two points must be variable by a step size as small as 2mm
- User must be able to indicate what kind of stimulus they felt and where

Force Application Testing:
- FSRs can detect forces ranging from 20gf-300gf (0.02N-0.3N) which is equivalent to healthy person’s minimum threshold to onset of pain
- Device can detect forces with a ± 50gf accuracy

Two-Point Discrimination Testing:
- Smallest linear step size achieved is 0.04mm
- Can vary distance between points from 0-110mm on the index finger and 0-48mm on the thumb
- Linear stepper motors have a max error of 0.24mm after zeroing
- Error depends on number of iterations and steps moved per iteration, but is always < 1mm.

Testing
In order to quantify the improvements in hand sensory made by a stroke/spinal cord injury victim, a device was made to test the force at which the patient can feel a sensation. This is a force threshold test. With this data, the patient can also be tested for two point discrimination where two randomly assigned points on the patients hand have pressure applied to it. The patient must then distinguish these two points. A Graphical User Interface (GUI) was developed in order to commence the tests and take user input from the therapist or patients for medical evaluation. These tests work with studies of Vagus Nerve Stimulation (VNS) in order to make greater strides in physical therapy for patients of stroke or spinal cord injury.

Conclusion

References