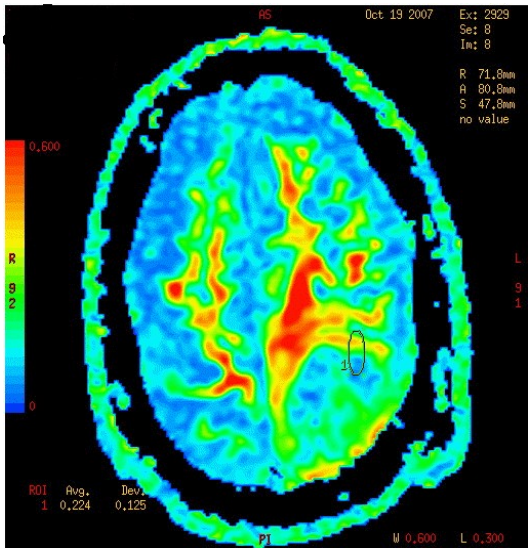
Master's Thesis Proposal

Thesis Title: Fractal and multifractal analyses of MRI images of the Human Brain
[Collaboration between the Univ. of Athens, the NCSR "Demokritos" & the Technische Universität Berlin.]

Aim: The study and comparison of MRI images from healthy human brains and from patients with schizophrenia, Alzheimer disease and Parkinson disease. The scope is to use the methods of fractal and multifractal analyses to analyse the structure of the network formed by the axons connecting the brain neurons, i.e. to uncover the structure of the neuron network. Comparison of healthy brains to brains suffering from schizophrenia, Parkinson disease and Alzheimer's disease will be undertaken for the understanding of the abnormalities in the formation of the network and the origin and evolution of these diseases. Relevant quantities to be computed for quantitative comparisons are the fractal dimensions of the image, the mass dimension, the autocorrelation function, the information dimension and the multifractal spectrum.



Typical MRI of the human brain

Methodology:

For each case the following steps will be followed:

- A number of high resolution 2D images are given for each subject coving all human brain (see picture).
- As a first step the superposition of the 2D images into a 3D structure is required.
- A 3D digital representation of the brain is performed.
- Different filters are applied to exclude unwanted tissues and to highlight suspicious regions.
- Quantitative indices (Fractal dimensions, Correlations, Multifractal Spectra etc) are computed.
- Quantitative indices of healthy and diseased brains are compared for selecting the appropriate indices which present maximum discriminating power.

The method will be applied to different subjects, for extraction of statistics.

Literature:

-Katsaloulis P, Hizanidis J, Verganelakis DA, et al., Complexity Measures And Noise Effects On Diffusion Magnetic Resonance Imaging of the Neuron Axons Network In The Human Brain, Fluctuation and Noise Letters 11 (4): Art. No. 1250032, 2012.
-Katsaloulis P, Ghosh A, Philippe AC, et al., Fractality in the neuron axonal topography of the human brain based on 3-D diffusion MRI , EUROPEAN PHYSICAL JOURNAL B 85 (5): Art. No. 150, 2012.
-Sfikas K, Theoharis T, Pratikakis I, 3D object retrieval via range image queries in a bag-of-visual-

words context, VISUAL COMPUTER 29 (12): 1351-1361, 2013.
-Danelakis A., Verganelakis D. A., Theoharis T, A new user-friendly visual environment for breast MRI data analysis, COMPUTER METHODS AND PROGRAMS IN BIOMEDICINE 110 (3): 411-423, 2013.

Collaboration:
This Master Thesis is performed in the framework of a collaboration between:
-the Department of Informatics of the University of Athens (Prof. T. Theoharis),
-the Institute of Nanoscience and Nanotechnology of the National Center for Scientific Research "Demokritos" (Dr. A. Provata) and
-the Technische Universität Berlin, Germany (Prof. P. Hoevel).

Requirements:

We are looking for an MA student with excellent knowledge of:

a) image analysis techniques
b) programming language C/C++ (or other)
d) English

Additional Skills (not required) could be useful:
a) Knowledge of Linux operating system
b) Knowledge of Fractal and Multifractal Analysis

Interested students, please contact:

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