UNIVERSITY OF GENOA
DEPARTMENT OF INFORMATICS, BIOENGINEERING, ROBOTICS AND SYSTEMS ENGINEERING
MASTER'S PROGRAM IN BIOENGINEERING

Dibris

Thesis Project Form

Title (tentative): Development of a neuromodulation technique based on ultrasound and piezoelectric nanoparticles

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Description

Motivation and application domain

Neurological disorders affect many millions of individuals worldwide. The advent of Brain-Machine Interfaces is giving locked-in patients the possibility to replace motor, sensory or cognitive modalities. Current state-of-the-art technology is based on extracellular electrical stimulation by invasive implantable neuro-chips. While these devices have been efficacious, they are often limited by their bulkiness, mechanical invasiveness, and inability to target single cells. Thus, researchers have looked for alternative, less invasive, approaches. I n this project we want to exploit low intensity pressure waves provided by ultrasound (US) that can reach virtually any region in the brain as a mechanical stimulus that is locally transduced into an electrical one by means of piezoelectric nanoparticles adsorbed on the neuron membrane. Such strategy has many potential advantages when compared to existing ones.

General objectives and main activities

The main objective of this thesis work is to show the possibility to selectively increase or decrease the spontaneous electrical activity of neuronal networks using ultrasound pulses and piezoelectric nanoparticles as localized mechano-electric transducers. The network electrical activity will be measured using microlectrodes.
Toward this goal the activities will include:
- nanoparticle functionalization for selective binding to excitatory or inhibitory neurons
â€“ experiments based on a custom-made setup consisting of an ultrasound (US) source , a network of neurons differentiated from human iPSCs decorated by piezoelectric nanoparticles (pizoNPs), and a microelectrode array (MEA) to record the electrical activity
-analysis of the date recorded during experiments, extraction of parameters indicating the neuromodulation effect induced by US stimulation and mediated by piezoNPs

Training Objectives (technical/analytical tools, experimental methodologies)

The student will be trained on:
- (bio)chemical nanoparticle functionalization techniques
- design and conduct experiments using a complex setup including US stimulation and electrophysiological measurements
- develop a data analysis protocol, evaluate measured data and draw conclusions to validate an hypothesis.

Place(s) where the thesis work will be carried out: DIBRIS

Additional information

Pre-requisite abilities/skills: Attitude toward experimental work

Maximum number of students: 2