



PhD position in medical imaging

Unified framework for change detection in multimodal brain MRI Application to longitudinal analysis of multiple sclerosis

Context

Automatic change detection in series of MRI acquisitions is essential for analyzing the evolution of pathologies over time. It is particularly useful in clinical routine for diagnosis and longitudinal monitoring of patients subject to treatments. It is also an important tool for large scale studies using imaging biomarkers to evaluate the efficiency of therapeutic strategies.

Intensity changes between MRI acquisitions of a patient at different times can have multiple origins. They can reveal the appearance or the evolution of a lesion, the deformation of brain structures (e.g. atrophy), or they can be caused by artefacts due to the acquisition device. The major issue is to distinguish these different sources to quantify their individual impact. Existing methods have a sequential approach that considers each phenomenon successively, without taking into account their interdependency. Thus, the detection of a given source of change is potentially biased by the presence of others. For example, the appearance of a new lesion can be interpreted as a deformation of the brain, and can be discarded by the registration process [1].

Another crucial point is the multimodal nature of the data. The features of different MRI modalities (T1, T2, FLAIR...) are complementary and should be combined to provide a complete description of a pathology. However, the changes are often estimated separately in each modality.

Objectives

The motivation of this thesis is to overcome the limitations of the sequential approach by designing a unified estimation framework. The goal is to estimate *jointly* the different physical and physiopathological phenomena involved in the changes observed in brain MRI sequences, while taking advantage of the multimodal nature of the data. To this end, we will formulate change detection as a blind inverse problem, where the brain deformation and the parameters of the change models will be estimated in a single optimization problem. Recent works for autocalibration with blind approaches have led to great progress in image reconstruction for MRI [6], confocal microscopy [4], structured illumination microscopy [5], or cryo-electron microscopy [7]. Similar approaches have been investigated in computer vision for joint estimation of motion and occlusions or illumination changes [2, 3]. The PhD student will have to design new models and algorithms inspired by

these advances and adapted to the specific issues of change detection in brain MRI. He/She will benefit from the long experience of the IMAGEs team in change detection for brain MRI.

In addition to this methodological goal, the PhD student will work in close interaction with hospital practitioners from the civil hospital of Strasbourg. The change detection methods will be applied to data of patients suffering from multiple sclerosis, to improve diagnosis and longitudinal monitoring. They will be compared with the software tools of our industrial partner Philips Health Research.

Working environment

The work will mainly take place at the ICube laboratory (UMR 7357, CNRS, University of Strasbourg), in the IMAGEs group (<http://images.icube.unistra.fr/fr/index.php/Accueil>). It is also a collaboration with the IMIS group of ICube (<http://icube-imis.unistra.fr/index.php/Accueil>), to guide the work by clinical expertise at the civil hospital of Strasbourg, and with the company Philips Health Research that will provide support for software implementation of the proposed methods.

Supervision

- Denis Fortun, IMAGEs group
- Vincent Noblet, IMAGEs group
- Stéphane Kremer, IMIS group

Candidate profile

- Master degree in Computer science or applied mathematics
- Solid background in signal/image processing
- Good programming skills, preferably in Python
- Experience in medical image processing would be desirable

Application

Applications should contain a CV, a cover letter, and recent university records. They must be sent to Denis Fortun (dfortun@unistra.fr) and Vincent Noblet (vincent.noblet@unistra.fr)

References

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- [3] J. Hur and S. Roth. Mirrorflow: Exploiting symmetries in joint optical flow and occlusion estimation. In *International Conference on Computer vision (ICCV)*, 2017.
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- [5] E. Mudry, K. Belkebir, J. Girard, J. Savatier, E. Le Moal, C. Nicoletti, M. Allain, and A. Sentenac. Structured illumination microscopy using unknown speckle patterns. *Nature Photonics*, 6(5):312–315, 2012.
- [6] M. Murphy, M. Alley, J. Demmel, K. Keutzer, S. Vasanawala, and M. Lustig. Fast l1-SPIRiT compressed sensing parallel imaging MRI: Scalable parallel implementation and clinically feasible runtime. *IEEE Transactions on Medical Imaging*, 31(6):1250–1262, 2012.
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