DOUBLE FEATURE IBI SEMINAR

Wednesday – September 12, 2012 – 2:15 p.m.
EPFL – room SV 1717a

host: Prof. D. Van De Ville

1. “Mathematical Problems of Functional Imaging Pipelines and their Optimization”

Prof. Stephen Strother
Medical Biophysics, University of Toronto (Can)

Abstract
I will introduce the basic components of the neuroimage processing and analysis pipelines in functional neuroimaging as a set of hierarchically nested optimization problems and discuss selected mathematical aspects in the context of single-subject and multi-subject-group analysis. Selected components of the functional MRI pipeline will be treated first as individual optimization, and finally as a joint optimization problems from among: (1) optimal image reconstruction, e.g., using prolate-spheroidal basis functions; (2) brain-nonbrain segmentation, (3) within-subject motion correction, (4) slice-timing correction, (5) physiological noise correction, (6) spatial filtering, (7) intensity normalization, (8) temporal filtering and detrending, and (9) removal of additional unwanted effects regressors, such as residual-movement artifacts and stimulus-correlated motion, (10) registration to a common space with some pros and cons, (11) approaches to the ill-posed problem of data analysis focused on the extraction of brain networks, e.g., so-called predictive mind-reading approaches and the role of sparsity and pattern stability. In particular I will argue that, particularly for fMRI, and possibly for other neuroimaging modalities, a critical and largely unexplored mathematical frontier is represented by the difficult problem of joint optimization of the neuroimaging pipeline including data acquisition, image processing and analysis.

2. “A Canonical Model of Multistability and Scale-Invariance in Biological Systems”

Prof. Michael Breakspear
University of New South Wales (Aus)

Abstract
Biological systems are able to adapt to rapidly and widely changing environments. Many biological organisms employ two distinct mechanisms that improve their survival in these circumstances: Firstly they exhibit rapid, qualitative changes in their internal dynamics; secondly they possess the ability to respond to change that is not absolute, but scales in proportion to the underlying intensity of the environment. In this paper, we study a simple class of noisy, dynamical systems that mathematically represent a very broad range of more complex models. We hence show how a combination of nonlinear instabilities and state-dependent noise in this model is able to unify these two apparently distinct biological phenomena. To illustrate its unifying potential, this simple model is applied to two very distinct biological processes – the spontaneous activity of the human cortex (i.e. when subjects are at rest), and genetic regulation in a bacteriophage. We also provide proof of principle that our model can be inverted from empirical data, allowing estimation of the parameters that express the nonlinear and stochastic influences at play in the underlying system.

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