Diffusion Tensor Imaging and Applications

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Diffusion Tensor Imaging (DTI), as implemented in MRI, is a non-invasive imaging technique that can be used to probe, in vivo, the intrinsic diffusion properties of deep issues. DTI is becoming a popular imaging tool. It has been applied to study the microstructural characteristics of the brain, the heart, muscle tissue, bone marrow, intervertebral discs and the spinal cord. In the brain, DTI has been applied in normal conditions to study brain function and development of human cerebral white matter, as well as, in disease conditions for the diagnosis of stroke, multiple sclerosis, and schizophrenia.

This thesis first describes a diffusion tensor pulse sequence, post processing tools for calculation of the diffusion tensors, limitations of DTI and ways to overcome them. Then several conventional acquisition schemes with different numbers of diffusion directions are compared. To increase the SNR of DTI indices for fibers with known orientation and type, variable repetitions (VR) acquisition, depending on the contribution of each acquisition to the SNR of the DTI indices of the specific fibers. Independent component analysis (ICA) is also applied to DTI to offer in some cases an alternative, and in others, preprocessing tool for conventional DTI processing. For example, some components produced when ICA is applied to the DTI raw data provide similar information to the diffusivity maps, and others identify large white mater fiber tracts. In addition, some

components detect eddy current induced distortions other map noise, therefore removing them before conventional DTI post processing improves the final results. Finally, DTI is applied to patients with traumatic brain injury and patients with temporal lobe epilepsy. In the first case, DTI is used to identify diffuse axonal injury and in the second DTI is used to study the effects of temporal lobe epilepsy on the diffusion and structural characteristics of white matter.