Mathematical Neuroscience Edinburgh 2010
Tutorials, Sunday April 18

12.30 - 12.45	Introduction by Steve Coombes and Mark van Rossum
12.45 - 13.45	Alex Roxin
13.45 - 14.45	John Terry
14.45 - 15.15	(break)
15.15 - 16.15	Marcelo Montemurro
16.15 - 17.15	Bard Ermentrout
17.15	Beer and pizza

Note that Tutorials are in a **different** place from the main meeting.
Location: Informatics Forum, Crichton Street, EH8 9AB (marked on map).
It is a 15 min walk from the train station, which is also the last stop of the airport bus.

Sponsored by the EPSRC Doctoral Training Centre for Neuroinformatics and Computational Neuroscience

From networks to normal forms: using reduced models to understand network dynamics

Alex Roxin

My goal in this tutorial is to convince you that one can userelatively simple models to understand the collective behavior of large numbers of recurrently connected neurons. I will start from the premise that networks represent a "best" description of neuronal dynamics given that they incorporate single-cell dynamics and chemical synapses which are the hallmarks of neurons. Therefore we should be interested in the dynamics of networks. I will furthermore focus on networks in which connections are sparse and random and spontaneous activity is highly irregular. In this case it is possible to capture the qualitative features of the dynamical states observed in the network with simplified firing rate models.

In some cases reduced dynamical equations can be derived directly from the network equations themselves. I will discuss two such cases: 1- fast oscillations in inhibitory networks, 2 - probabilistic two-choice forced alternative decision making. For both cases I will present the network model, discuss a phenomenological firing rate description
and finally outline the derivation of normal form equations for the relevant bifurcations.

References, Fast oscillations:
Brunel and Hakim, Neural Comp. 1999.
Roxin et al., PRL 2005.

Decision Making:
Wang, X.-J., Neuron, 2002.
Wong and Wang, J. Neurosci. 2006.
Roxin and Ledberg, PLoS Comp. Biol. 2008.

Applications of modelling clinically recorded data

John Terry

I will introduce various approaches to modelling clinically recorded neural dynamics (for example electro-encephalography (EEG), magnetoencephalography (MEG) and functional Magnetic Resonance Imaging (fMRI)) and focus on recent advances in understanding and interpreting such data sets. We will draw upon examples from pathological brain states such as epilepsy and Parkinson's, as well as exploring the use of mean-field models for measuring the depth of anaesthesia.

Applications of information theory to the problem of neural coding

Marcelo Montemurro

Physical and chemical signals from the external world are processed by sensory organs and converted into patterns of neural activity. A key question in Neuroscience is to understand what aspects of the neural response are most relevant for the encoding of information about an external stimulus. An ideal tool to probe different coding hypotheses is provided by information theory (IT). Within this rigorous framework it is possible to quantify the knowledge about the stimulus that can be obtained from specific features of the neural response. Thus, IT can be used to assess the performance of different candidate neural codes. A powerful theoretical advantage of IT is that it does not require a predefined model for the transformation of the stimulus into neural activity. However, the practical application of IT to neural signals has been difficult due to the large data requirements to estimate the relevant probabilities from empirical data.

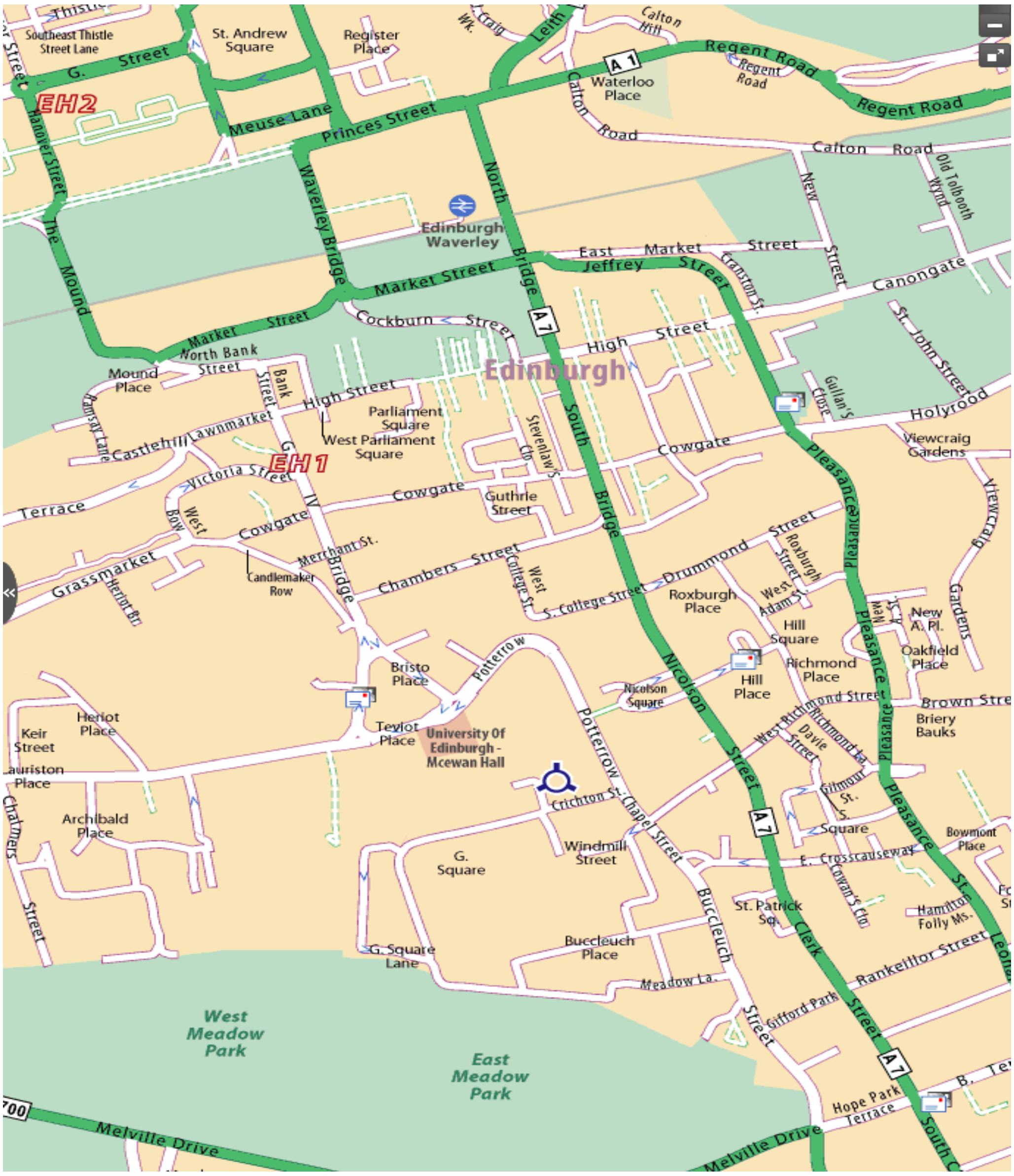
Here, I will review the basic concepts of IT and show how it can be used to address specific questions about neural coding. I will also address the practical problem of estimating information theoretic quantities and give examples of possible solutions to overcome the finite data problem.

1-Montemurro MA, Rasch MJ, Murayama Y, Logothetis NK, Panzeri S. (2008). Phase-of-firing coding of natural visual stimuli in primary visual cortex. Current Biology, 18. (main paper and supplementary information)
2-Montemurro MA, Panzeri S, Maravall M, Alenda A, Bale MR, Brambilla M, Petersen RS. (2007). Role of precise spike timing in coding of dynamic vibrissa stimuli in somatosensory thalamus. Journal of Neurophysiology, 98.
3-Panzeri S, Senatore R, Montemurro MA, Petersen RS. (2007). Correcting for the sampling bias problem in spike train information measures. Journal of Neurophysiology, 98
4-Shannon, C.E. (1948). A mathematical theory of communication. Bell System Technical Journal 27, 623–656.

Introduction to neural oscillators

Bard Ermentrout

I will discuss the notion of limit cycles, and how they respond to inputs. I will describe the relationship between bifurcations and phase resetting and how these define the collective dynamics of oscillators in the presence of inputs and coupling. It will be a chalk talk.



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