Numerical Solution of Problems with Functional Dependence in Medicine and Biology

Zdzislaw Jackiewicz
Department of Mathematics, Arizona State University, Tempe, Arizona 85287, USA. E-mail: jackiewi@math.la.asu.edu

Many problems in medicine and biology are modeled by equations with functional dependence, i.e., equations where the right hand side depends not only on the present state of the system but also on the history of the solution and/or the history of the derivative of the solution. Such equations fall into the general class of ordinary or partial functional differential equations and include as special cases delay-differential equations and Volterra integral and integro-differential equations.

The equations with functional dependence are quite diverse and different numerical techniques appropriately designed for specific types of models are required. Our research on new efficient methods for these equations is motivated by specific problems in applied sciences which we came across cooperating with colleagues working in medicine and mathematical biology. Some of these problems include:

1. Threshold models in the theory of epidemics and population dynamics.

We consider a model for the spread of infection in which an individual becomes infectious at time t after accumulated dosage of infection reaches a known threshold. This model can be described by the system of delay-differential equations, where the delay function is not known explicitly and must be determined from appropriate threshold conditions as the integration progresses from step to step.

2. Integro-differential equations modeling neural networks.

This problem can be described by the initial-value problem for the integro-differential equation of convolution type where the kernel is assumed to be a nonnegative integrable function defined on real line. This problem is a continuous analog of a discrete Voltage Controlled Oscillator Neuron (VCON) model of transmission line in neural networks.

3. Calcium-mediated dendritic branch model

We present a new numerical method for the simulation of calcium-mediated dendritic branch model. Using this method we will illustrate the impact of time-dependent changes in spine density and spine shape on the input-output properties of the dendritic branch.

All these problems require nonstandard algorithms for their efficient numerical solution and some of them will be described in this talk.

Friday, February 22nd, 2008
3:40PM
MG 106
Refreshments: 3:10 pm in MG226