Jan Brabec

Diffusion MRI of Brain Tissue:
Importance of Axonal Trajectory

Magnetic resonance (MR) is a well-established modality that uses the nuclear magnetic resonance (NMR) phenomenon to probe magnetic properties of samples. MRI can serve as an example of successfully applied fundamental research from physics to biological sciences, humanities, chemistry or medicine. Biomolecules in biochemistry can be probed with atomic resolution. Nanomaterials in material sciences, porous rocks in geology, cell structures or tissues in biology and medicine can be examined. Statistical analysis of MRI signal can reveal functional state of the brain and is relevant in e.g. psychology. This thesis deals mainly with applications within medical sciences.

Diffusion magnetic resonance imaging (dMRI) unravels the tissue microstructure, i.e. the structure of tissue on the micrometer length scale. At this scale, the arrangement of cells and other biologically relevant structures emerges as a new property from a deeper, biochemical, scale. Microstructural appearance is often defining feature of biological tissues and is intertwined with their biological behavior, which is a highly interesting information from a medical point of view.

In this project, we study in a systematic way, often neglected, geometrical aspects of axons called *axonal trajectories*. Axons are the wiring of the brain. Based on microscopical images we proposed their representation, inspected their properties and forecasted the outcome of a diffusion measurement. The inverse question, whether the information on the axonal trajectories can be inferred from the outcome of measurement, and whether they could be neglected was answered as well. The results suggest that non-straight axonal trajectories need to be considered in the of representations of axons, although to estimate them reliably the practical diffusion measurements need to be improved. The estimated properties of axonal trajectories were congruent to the gold-standard method, microscopy.

Same methodology applied to the investigation of axonal trajectories can be employed in other problems in the dMRI field and may also lead to better understanding of the nature of the results of the diffusion measurements in the human tissue. Potentially, novel biomarkers that could help to diagnose diseases could be discovered. Generally, dMRI is an interesting research field where potential breakthrough could be made. It probes the microstructural region that is highly important from the biological point of view, has a solid foundation in physical theory, allows for large variety of possible arrangements of the dMRI experiments and is not as widespread as other imaging modalities.

Handledare: **Markus Nilsson, Jan Pallon**
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MR Physics Group och Fysiska institutionen, Lunds universitet

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