SINAPSE
Scottish Imaging Network - A Platform for Scientific Excellence

SINAPSE
PhD Project Proposal Template for PhDs starting in 2009

SINAPSE Centre (i.e. primary university to which this studentship will be attached*):

University of Edinburgh

First supervisor: contact details

Name: Dr Jano I. van Hemert
Department: National e-Science Centre
Address: 15 South College Street, Edinburgh EH8 9AA
Email: j.vanhemert@ed.ac.uk phone: +44 131 6 509820

Second supervisor: contact details

Name: Dr David Rodriguez Gonzalez
Department: SFC Brain Imaging Research Centre.
Address: Western General Hospital, Crewe Road, Edinburgh EH4 2XU
Email: david.rodriguez@ed.ac.uk phone: +44 131 5372663

Name: Dr Trevor Carpenter
Department: SFC Brain Imaging Research Centre
Address: Western General Hospital, Crewe Road, Edinburgh EH4 2XU
Email: Trevor.carpenter@ed.ac.uk phone: +44 131 5372663

Speciality of first supervisor:

Algorithm development, e-Science, computational and data infrastructure

Speciality of second supervisor:

Image analysis, computational and data infrastructure in the context of brain imaging

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PROJECT

Title:

Gaussian Process deconvolution for perfusion imaging: evaluation of the usage of distributed and parallel computing.

Planned start date (month/year):

April 2009

Likely background of suitable student (e.g. Neuroscience, MR Physics, Chemistry, Psychology) and <u>essential skills</u> required prior to starting this PhD:

Background: At least one in Informatics, Mathematics or Neuroimaging

Essential:

- **Proficient in one or more computer programming languages.**
- **First degree (or equivalent) in a relevant discipline.**
- **A user-focused approach to software development.**
- **An ability to design good user interfaces.**

*usually this would be the university in which the first supervisor is based.

Summary of proposed project (approximately 200 words):

Deconvolution is used in perfusion imaging to obtain the impulse residue function (IRF) that is then used to create parametric maps of relevant haemodynamic quantities such as CBF, CBV and MTT [1]. A popular method to achieve this is Singular Value Decomposition (SVD), but it has been shown that for MRI Gaussian Process Deconvolution (GPD) [2] is comparable to SVD when determining the maximum of the IRF, and superior estimating the full IRF. Furthermore, it clearly outperforms SVD when the signal-to-noise ratio improves.

Gaussian Process regression [3] arises from a Bayesian approach to the regression problem, and as in the case of other kernel-based methods the scalability with data size is very poor. This constitutes the main drawback of this technique to compute deconvolution when compared with SVD.

The currently running Wyeth-TMRC multicenter project on acute stroke brings the opportunity to test this technique with data from several SINAPSE centres and different modalities. This PhD project will benefit from the expertise in these centres and would seek to collaborate with them through the centres' contacts: M.J. McLeod (Aberdeen), J. Wardlaw (Edinburgh) and K. Muir (Glasgow).

The project will research the possibilities that distributed (and parallel) computing brings to make this method usable in practice. There have been some previous works like the data-parallel approach proposed in [4]. The project will study the consequences on the final results of the local learning used in it.
As a by product, the project will produce a data processing framework prototype reusable for other types of image processing.

Key references (up to five):

1. Ostergaard L, Weisskoff RM, Chesler DA, Gyldensted C and Rosen BR "High resolution measurement of cerebral blood flow using intravascular tracer bolus passages: I. Mathematical approach and statistical analysis" *Magn. Reson. Med.* **36** 715–25
2. Andersen IK et al; "Perfusion Quantification Using Gaussian Process Deconvolution". Magnetic Resonance in Medicine 48:351-361 (2002).
3. Williams CKI and Rasmussen CE; "Gaussian processes for regression". Advances in neural information processing systems, (1996), 514-520.
4. Choudhury A, Nair PB and Keane A; "A Data Parallel Approach for Large-Scale Gaussian Process Modeling". Proc. the Second SIAM International Conference on Data Mining (2002).

In what way does this PhD proposal meet the SINAPSE criteria as described in the call for proposals? (100 words)

The proposal directly contributes to the development of novel methodologies for improving the quality and efficiency of image analysis. The project will be supervised from the National e-Science Centre, and will use clinical data from centres within the SINAPSE consortium to ensure its output is relevant to them. Thus, this project aims are interdisciplinary, where the outcome of the Informatics research is directly applied in brain imaging for its immediate benefits.

Please state the name of the local SINAPSE Centre Lead with whom you have discussed this project (Leads are listed on the Call for Proposals, applications submitted without prior discussion will not be considered.):

Joanna Wardlaw