Human to human interface

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ABSTRACT

The human to human interface is a state of the art project which will lay grounds for the development of a simplified prototype for the demonstration of Neuroscience. Through this, we will try to create a feasible way to control the actions of the subject on the base level, which is arm movement. This will enable us to understand the behavior of the muscles and their response to external stimuli. We strive to create what is aimed at being a step further in human-aided computer intelligence through the use of neuroscientific principles. It will also establish a basis for further development and provide insight on the possibilities in this field. This project consists of the controller, which is the input end of the system. It feeds the processing unit with the nerve signals from the Radial, Median and Ulnar nerves of the hand. The Processing unit is the heart of the system. It processes the incoming data. This is transmitted to the subject via the Transcutaneous Electrical Nerve Stimulation Unit or TENS Unit, which is a device used to stimulate the subject’s nerves through controlled pulses of micro currents. The Subject is the person who receives these signals through electrodes. This will cause the subject’s muscles to move involuntarily.

Keywords: Neuroscience, Nerve signals, Radial, TENS Unit, electrodes, Median and Ulnar nerves.

1. INTRODUCTION

The human brain has always been a subject of great fascination. The field of neuroscience is a place where we can possibly make many more Break throughs and invent more intelligent and partially automated machines that can make life easier. Here, we strive to create what is aimed at being a step further in human-aided computer intelligence through the use of neuroscientific principles. The human to the human interface is a basic step towards better neuromaschines and human-aided computer intelligence. Neuromaschines includes designing a machine that interfaces with living neurons to control a device or for sensory substitution. And as for muscles, if people have damage to their spinal nerves, the muscles themselves can be stimulated, and this line of research is called “Functional Electrical Stimulation” (FES). For example, functional electrical stimulation can often be used to help someone stand up or to improve walking by helping to swing a foot forward. This demonstrates the vast use of the HHI in helping and aiding differently abled humans, and also improves the technology in a way where remote control over a specific entity becomes possible. As of now the amount of potential in the field is at an all-time rise and many new inventions are on their way. Functional electrical stimulation (FES) is a technique that uses low energy electrical pulses to artificially generate body movements in individuals who have been paralyzed due to injury to the central nervous system. More specifically, FES can be used to generate muscle contraction in otherwise paralyzed limbs to produce functions such as grasping, walking, bladder voiding and standing. This technology was originally used to develop neuromaschines that were implemented to permanently substitute impaired functions in individuals with spinal cord injury (SCI), head injury, stroke and other neurological disorders. In other words, a consumer would use the device each time he/she wanted to generate the desired function. FES is sometimes also referred to as Neuromuscular Electrical Stimulation (NMES).
1.1 Neurons, Nerves, and FES

Neurons are electrically active cells. In neurons, information is coded and transmitted as a series of electrical impulses called action potentials, which represent a brief change in cell electric potential of approximately 80–90 mV. Nerve signals are frequency modulated; i.e. the number of action potentials that occur in a unit of time is proportional to the intensity of the transmitted signal. Typical action potential frequency is between 4 and 12 Hz. An electrical stimulation can artificially elicit this action potential by changing the electric potential across a nerve cell membrane (this also includes the nerve axon) by inducing an electrical charge in the immediate vicinity of the outer membrane of the cell.

1.2 The Human to Human Interface (HHI)

The HHI is a simple yet informative demonstration of the various aspects involved in nerve signal capturing, analysis, processing and enhancement, muscle and nerve stimulation, therapeutic research and small-scale development of neuroscience-based intelligent machines. It strives to represent a vast array of possibilities in the field and educate the masses on the plethora of benefits offered by this effort. It uses the principles mentioned above to create a comprehensive yet lucid understanding of the various aspects of the field.

2. THE NERVOUS SYSTEM

In vertebrates, the nervous system can be split into two parts: the central nervous system (brain and spinal cord), and the peripheral nervous system. In many species — including all vertebrates — the nervous system is the most complex organ system in the body, with most of the complexity residing in the brain. The human brain alone contains around one hundred billion neurons and one hundred trillion synapses. The majority of the approximately 20,000–25,000 genes belonging to the human genome are expressed specifically in the brain. Due to the plasticity of the human brain, the structure of its synapses and their resulting functions change throughout life. Thus the challenge of making sense of all this complexity is formidable. The figure shows the human nervous system. The project mainly focuses on the arm of the subject, specifically the Brachial Plexus nerves: Radial, Media, and Ulnar nerves, as shown in the Fig. 2.2.2.

Fig. Nervous System

Fig. Nerve Positions
The figure shows the human nervous system. The project mainly focuses on the arm of the subject, specifically the Brachial Plexus nerves: Radial, Media, and Ulnar nerves, as shown in the Fig. 2.2.2 These nerves help transmit nerve signals from the brain to various regions of the hand controlled by the specific nerve endings. The regions are shown in the Fig. 2.2.3.

2.1 Applications of Neuroscience in the HHI

The Human to Human Interface uses the signals generated by the nerves in the arm to control the muscular movements of the subject in question, who may or may not have the ability to create muscle movements of the specific region of the arm. Through FES, the nerves can be stimulated using either surface (transcutaneous) or subcutaneous (percutaneous or implanted) electrodes. The surface electrodes used here are placed on the skin surface above the nerve or muscle that needs to be "activated". They are noninvasive, meaning the project is implemented without cutaneous penetration, leaving the patients physical appearance intact. The figure below shows the basic procedure of muscle stimulation which is the base of the HHI project.

3. PROJECT DESIGN

The Basic Components There are mainly 4 main components which are broadly broken down later on. They are 1. The Controller, 2. The Arduino based Processing Unit, 3. The Transcutaneous Electrical Nerve Stimulation (TENS) Unit 4. The Subject. The data flow can be represented by the simple block diagram given below.

- The controller is the input end of the system which feeds the processing unit with the nerve signals from the Radial, Median and Ulnar nerves of the hand.
- The Processing unit is the heart of the system, which processes the incoming data and converts it into signals that can be directly transmitted to the subject.
- The TENS Unit is responsible for delivering nerve stimulation signals in the form of pulses to the subject.
• The Subject is the person who receives these signals through electrodes placed on the same nerves, which in turn will cause them to make movements involuntarily

3.1 Major Components

1. Electrodes for the input
2. The Processing Unit
   a. Arduino microprocessor
   b. Electromyograph (EMG) Spiker Shield (Constituents below)
3. The TENS Unit
4. Output Electrodes with alligator clips and wires.
5. Constituents of the EMG Spiker Shield
6. 4 Capacitors - 10 µF
   • 1 Capacitor - 560 µF
   • 1 Capacitor - 0.47 µF
   • 4 Resistors – 10 kΩ
   • 4 Resistors – 47 kΩ
   • 2 Resistors – 1 kΩ
   • 1 Resistor – 390 Ω
   • 1 Resistor – 33 kΩ
   • 1 Resistor – 220 kΩ
   • 6 LEDs (2 Red, 2 Yellow, 2 Green)
   • 3 RCA Inputs (White, Red, Yellow)
   • 8 Pin Female Headers
   • 6 Pin Female Headers
   • Two 6 Pin Male Headers with Jumpers
   • Switch between raw/envelope mode
   • Potentiometer
   • Diodes
   • Audio Output
   • 5V DC Relay
   • 9V Adapter for power
   • Servo Motor
   • ICs
     o TLC2272
     o AD623

3.2 Electrode Specifications

The project uses mainly two types of electrodes, a three-input reusable high sensitivity electrode strap, and the conventional ECG electrodes for a controlled output.
1. Reusable electrodes:

![High Sensitivity Electrode Strap](image)

The reusable electrodes connect to the system via RCA inputs and deliver the required signals to the EMG Spiker Shield. These electrodes use the RCA jack shown below to provide input to the EMG Spiker Shield.

![Fig. RCA Slots](image)

2. ECG Electrodes

![Fig. ECG Electrodes (Subject)](image)

Adhesive solid gel SGLTs have a specially formulated solid gel that improves adhesion and ease of application while reducing the need for cleaning up. Available in diaphoretic foam, clear tape or soft-cloth. Options available are stainless steel snap, radio-translucent snap & 4mm Banana adaptor. Carbon snap electrodes are also used in Cath-Lab, CCU, Nuclear medicine and MRI.

Specifications:

4. SOFTWARE

Software Used Proteus Design Suite 8.7j Arduino IDE

BYB Spiker Shield, Arduino Code for the HHI system

5. WORKING OF THE PROJECT

There are mainly 4 parts to the working (as shown in Fig.3.1.1 Simplified Block Diagram, Page 8). They are:

- The Controller
- The Processing Unit
- The TENS Unit
- The Subject
5.1 The Controller

The Controller is nothing but the input high-sensitivity reusable electrode straps which are used to sense any nerve signals originating from the Subject’s hand.

5.2 The Processing Unit

The processing unit is the heart of the system and consists mainly of the Arduino microprocessor and the EMG Spiker Shield. The EMG Spiker Shield is responsible for capturing the signals emanating from the nerves of the Controller via the electrodes mentioned earlier. These signals are then sent to the Arduino microprocessor. The Arduino runs the code to enable the signal to pass through to the TENS Unit, which gets triggered by movement of the Controller’s arm.

The buttons on the EMG Board serve two distinct purposes: the first button resets the board and all interfaced devices and the second one changes the sensitivity of the input signal to be sensed by the strap electrodes and indicates it on the LEDs.

One of the interfaced devices used is the Servo motor shown below. It serves as a visual indicator of Controller movement along with the LED bar shown in the previous figure.
The whole setup is interfaced to form the Processing unit and looks something like this:

Fig. Interfaced Processor Unit Setup

The upper portion is the EMG Spiker Shield and the lower half is the Arduino microprocessor. The 3.5mm Audio Output is another secondary output to the EMG Spiker Shield apart from the connection to the TENS Unit.

Fig: Audio Output Jack

The audio output is measured through an external application pre-installed either on a computer, and an output waveform is generated to replicate the changes in muscle activity and nerve signals. The output looks like this:

Fig. Audio Output Waveform

5.3 The TENS Unit

The Transcutaneous Electrical Nerve Stimulation (TENS) Unit used to provide electric current produced by the device to stimulate the nerves for therapeutic purposes. TENS, by definition, covers the complete range of transcutaneously applied currents used for nerve excitation, namely to describe the kind of pulses produced by portable stimulators used to treat pain.
The unit is usually connected to the skin using two or more electrodes. The typical battery-operated TENS unit is able to modulate pulse width, frequency, and intensity. Generally, TENS is applied at high frequency (>50 Hz) with an intensity below motor contraction (sensory intensity) or low frequency (<10 Hz) with an intensity that produces motor contraction. The TENS Unit used here is the TENS 3000. The technical specifications are as follows:

6. ADVANTAGES

- One of the most fast-growing concepts and has immense value in the field of medicine.
- Can be optimized to be implemented over a variety of applications and reduce human involvement in complex procedures.
- Has a life-changing influence on the way many tasks are currently performed.
- Can improve speeds at which current human tasks are performed.
- Partially paralytic patients can be treated and taught individual muscle movements and given personal attention for the same.
- The project will change the way normal muscle movements are monitored and can also aid in quicker diagnosis and detection of issues in the body of the subject.
- Serves as a basis to learn and implement various new concepts related to neuroscience and neuroprosthetics, and create an interesting learning environment showcasing more feasible and efficient ways to study the subject.
- One of the main advances achieved is a cost reduction to bring the overall cost to one-fourth of the cost of the originally developed project. This makes the project highly affordable.
- The small size ensures ease of mobility and can be used tested in various environments due to its robustness.

7. INFERENCES

- The Human to Human Interface is aimed at being one of the most cost-effective ways to create a design suitable for both implementing and learning the various aspects of neuroscience, and also broaden the perspective on the use of the project in the field.
- Through this, we will try to create a feasible way to control the actions of the subject on the base level, which is arm movement.
- This will enable us to understand the behavior of the muscles and their response to external stimuli.
- The project will change the way normal muscle movements are monitored and can also aid in quicker diagnosis and detection of issues in the body of the subject.
- This will revolutionize the use of nerve stimulation techniques in medicine and may possibly change common practices in the field by replacing them with improved methods.
- It will also establish a basis for further development and provide insight on the possibilities in this field.

8. REFERENCES

[1] https://backyardbrains.com/experiments/