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A Study in Technologies with Pressure Transduction for Possible Neurological Rehabilitation Treatments on Hand Sensory Impairments.

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Abstract

The objective of this research is the development of equipments to be used in the rehabilitation of people who suffer with somatosensory losses. The equipment substitutes the tactile response by a visual response using sensors that transduce the pressure applied on them into electric signals. The research is still ongoing and consists mainly of two projects: the first is a glove with sensors at the fingertips, for which we are currently assembling the second prototype; the second project, which is still under initial development, is a board game which electronically transforms the pressure made by the finger on the sensor into a signal within the game design.

Key words:

rehabilitation, wearable sensors, somatosensory loss.

Introduction

Somatosensory loss is the deficiency when the capacity of feeling pain, temperature or touch is either debilitated or completely disabled in parts of the body of a neurologic patient. Under these circumstances, patients might not be able to measure their own strength, causing involuntary physical effort and muscular fatigue, with consequences such as difficulty on writing and loss of balance, for example. Stroke and other diseases and traumas that can damage the central nervous system may cause this type of impairment. However, the treatment of the somatosensory loss nowadays consist mostly on physical and occupational therapy exercises, which lack a more technological approach.

This research consists on developing inexpensive technology that could aid neuroplastic rehabilitation processes. Neuroplasticity is the ability of the central nervous system to respond to intrinsic and extrinsic stimuli by reorganizing its structure, functions and connections. These brain changes are visible, for example, in the sensorimotor cortex in Braille readers¹. Nowadays, this brain adaptability has a large use in rehabilitation. Our objective was to develop wearable sensors that could replace the debilitated tactile stimulus by a visual stimulus, following on original, early work by Bach-y-Rita².

In our ongoing study, we aimed exclusively in loss of hand sensation, with two main projects that share similar concepts, but used in different situations. In our first project, we created a glove with sensors on the fingertips, and light emitting diodes (LEDs) which respond to the tactile feedback of the sensors with luminosity variations. The second project aimed on the rehabilitation process of children, with the design of board games using pressure sensors.

Results and Discussion

Our major idea on the first project was to create a glove with pressure sensors at some of the main pressure points applied by the hand, transforming the corresponding force into an electric signal. This signal then drives LEDs with the intensity roughly equivalent to the applied pressure. Our main obstacle was to find pressure sensors that could be used in our project. The material needed to be small, light and flexible, so that the patient wears it with no

discomfort, and the feedback given by the sensors needed to be immediate and reproducible. The one that best fitted our expectations was the Flexiforce A101, produced by Tekscan, USA, and two glove prototypes were created. The first used a simple analog circuit, and the feedback was given by the variation of intensity of LEDs. The second prototype uses a microcontroller for improved battery lifetime and more precise feedback. In addition, it uses RGB LED for a discrete feedback, which has advantages compared with the continuous feedback. Our goal was to design a light and portable equipment, so that the patient could use it in domestic activities and not necessarily only during rehabilitation sessions.

The second project focuses on a particularly difficult situation, which is the treatment of children with somatosensory loss. Due the impatience and disinterest with the physical therapy exercises that some children may show, the rehabilitation process can be slow or ineffective. This way, we aimed on developing an equipment to be used on the treatment of somatosensory loss that could provide a form of entertainment for kids. We are creating a game with pressure sensors on its surface, and the objective of the player is to press the correct position on the board in a specific range of force. In this project, we used the tactile sensor Quantum Tunneling Composite (QTC), produced by Peratech, UK, which showed a good feedback signal in flat and static situations, with a price range that can make the game available at low cost.

Conclusions

In the first project, the tests showed that the prototypes provide immediate feedback with good precision and the battery charge lasts enough for daily tasks. The first equipment does not capture very light touch, but this factor was revised on the second prototype. In addition, a review on the layout of the first glove was necessary and a new design was created for the second prototype.

¹ Pascual-Leone A, Torres F. Plasticity of the sensorimotor cortex representation of the reading finger in Braille readers. *Brain* 1993; 116:39-52

² Sampaio E, Maris S, Bach-y-Rita P. Brain plasticity: "visual" acuity of blind persons via the tongue. *Brain Res* 2001;908:204-7.