Cortical morphometry for discovering new biomarkers of neurodegenerative diseases

Résumé du projet de recherche (Langue 1)

The ARAMIS team (www.aramislab.fr) is developing advanced methods for the statistical analyses of the shape of brain structures. These approaches are applied to detect alterations in neurodegenerative disorders, in order to enhance their early diagnosis. The principle of our approach is to estimate anatomical configuration prototypes whose topology reflects the organization of different structures studied. These prototypes configurations are mapped to the anatomical data of each subject through regular deformations of the space. The parameters of these deformations, which are also optimized, are used for statistical analysis. They can be used in classification or regression tasks to model anatomical changes depending on clinical or behavioral variables. Until now, these methods have been mainly applied to subcortical structures, including in particular the hippocampus which is a known marker of Alzheimer’s disease. The purpose of this thesis is to extend these methods to cortical structures. Indeed, it is quite clear that neuronal death in neurodegenerative diseases induces thinning of the cortex, as well as a widening and a reduction in the depth of the cortical sulci. However, there is very little work to date for a systematic and quantitative assessment of these anatomical changes. The main challenge lies in the comparison of the shape of the cortex between different subjects. Indeed, the shape, topology, and the number of sulci are specific to each subject. The primary aim of the thesis will be to adapt the registration algorithms developed in the team to carry out a mapping of cortical surfaces that takes into account the location of the main sulci and that adapts to topology changes. Then, this registration method will be used for estimating cortical prototype configurations. The use of multi-class methods will allow the estimation of several prototypes and provide a partition of the set of subjects according to the shape and topology of their cortical sulci. The thesis will build on the Deformetrica software developed in the ARAMIS team for the registration of anatomical surfaces and estimation of statistical models. The methods will be evaluated on the public database of the Alzheimer's Disease Neuroimaging Initiative (www.adni-info.org) containing MRI images of hundreds of subjects at various disease stages as well as on local databases of patients with Alzheimer’s disease and other neurodegenerative dementias acquired at the Brain and Spinal Cord Institute (ICM).

Résumé du projet de recherche (Langue 2)

The main challenge of the thesis is to build algorithmic tools to detect early changes in the shape of the cortex in patients with neurological diseases. The complexity of the shape of the cortex and its huge variability among individuals require a radically new approach to morphometry. The tools we develop for several years should enable us to make significant progress in this area, in particular to provide the pharmaceutical industry markers of cortical atrophy enabling better detection of treatment effects.