

Design of A Haptic Hand to Stimulate by Vibration the Human Nervous System

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ABSTRACT

Mechanical vibration signals are designed. Managing different frequencies seeks to induce predefined virtual sensations in the human being. Five coin vibrators are fixed on each finger and the generated vibration is controlled by one of ARDUINO. A group of programs is developed to create the appropriate signal for a predefined perception. The device is tested on 20 people.

1. Introduction

The hand is the most mobile region of the body. It involves the action of various muscles and ligaments [1] for a very versatile function.

The Peripheral Nervous System (PNS) is made up of nerve fibers and cell bodies outside the Central Nervous System (CNS) that transmit signals from different parts of the body. Although it involves a very complex function, it can be said that they transmit external information and a kind of feedback signal through proprioception [2].

The region of the skin in which sensation is under the control of a single spinal or spinal nerve together with its corresponding spinal ganglion is called a dermatome (Figure 1).

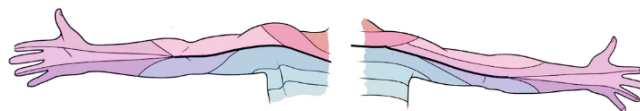


Fig. 1. Arm dermatomes

The cutaneous innervation of the upper limb derives from the brachial plexus, a nerve network formed by the anterior roots of the spinal nerves [7]. There are different types of tactile receptors, the main ones being [8]: free nerve endings, Meissner corpuscle, Merkel discs, Ruffini end organs, and Pacinian corpuscles.

The sensitivity function cannot be restricted to a single point, however, the transmission of vibrations throughout the body is an integral part of the sensitivity function [3]. In general, the sensitivity threshold of the skin appears to be a function of its proximity to areas of increased mobility [4].

The sensing frequencies are in the range of 8 to 64 Hz, the Meissner corpuscles sense low frequencies, and the Paccian corpuscles are responsible for high-frequency vibrations [9] and [10]. Sensitivity is also affected by amplitude.

This work presents the design of a device that through mechanical vibration produces stimuli to the CNS to produce a sensation that makes the Brain interpret different virtual circumstances. Some sensations are designed and tested on 20 individuals.

2. Methodology

To generate the signal on the fingers, a model 1027 coin vibrator is selected (Figure 2). The output frequency is a function of the input voltage that goes from 0.5 to 5 volts, the output frequency can be seen in Table 1.



Fig. 2. Coin vibrators

The controller is an ARDUINO ONE, the microprocessor is an ATmega328P with 12 inputs/outputs. Of them, 6 can be used as PWM (Pulse Wide Modulation) and 6 for analog signals [6].

The haptic glove is shown in Figures 3 to 8 showing the sequence of each sensation.

- Sensation of travel: It is a sequence of turning on and off from left to right and vice versa.
 - Feeling of rain: Random sequence and voltage intensity around all points
 - Tickling sensation: Continuous signal with variable voltage
 - Light pressure: All fingers with simultaneous low voltage pulses
 - Strong pressure: All fingers with simultaneous high voltage pulses
 - Plier grip: Simultaneous signals at all points, but the voltage is calibrated based on the movement of the fingers
 - Hook grip
- Simultaneous signals at all points, but Voltage calibrated based on the movement of the fingers, different from that of the pliers

Table 1
Response of the coin vibrator1027

Voltage	FX (Hz)	FY (Hz)	FZ (Hz)
0.5	1.666	1.666	9.166
0.75	2.5	2.5	13.75
1	3.33	3.33	18.33
1.5	5	5	27.5
2	6.663	6.663	36.66
2.5	8.32663	8.32663	45.83
3	10	10	55
3.5	11.66	11.66	64.16
4	13.33	13.33	73.33
4.5	15	15	82.5
5	16.66	16.66	91.66

The coin vibrators are connected to a pair of gloves and then the following induced sensation are designed,



Fig 3. Haptic globe and traveling sensation sequence



Fig. 4. Rain pattern



Fig 5. Tickling sensation



Fig. 6. Light pressure



Fig. 7. Strong pressure



Fig. 8. Tweezer grip

3. Results

A program is developed for each of the desired sensations and loaded into the ARDUINO ONE, then 20 people are tested for each sensation, the results are shown in Table 2. Tickling and strong pressure are the least successful, however, is still a positive result. Rain, tickling and strong pressure produce undesirable sensations.

Table 2
Sensations of the test subjects

Sensation	True	False	Other
Traveling sensation	20	0	-----
Rain	18	1	Numbness
Tickling	17	2	Discomfort
Light pressure	20	0	-----
Strong pressure	17	0	Discomfort
Tweezer grip	20	0	-----
Hook grip	19	1	-----

4. Conclusions

The haptic hand design was functional, the frequencies were perfectly generated by the controller. In all cases, the desired sensation occurred in more than 85% of the individuals. The causes of negative sensations such as numbness and discomfort still need to be understood to ensure not produce any harm. The design is promising for the study of how to induce virtual environments by sensations produced for vibration. It is of great importance in microsurgery and the game business. The system can be used for assessing certain damage to the central and peripheral nervous

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