Multi-level modelling of neuromodulation and lesioning

Dr Nada Yousif

Understanding the human nervous system in health and disease is at the heart of these PhD projects. In particular, I am interested in biologically accurate computational modelling of neurons and systems of neurons, and the alliance between experimental, theoretical and clinical work.

At present I am using such techniques to address clinical questions about the mechanism of therapeutic interventions, specifically magnetic resonance guided focussed ultrasound, deep brain stimulation and sacral nerve stimulation. With the view to engineer optimal approaches to these treatments.

Project 1: Imaging based modelling of sacral nerve stimulation.

Sacral nerve stimulation (SNS) is a surgical therapy used to treat incontinence disorders and involves implantation of electrodes into the lower part of the spine. Though SNS is effective, the mechanisms are not well understood. A computational modelling approach can be used to model the effect of stimulation on nerves, to explore how the electrical pulses affect their activity. This project will involve data driven computational modelling of the SNS induced electric field and the impact on biophysical models of nerve fibres. We have clinical imaging data from a clinical collaboration, to define and constrain the models and investigate the impact of different parameters on clinical outcome.

Project 2: Optimising MRgFUS through modelling.

Magnetic resonance guided focussed ultrasound (MRgFUS) is a non-invasive therapy used to treat neurological disorders such as Parkinson's disease and essential tremor. MRgFUS involves using a focussed ultrasound beams to lesion the human brain in the thalamus. This project will involve using computational modelling based on neuroimaging (via a clinical collaboration) to model the heating induced in the human brain by MRgFUS and the impact of on the surrounding neurons, axons and networks. Here we will look at the impact of lesion sites on the predicted clinical improvement and compare to clinical data.

Project 3: Data driven modelling of deep brain stimulation.

Deep brain stimulation (DBS) is a surgical therapy used to treat neurological disorders such as Parkinson's disease and involves implantation of electrodes into the human brain. DBS is an effective treatment, but the mechanisms are not fully understood. A computational modelling approach will be used to model the electric field induced by DBS, the effect of this field on neurons and axons and the downstream effect on networks. Via a clinical collaboration, the predictions from the modelling work can be compared to clinical outcomes and proposals for improvements to the stimulation approach and hardware can be made.

Background / Person Profile

Applicants should either have a background in computer science, mathematics, physics, engineering or neuroscience. Useful skills and knowledge include programming, signal processing, finite element analysis, 3D modelling and image processing.

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Selected references

A population model of deep brain stimulation in movement disorders from circuits to cells N Yousif, PG Bain, D Nandi, R Borisyuk Frontiers in human neuroscience 14, 55, 2020

Traditional trial and error versus neuroanatomic 3-dimensional image software-assisted deep brain stimulation programming in patients with Parkinson disease. N Pavese, YF Tai, N Yousif, D Nandi, PG Bain. World Neurosurgery 134, e98-e102. 2020

Mapping the current flow in sacral nerve stimulation using computational modelling. N Yousif, CJ Vaizey, Y Maeda. Healthcare technology letters 6 (1), 8-12. 2019

The effect of deep brain stimulation in a computational model of essential tremor. N Yousif, M Mace, N Pavese, S Al-Rasheed, R Borisyuk, P Bain, D Nandi. MOVEMENT DISORDERS 32. 2017

A network model of local field potential activity in essential tremor and the impact of deep brain stimulation N Yousif, M Mace, N Pavese, R Borisyuk, D Nandi, P Bain. PLoS computational biology 13 (1), e1005326. 2017