Post-Processing of Diffusion MRI : Basic Theory and Clinical Application

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The “diffusion” may be one of the most important and attractive notions in mathematical methods for image analysis. For instance, the anisotropic diffusion filter simulates signal diffusion for smoothing in virtual image space. On the other hand, measuring diffusion in the real space, for instance water diffusion in a living body, is not a simple task though it provides useful and important information. Indeed, incoherent motion of water molecules has certain anisotropy in living bodies relating to normal and abnormal structures. One of the important developments in the technology of water diffusion measurement is diffusion magnetic resonance (MR) imaging, which is mainly employed for biomedical purposes. The diffusion MRI can reveal orientation-dependent behavior of water molecules for localization of specific organs and pathologies, and for functionality assessment. The lecture consists of several parts of topics as followings.

1) Basic theory of diffusion as a physical phenomenon
2) Fundamentals of diffusion MR imaging and diffusion anisotropy in living bodies
3) Techniques of post-processing for diffusion MRI
4) Clinical application results

In the first part, several historic studies related to diffusion are outlined including the botanist’s discovery known as “Brownian motion”. The later formulation of diffusion as a stochastic process is also introduced for derivation of diffusion equation as a PDE.

The next section covers fundamentals of diffusion MR imaging by using the Stejskal-Tanner’s scheme based on motion probing gradient of magnetic field, and introduction of diffusion anisotropy in organs of living bodies such as the brain white matter. Recent development of diffusion tensor (DT)-MR imaging and higher angular resolution diffusion (HARD)-MR imaging are also referred.

Then, several post-processing techniques for diffusion MRI are introduced and reviewed, such as diffusion tensor determination from multiple diffusion measurement, white matter visualization via DT fiber tracking, connectivity assessment by diffusion simulation, and so on. In addition, on-site demonstrations of several post-processing techniques are performed by using our original softwares.

Finally, clinical application results for diagnostic and therapeutic purposes in our institute are presented based on clinical data sets of neurological disorder.

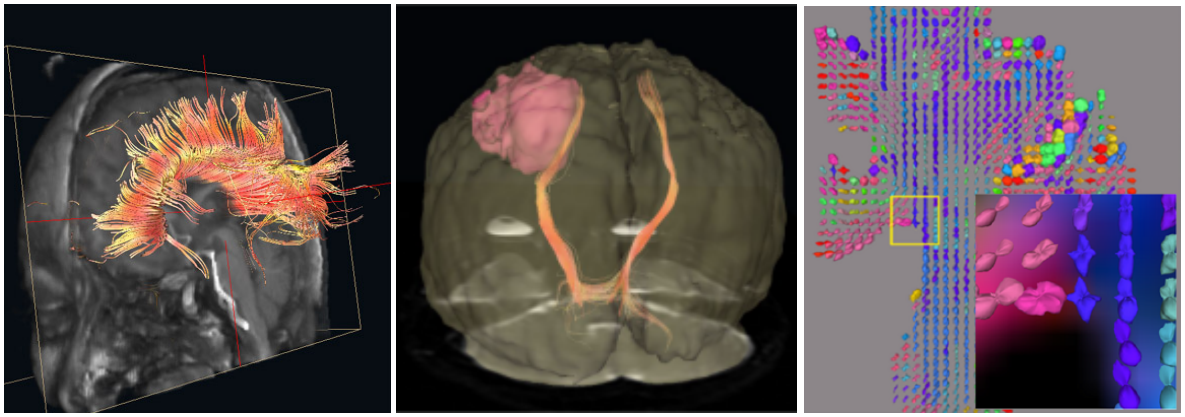

Fig. Application of diffusion MRI post-processing

Left: DT fiber tracking through the Corpse Callosum, Middle: brain tumor case, and Right: HARD profiles