**ThinkBS 305 (update course page)**

**Course title:**

**Innovative mathematical modeling techniques: fractional calculus, wavelet analysis, and estimating of nonlinearities**

Information about course:

This course is composed of three theoretical parts with applications that present: two sections which contain the notions of fractional calculus and wavelet analysis, as well as a section of methods for estimating nonlinearities.

**Fractional Calculus**

The last decades proved that derivatives and integrals of arbitrary order are very convenient for describing properties of real materials (for example, polymers). The new fractional-order models are more satisfying than former integer-order ones. Fractional derivatives are a remarkable tool for describing the memory and hereditary properties of various materials and processes while in integer-order models such effects are neglected. The fractional calculus has significant applications in different fields of science, including the theory of fractals, numerical analysis, physics, engineering, biology, economics, and finance. Also, fractional derivatives and integrals, respectively fractional differential equations are used in the theory of control of dynamical systems to describe the controlled system and the controller.

**Wavelet Analysis**

As many notions - dynamic system, Fourier analysis, processing algorithms, Shannon information, etc., the notion of signal is claimed not only by communications engineering, but also by mathematics, in communion with computer techniques. The theory of waves ("wavelets") became the subject of scientific research and also of the disciplines to be learned, after 1980; this theory does not replace Fourier analysis, as an extension of it, with special virtues, we mention in this sense the good localization of signals (in time, frequency and scale); decomposition of signals and 2D images into "rocks", with the creation of zooms; digital analysis (A/D), directly related to the digital age in which we have irreversibly entered. Wavelet transform is a mathematical approach widely used for signal processing applications. It can decompose special patterns hidden in mass of data. Regarding the prediction issue through time series and neural networks, we need modeling task. Wavelet transform has the ability to simultaneously display functions and manifest their local characteristics in time-frequency domain.

**Estimating of nonlinearities**

Some topics in this section that will be discussed: functions approximations by polynomial interpolation, iterative methods for calculating the eigenvalues and eigenvectors of a matrix, estimation methods of probability densities functions, estimation methods for solutions of nonlinear ODEs.

**References**

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**Teachers**

The lecturers of this course are as follows: Simona Mihaela BIBIC, Elena Corina CIPU, Mihai Rebenciuc, Carmina GEORGESCU, Emil SIMION and Antonela TOMA from the Center for Research and Training in Innovative Techniques of Applied Mathematics in Engineering “Traian Lalescu” (CiTi), University Politehnica of Bucharest.