Motivation Driven Stroke Rehabilitation via Bio-Signal Control System

Principal Investigator: Professor Ang Wei Tech
Email: WTAng@ntu.edu.sg
Office: N3-02a-25
Tel: (65) 6790 5521 (Office)

PROJECT DESCRIPTION:

Abstract
This research adopts an engineering approach to restore voluntary motor function by bridging the gap in damaged/diseased parts of the nervous system. A brain-computer interface (BCI) senses surface electroencephalogram (EEG) signals elicited by motor imagery, and processes it into semantic signals that are used to control functional electrical stimulation (FES) of skeletal muscles. It is hypothesized that the patient's motivation is paramount to successful rehabilitation, and that a BCI-FES rehabilitation protocol will yield better results than conventional therapy. Clinical trials will be conducted to verify this concept, and plasticity of the brain in response to such treatment will be examined.

Introduction
Cerebro-vascular infarction (stroke) and spinal cord injury are the two main causes of paralysis worldwide. Paralysis is caused by the disruption of the flow of information to the peripheral nerves, often due to injury to the central nervous system. While it is not yet medically possible to treat such pathologies, this research seeks an engineering approach to bridge the gap between the brain and the body by creating an artificial pathway for the flow of information.

Procedural learning can be implicit (unintentional /unconscious) or explicit (requires conscious effort). Traditional rehabilitation of continuous passive motion and FES alone can be considered implicit learning, while conscious effort in imagining motor movement to trigger electrical stimulation of muscles would constitute explicit learning. Hence we posit that this method could potentially improve the recovery process because the patient learns to use another part of the brain to...
control the corresponding body part, which could speed up the learning and plasticity processes. There are two scientific objectives:

a) To research and develop a bio-signal control system that combines BCI with FES techniques for stroke patient rehabilitation.

b) To research and develop an effective motivation driven training protocol with the proposed bio-signal control system for stroke rehabilitation.

Methodology
It has been proven that persons who lack complete muscular control can learn to control slow cortical potentials to operate devices. The basis of our attention-detection and intent-recognition comes from neuropsychological findings which suggest the modulation of particular EEG oscillations in response to motor activities both actual and imagined. It is known that the populations of neurons can form complex networks whereby feedback loops are responsible for the generation of oscillatory activity. Hence, mental imagination of certain movements will invoke self-induced variations of EEG.

Once the user's intention is recognized, electrical pulses are sent to the muscles, causing muscle fibers to contract, resulting in motor function. The force exerted and motion of the limb can be controlled by varying the intensity and frequency of the electrical stimulation to the agonist and antagonist muscles.

GRANT:

PERSONNEL:

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. ANG Wei Tech</td>
<td>Associate Professor, School of Mechanical &amp; Aerospace Engineering, NTU</td>
<td><a href="mailto:wtang@ntu.edu.sg">wtang@ntu.edu.sg</a></td>
</tr>
<tr>
<td>Dr Cuntai GUAN</td>
<td>Senior Scientist &amp; Department Manager, Institute for Infocomm Research</td>
<td><a href="mailto:ctguan@i2r.a-star.edu.sg">ctguan@i2r.a-star.edu.sg</a></td>
</tr>
<tr>
<td>Dr Kuanyi ZHU</td>
<td>Associate Professor, School of Electrical &amp; Electronic Engineering, NTU</td>
<td><a href="mailto:EKYZHU@ntu.edu.sg">EKYZHU@ntu.edu.sg</a></td>
</tr>
<tr>
<td>Dr N. V. RAMANI</td>
<td>Sr. Consultant, National Neuroscience Institute</td>
<td><a href="mailto:Ramani_NV@nni.com.sg">Ramani_NV@nni.com.sg</a></td>
</tr>
<tr>
<td>Dr Robert Ngo GAN</td>
<td>Consultant, National Neuroscience Institute</td>
<td><a href="mailto:Robert_Gan@nni.com.sg">Robert_Gan@nni.com.sg</a></td>
</tr>
<tr>
<td>Ms Hwee Lin TAY</td>
<td>Head, Therapy Services &amp; Rehabilitative Division, Society for the Physically Disabled</td>
<td><a href="mailto:tay_hwee_lin@spd.org.sg">tay_hwee_lin@spd.org.sg</a></td>
</tr>
<tr>
<td>Dr Patrick Thye San KER</td>
<td>Head, Occupational Therapy Department, Singapore General Hospital</td>
<td><a href="mailto:patrick.ker.t.s@sgh.com.sg">patrick.ker.t.s@sgh.com.sg</a></td>
</tr>
<tr>
<td>Dr Louis SHUE</td>
<td>Research Scientist, Institute for Infocomm Research</td>
<td><a href="mailto:lshue@i2r.a-star.edu.sg">lshue@i2r.a-star.edu.sg</a></td>
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