Guest Editorial

The fifth issue of Critical Reviews™ in Biomedical Engineering offers two papers: “Fractional Calculus Models of Magnetic Resonance Phenomena: Relaxation and Diffusion” by Magin et al. and “A Review of MRI and Exercise Treatment for Improved Concussion Diagnosis and Recovery” by Danielli et al. These papers review the current state of magnetic resonance imaging (MRI) and its extensive application in the human body.

Dr. Richard Magin’s team reviews advances in MRI imaging that employ fractional calculus to identify early traces of disease. Mathematically, the order of fractional derivatives in space and time provides a concise description of non-Gaussian diffusion and nonexponential relaxation, both of which, because of their ability to modulate contrast in MRI images, are key for understanding the complexity of tissue is sufficient. In this way, fractional calculus extends molecular transport models across multiple time and length scales (nm to cm) in the same manner that fractals capture geometric complexity. Dr. Magin’s group describes fractional-order models of NMR relaxation (spin correlation, spectral density, and the Bloch equation) and diffusion (pulsed field gradients, diffusion, and the Bloch-Torrey equation) that can be used to investigate molecular, cellular, and tissue structures in a multifaceted approach that uses coarse graining, simulation, and fractional-order models to identify new biomarkers of disease.

This review surveys principal fractional-order models, identifies their connections and limitations, and points to their future applications.

Danielli and colleagues propose a quantitative Z-scoring method for comparing over time the brains of healthy individuals with those of patients undergoing treatment of concussion following traumatic brain injury (TBI). Concussion is a multifactorial pathology in all age groups and over both the short and the long term, often caused by sports involving body contact. Various imaging modalities, including MRI, provide anatomical and physiological clues for diagnosing TBI and for optimizing its treatment. The objective is to minimize recovery time and concomitantly reduce symptom severity. It has been documented that aerobic exercise is effective in both cases. The exact mechanisms of exercise’s effect on concussion is not well understood. The authors provide a number of databases of images of healthy brains that may be accessed to compare, through quantitative MRI, injured brains and those of healthy controls and the sequelae following exercise therapy.

Guest Editors:

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