T22

Characterization of tissue microstructure using porous media concepts

Evren Özarslan[1]

[1] Section on Tissue Biophysics and Biomimetics, NICHD, National Institutes of Health, Bethesda, MD, USA.

Abstract:

Magnetic resonance (MR) imaging or spectroscopy measurements have been widely employed to characterize the structure of materials and biological tissues. The noninvasive character of the MR acquisitions as well as the exquisite contrast obtained within soft tissue has made MR imaging (MRI) an indispensable tool in monitoring functional activation in the brain and the morphological changes associated with development and aging. Due to its sensitivity to numerous diseases, MRI is also employed in routine clinical practice for diagnostic purposes. Despite aforementioned advantages, conventional MRI scans suffer from limited resolution that prohibits the visualization of individual cells thus providing information at coarse length scales. To obtain information at smaller length scales, the MR signal can be sensitized to the diffusion of water molecules [1] whose motional history is influenced by the local structure. To exploit this phenomenon, it is necessary to develop models that link the geometric characteristics of the medium to the MR signal intensity. These models can then be used in the inverse problem of extracting the microstructural features of the specimen from the acquired MR signal.

In this talk, we will discuss several such models that we have developed over the years. Specifically, characterizing diffusion anisotropy enables the mapping of local axonal fiber orientation, which can be subsequently used to map the neural connections between different regions of the brain. Another novel application of anisotropic diffusion enables the mapping of directions perpendicular to macroscopic interfaces which could be used in generating a differential structure of the cortical surface. We will also discuss how an anomalous diffusion model for gray-matter structures can be employed to quantify the scaling characteristics of diffusion and an apparent fractal dimension for tissue. Finally, recent developments in the double pulsed field gradient MR acquisitions to infer the cell size, shape, and orientation distribution function will be discussed.

1. P.T. Callaghan, A. Coy, D. MacGowan, K.J. Packer, F.O. Zelaya, Diffraction-like effects in NMR diffusion studies of fluids in porous solids, Nature 351 (1991) 467–469.