Master 2 Internship

«Simulating the cortical activity evoked by artificial retinal implants»

Project: Recent advances in neuroscience and microelectronics opens up the possibility of partially restoring vision to blind patients using retinal prostheses. These are devices capturing the light of a visual scene and converting it to electric impulses sent by a matrix of electrodes chirurgically implanted on the retina. The simulation of an electrode in blind patients are known to elicit a light spot (phosphene) percept. The joint stimulation of electrodes allows to reproduce simple shapes (letters, objects, stairs) and to restore a low resolution vision to blind people. This domain of research is however at an early stage compared to cochlear implants. Especially, the way an electric stimulation activates the visual cortex is still poorly understood. The group of F. Chavane (NeOpTo team at INT Marseille) has used mesoscopic recordings of cortical activity (optical imaging) to better understand the activity evoked by stimulation of the retina with implanted multi electrodes arrays (Roux et al 2016 eLife). Their results show that local stimulation of the retina evoked a cortical activity that is up to 10 times larger than what is expected based on the activity evoked by visual stimuli. This result is in line with known poor resolutions of percepts evoked by stimulation of artificial retinas implanted in blind patients. An important effect, evidenced by Roux et al (2016) is the asymmetrical spread of electric activity induced by the direct activation of retinal cells axons away from their somata. This effect can be modelled at the level of a single electrode with a significant match to experimental measurement. However, retinal prostheses integrates hundreds of electrodes and there is no study yet about the effect of the simultaneous activation of several electrodes reproducing the shape of an object.

The Biovision team at Inria is designing a retina simulator, called Macular, aiming at reproducing the retina response to stimulation in normal (stimulation by light) and pathological conditions (electric stimulation by prostheses). The goal of the internship is to integrate the model proposed by Roux et al (2016) in Macular so as to numerically model the effect of the joint stimulation of electrodes in retina prostheses on the cortex V1 and to compare it to normal vision.

The internship will be done in collaboration between Bruno Cessac (Biovision, INRIA, Sophia-Antipolis) and F. Chavane (INT, CNRS, Marseille). The duration is 6 months. The internship will be done at INRIA with several visits to INT.

Profile. The candidate is expected to have a strong background in programming (C++, git, cmake). He/she must also have a great interest in the field of visual neuroscience, both for fundamental aspects of visual processing and clinical research.

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Teams
The team NeOpTo (Neuronal Operations in Topographic maps) at the Institut des Neurosciences de la Timone (INT-CNRS) aims at elucidating the neural computations that underlies active vision. Vision is a major sensory input for guiding our actions, perceiving our environment and conducting

cognitive tasks. Yet the visual inputs that reach the brain represent a computational challenge: they are ambiguous, dynamical, segmented into a myriad of piecewise cues and constantly influenced by eye movements. To overcome this problem, our visual system must link sensory inputs with a priori knowledge at multiple spatial and temporal scales. To investigate how the visual system achieve such challenge, the NeOpTo team combines multiple expertises involving behavioral studies in both humans and monkeys, ophthalmologic clinical approaches, electrophysiological and real-time optical imaging studies in behaving monkeys and Bayesian modeling approaches.

The goal of the Biovision team is to investigate new solutions to help vision impaired people. Visual impairment affects some 285 million people in the world, mostly in developed countries: 85% have low vision, i.e., have remaining sight, and 15% are totally blind. It is predicted that the prevalence of visual disabilities will increase markedly during the next 20 years, owing largely to the aging. In this context, Biovision aims at developing fundamental research as well as technological transfer along two axes (i) development of high tech vision aid systems for low vision patients (ii) precise modeling of the visual system for normal and distrophic conditions, targeting applications for low vision and blind patients. These axes are developed in strong synergy, involving a large network of national and international collaborators with neuroscientists, physicians, and modellers.