Abstract for GR-TR Conference on Statistical Mechanics and Dynamical Systems

Topic: Neuro-Dynamics — Preference: Oral

Fractal Analysis of Human Brain Diffusion Tensor Images in the 2-D and 3-D Space

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One of the most difficult problems today is to understand the structure and the functionality of the brain. A lot of biophysical methods have been proposed and applied in modern medicine, but the brain still remains an open problem. One of the currently active methods in today's research is the Diffusion Tensor Imaging, a method used to define the structure of the brain, by calculating the direction of neurons, based on the movement of water molecules. Using this method it is possible to trace the general direction of the neuron axons, and thus the physical structure of the brain.

On top of the DTI methods, we were able to estimate the fractal dimension D_f of the brain as a complex structure. The methods used were box counting, lacunarity analysis, correlation dimension and mass dimension. Two types of data sets have been used; a) a 2-D projection of a 3-D tractography based on a specific areas of interest and b) a 3-D representation of the neuron tracts emanating from the whole human brain area.

The calculated fractal dimension for the 2-D projection was found to be $D_f \simeq 1.6$ for small areas of interest, and for larger areas of interest seems to occupy the whole 2-D space. In the 3-D space the value of D_f was again constant, varying from 1.5 in the small scales, up to 3 in medium and large scales, thus reflecting the local topology of the neurons. The results in both cases are compatible; when using small areas of interest in the 2-D method, the value of D_f is roughly equal to the D_f of the 3-D approach in the small scales, while both areas in these two approaches have approximately the same size. In large scales both approaches demonstrate that the human brain occupies the whole area, and thus its D_f tends to be equal to the embedded space.

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[1] B. J. West, "Fractal physiology and chaos in medicine", World Scientic (1990)

[2] P. Katsaloulis and D. Verganelakis and A. Provata, "Fractal dimension and lacunarity of tractography images of the human brain", *Fractals*, **17**, 2(2009)1-9

[3] R. Deriche and D. Tschumperl'e and and C. Lenglet, "DT-MRI estimation, regularization and ber tractography", *ISBI*, (2004), 912

[4] P. Katsaloulis and A. Ghosh and A. Provata and R. Deriche, "Fractality in the neuron axonal topography of the human brain based on 3-D Diusion MR Imaging", submitted