Thesis proposal

2013/2014

Title:

NeuronDyn: Live dynamics characterization in-vivo neurons

Supervision:

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Thematic Area: Machine learning/Medical imaging processing

Description:

Live neuron dynamics characterization is a recent hot topic in neuroscience. Two imaging trends are emerging in the literature that are pleading for engineering approaches: Axonal neurotransmitters transport [1] and optogenetics [2].

For the first approach, automated tracking of the axonal transport is the most challenging problem. Neurons —composed of a cell body, dendrites and an axon— communicate between them by neurotransmitters, which migrate through these cells aggregated in vesicles [1]. The axonal transport of materials that migrate in vesicles is crucial for the survival and maintenance of neuronal network structures and physiological functions.

Recent studies confirm that the way these vesicles and other cellular constituents move along the axon differs when cells are in healthy or disease states. It can cause or be correlated with some human neurodegenerative conditions including Alzheimer's, Huntington's and Parkinson's diseases, spastic paraplegia, Charcot-Marie-Tooth and amyotrophic lateral sclerosis [3, 4].

Thus, the characterization of the dynamics of this "transport" within the living neuron is a powerful tool to study inner cellular mechanisms. This phenomenon is visible in confocal microscopy imaging but, to be quantified, still needs a difficult and human intensive manual tracking process [3].

The second emerging neuroimaging approach (optogenetics) is a neuromodulation procedure that uses a combination of techniques from optics and genetics to control the activity of individual neurons in living tissue even within freely moving animals and to precisely measure the effects of those manipulations in real-time [2]. Being an imaging animal monitoring technique that can run for long periods, it generates large datasets in the

form of videos presenting bright spots that need to be tracked to obtain scientific results. Again, in this second approach, tracking relies nowadays mainly on human manual tracking [5].

Noticing the engineering similarities of the problems that neuroscientists face in these emerging technique and our background in movement tracking techniques for neurological diseases [6, 7] we have decided to "sprout" a line of research to approach the above problem.

Recently our group developed a new algorithm based on a frame to frame object nearest neighbor association approach cascaded with a recursive Bayesian estimation [8] using a multihypothesis tracking that presents promising results in the tracking problem of intra-neuronal vesicle transportation measured from con-focal microscopy [9].

In this framework, the present proposal is aimed at the re-enforcement of the current pluridisciplinary team involved in this line of research (fom BRAINgroup@INESC-TEC, IBMC, FMUP and the Champalimaud Foundation). We are cooperatively working to devise and implement automated machine learning tracking methods that may ease the neurocientists' nightmare that is tracking large in-vivo neuron datasets manually for the presented scenarios and jointly contribute to the progress of neurosciences.

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