Phantom pain modulation using transcutaneous electrical nerve stimulation (TENS)

Background: A significant side effect of amputation beyond the loss of functionality is the sensation referred to as phantom pain. This sensation can vary greatly in its intensity and is generally caused by the formation of neuromas (generally benign tumor-like growths) at the end of the severed nerves. These nerves, once connected to the limb, now have no tissue to terminate in, causing often serve shooting pains and chronic discomfort to amputees. This can lead to sleep disorders, the inability to work, and the need for chronic pain management with opioids.

Preliminary academic work in the sensory feedback domain has shown that stimulating these nerves can reduce phantom pain. The precise mechanism and the optimal attributes of the stimulus however are not yet clear. What is certain is that providing a non-pharmaceutical pain management method to amputees suffering from chronic phantom pain would significantly benefit the patient population.

Goal of the project: The primary goal of the project is to characterize the stimulation attributes (frequency, amplitude, pulse width) that have the most likely effect of mitigating phantom pain, and what the variability of these attributes are on a subject-by-subject basis. The student(s) selecting this project will familiarize themselves with the existing body of research and the preliminary work completed in the lab. Once aquatinted with the background, the student will characterize stimulation attributes that affect pain perception. Once a range of attributes are determined, the student will work with amputees to assess the effect of stimulation on phantom pain perception.

Benefits to the student: The opportunity to get hands on experience in basic research and the development of early phase hardware, conducting experiments with human subjects in the relevant patient population, and the potential for journal publication. We are seeking funding for this project. A pilot project will be jointly carried out with collaborators at Infinite Biomedical Technologies, giving the student startup/small company collaboration and translational research experience.

Skills/Experience:

- *Fundamental knowledge in neurobiology:* the student must have an understanding of the sensory and motor functions of the brain and the connection between peripheral nervous system and the brain.
- *Intermediate experience in instrumentation:* Debugging and modifying the TENS system requires a fundamental understanding of circuitry design. Accordingly, the student should take appropriate courses on Medical Sensors and Instrumentation.
- *Intermediate coding skills in Matlab and/or Python:* interfacing with the TENS is done through Matlab a Python software components. Modifying, debugging and using these components requires a fundamental understanding of the programming languages. The student should have prior experience coding in both Matlab and/or Python with experience beyond class assignments with at least one.
- *Self-motivation and the ability to conduct independent work:* The student should take the take suitable courses, acquire relevant skills, and then implement a realistic TENS system for the prosthesis environments and then test on amputees. This will take a disciplined and focused approach to developing the TENS devices, experimentation, working with amputees. New ideas and independent work are highly encouraged and valued in the lab.

Expectations: Motivation to translate the technology for amputee needs. Publication and/or patenting of the original work is a must.