ECE 449/549 - CONTINUOUS-SYSTEM MODELING

Fall, 2005

Objectives: To enable students with some engineering or equivalent background to model continuous dynamical systems for digital computer simulation; to appreciate the strengths and limitations of modeling and simulation; and to understand how continuous system formalisms fit into the broader picture of simulation models in general. The course will focus on languages and environments for continuous modeling and simulation with emphasis on their conceptual/theoretical basis as well as hands-on experience with constructing models and executing simulations. We also discuss types of dynamic system behavior including linear and non-linear, fractal dynamics, and chaotic dynamics.

Outcomes: At the end of the course, the student should be able to use approaches covered in class to construct a reasonably complex model of a real system of interest, describe it in acceptable form, and execute it to obtain meaningful results. The student should be able to understand the foundation of modeling and simulation, the role of continuous system models within it, and how they can be combined with other types of models to solve complex design and other system problems.

Course Description: The discussion will consist of lectures and demonstrations involving construction of continuous simulation models and the underlying mathematical foundations that justify such constructions. Appropriate software will be made available either in the ECE departmental labs or downloadable online. Course work consists of weekly homework assignments, a midterm, and a final project. The project, to be done individually, or in a small team, will enable students to apply the concepts and methods they learned to a real world problem of their choice.

Grades:

Homework: 25%
Midterm: 35%
Final Project: 40%

Usual breakpoints are: A = 85and above, B= 70 and above, C= 60 and above, D = 50 and above, E = less than 50.

Topics:

Advances in system development – whether in newer domains such as information and bio- technologies, or traditional fields such as electrical and mechanical engineering –

ultimately rely on well-constructed predictive models. Using appropriate simulation software, we can derive solutions to difficult problems using such models. Success often depends on having a variety of modeling approaches available to formulate the right model for the particular issue at hand. Therefore, a broad familiarity with different types of models is desirable.

Continuous system models were the first widely employed models and are traditionally described by ordinary and partial differential equations. Such models originated in such areas as physics and chemistry, electrical circuits, mechanics, and aeronautics. They have been extended to many new areas such as bio-informatics, homeland security, and social systems. However, a host of formalisms have emerged in the last few decades that greatly increase our ability to express features of the real world and employ them in engineering systems. Such formalisms include Neural Networks, Fuzzy Logic Systems, Cellular Automata, Evolutionary and Genetic Algorithms, among others. Hybrid models combine two or more formalisms, e.g., fuzzy logic control of continuous manufacturing process, Most often, applications will require such hybrids to address the problem domain of interest. However, continuous differential equation models remain an essential component in such multi-formalism compositions.

In this course, we learn how to construct and simulate continuous system models in traditional form. We then go on to consider some of the newer formalisms mentioned above. To make these different formalisms work together, we discuss a common framework for including both continuous and discrete models that uses DEVS (Discrete Event System Specification). Although we discuss DEVS in this class to the extent needed, we leave to other courses (e.g., ECE 575) its consideration in detail.

There is no textbook for the course.

A list of literature illustrative of the course content is:

A First Course in Differential Equations: The Classic Fifth Edition (Hardcover) by Dennis G. Zill, Brooks Cole; 5 edition (December 8, 2000)

The Nonlinear Workbook: Chaos, Fractals, Celluar Automata, Neural Networks, Genetic Algorithms, Gene Expression Programming, Support Vector Machine, Wavelets, Hidden Markov M (Paperback) by Willi-Hans Steeb, 588 pages, Publisher: World Scientific Publishing Company; 3rd edition (July 15, 2005)

Modeling and Analysis of Post-Conflict Reconstruction, Damon B. Richardson, Richard F. Deckro, and Victor D. Wiley, JDMS: The Journal of Defense Modeling and Simulation,October 2004, Volume 1 Number 4

Fernando J. Barros, A Formal Representation of Hybrid Mobile Component, SIMULATION, May 2005; 81: 381 - 393.

What is signal and what is noise in the brain? A.Knoblauch, G.Palm, Biosystems 79(1-3), pp 83-90, 2005.

Discrete Event Multi-Level Models for Systems Biology, Uhrmacher, A.M. and Degenring, D. and Zeigler, B.P, LNCS Transactions on Computational Systems Biology, Vol. 1, 3380/2005, pp. 66-85.

Modifications of the Helbing-Molnár-Farkas-Vicsek Social Force Model for Pedestrian Evolution, Taras I. Lakoba, D. J. Kaup, and Neal M. Finkelstein, SIMULATION 2005 81: 339-352.