PhD proposal

Icono-geometric atlas construction for brain glioblastoma

Context Glioblastoma is the most common and agressive malignant primary brain tumor with a survival median between 12 and 15 months in adults [6]. The current standard of care is based on neurosurgery, chemotherapy and radiation treatment. They can be associated to refractory epileptic seizures [5] which impact strongly the quality of life. The low survival rate and negative prognosis have fostered a lot of research for better understanding the behavior of this kind of tumor [8]. Clinical evidence suggests that tumor size, location and shape could be important factors related to recurrence and seizures [2]. Currently, MR imaging, with typically T1, T2, and T2 FLAIR acquisitions, is the only non-invasive technique capable of capturing this information.
Population-based atlases derived from 3D MR scans have become an essential tool in neuroimaging [3, 4]. This type of analysis has been widely used for populations of healthy subjects, but it is hampered by the lack of correspondences when dealing with pathological brains. In fact, standard registration techniques [1] aim at spatially aligning homologous structures between two images. Since the images might have a different number of components, due to the presence of tumors, one should not assume correspondences.
A glioblastoma may entail three kinds of variations between two images: 1- *Topology*, 2- *Appearance* and 3- *Shape*. The first one is due to the presence of the tumor, which means that images might have a different number of components. The second difference is related to a variation in intensity (appearance) which can be caused, for instance, by the tumor infiltration. The third variation is instead caused by the tumor growth which deforms the surrounding healthy tissues (mass effect).

Objectives The goal of the PhD project is to propose a method to estimate a 3D atlas of glioblastoma using a population of MR brain images. The resulting atlas should describe the average shape of glioblastoma and its variability, which will depend on its anatomical location, as well as the main variations of the surrounding tissues (mass effect). To this end, the student will propose an original registration method that will take into account all sources of variation induced by the presence of a glioblastoma: topology, appearance and shape. A possible research line will be to extend the framework of (iconic) metamorphoses [7] by also including topological changes. To this end, a part of the PhD project will be devoted to exploring mathematical frameworks which belong to the field of shapes spaces and computational anatomy, more precisely diffeomorphic registration methods (LDDMM) and geometric data attachment models such as currents and varifolds. This project will contribute to a better understanding of the pathophysiology of glioblastoma, and thus to a better surgical and chemotherapeutic treatment. It could also shed light on the morphological characteristics of the tumor that are more related to recurrence and seizures.

Contacts The student will be supervised by:
- Joan Glaunès (MAP5, Paris Descartes)
- Isabelle Bloch (LTCI, Télécom ParisTech)
- Pietro Gori (LTCI, Télécom ParisTech)
- Pauline Roca (IMABrain, St. Anne hospital)
- Johan Pallud (IMABrain, St. Anne hospital)

Labs The project is a collaboration between the LTCI (Télécom ParisTech), MAP5 (Paris Descartes) and the IMABrain team (St. Anne Hospital).

Student profile The candidate should have a master in computer science, applied mathematics or geometric modeling with a strong interest in medical imaging and programming.

Starting date September/October 2018

How to apply Candidates are invited to send their CV before the 15th of May 2018 detailing their academic background with courses and grades to pietro.gori@telecom-paristech.fr, alexis.glaunes@parisdescartes.fr and isabelle.bloch@telecom-paristech.fr.

References

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