Post-doctoral subject proposal

Title: Markovian segmentation of multidimensional MRI sequences and abnormality detection in stroke and multiple sclerosis data

Inria team: Mistis
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Scientific context:

This post-doctoral position is part of a two year national ARC project (SeLMIC) supported by INRIA. The SeLMIC project (`http://r2-d2.ujf-grenoble.fr/selmic/doku.php`) aims at developing new statistical methods for the segmentation of multidimensional MR sequences corresponding to different types of MRI modalities and longitudinal data. The applications include the detection of brain abnormalities and more specifically stroke and Multiple Sclerosis lesions. The partners involved are the VisAGeS U746 INRIA/INSERM Team in Rennes, Team Mistis from INRIA Rhône-Alpes, team Functional and Metabolic Neuroimaging from INSERM U 836 and team Magma from LIG in Grenoble.

The proposed work aims at combining tools and expertise developed by the partners. This expertise is related to Markov modelling of MRI data and to robust processing of multidimensional MR sequences.

Subject:

Accurate tissue and structure segmentation of MRI brain scan is critical for several applications. Markov Random Fields (MRF) are commonly used for tissue segmentation to take into account spatial dependencies between voxels. However, such a task requires the estimation of the model parameters (eg. Potts model) which is not tractable without approximations. The algorithms in [1] based on EM and variational approximations are considered. They show interesting results for tissue segmentation but are not sufficient for structure segmentation without introducing a priori anatomical knowledge. In most approaches, structure segmentation is performed after tissue segmentation. We suggest considering them as combined processes that cooperate. In addition a priori knowledge is incorporated in the model by describing brain anatomy through fuzzy spatial relations between structures (distances, orientations or symmetries). Tissue and structure segmentations then appear as dynamical and cooperative MRF procedures whose performance increases gradually. This approach is implemented into a multi-agent framework, where autonomous entities, distributed into the image, estimate local Markov fields and cooperate to ensure consistency [2].

The current investigation deals only with one type (T1) of MR images with no temporal information. The aim of this work is to extend these tools to include multidimensional MR sequences corresponding to other types of MR modalities and longitudinal data. This will use the expertise of team VisAGeS from INRIA Rennes in the processing of longitudinal multi-sequences of clinical data [3]. Such extensions are particularly relevant in the study of some central nervous system disorders such as Multiple Sclerosis and stroke.

Considering these two application domains, our aim is then twofold. As regards Multiple Sclerosis, the aim is to extend the work in [3] by embedding it into a Markovian framework possibly both in time and space. As regards stroke, the aim is to extend the Markovian framework to multidimensional MRI sequences containing lesions and to inject a priori knowledge about vascular territories. We couls also introduce a priori information coming from probabilistic templates registered to the data.

Conditions for applicants:

An ideal candidate should have a PhD in applied mathematics with some previous experience in statistics, in particular hidden Markov models and clustering methods. Programming skills with C/C++ are desired. Knowledge in Neuroscience is welcomed. Also the collaboration between two sites in Rennes and Grenoble will require travelling and spending visiting periods between these two sites. See also the official INRIA conditions at `http://www.inria.fr/travailler/opportunites/postdoc/postdoc.en.html`.

References

[1] G. Celeux, F. Forbes, and N. Peyrard. EM procedures using mean field-like approximations for Markov model-based image segmentation. *Pattern Recognition*, 36(1):131–144, 2003.

[2] B. Schrerrer, M. Dojat, F. Forbes, and C. Garbay. Distributed and Cooperative Markovian Segmentation of tissues and structures in MRI brain scans. In *HBM meeting*, Florence Italy, June 11-15 2006.

[3] L. At-ali, S. Prima, P. Hellier, B. Carsin, G. Edan, and C. Barillot. STREM: a robust multidimensional parametric method to segment MS lesions in MRI. In *MICCAI'2005, J. Duncan, G. Gerig (eds.), Lecture Notes in CS*, pages 409–416, Palm Springs, USA, Oct. 2005.