Approval: 4th Senate Meeting

Course Name : Computational Modeling of Social Systems
Course Number : CS-606
Credits : 3-0-0-3
Prerequisites : IC110 Engineering Mathematics and IC 150 Computation for Engineers; or, after instructor's permission
Intended for : 3rd, 4th year B. Tech./M.S./Ph.D.
Distribution : Discipline-elective forCSE B. Tech. students; Free elective for other B. Tech. students
Semester : Odd, Even

Preamble: This course forms a part of the field of computational science, where the emphasis is to build complex mathematical models to understand and improve social systems. This course forms a natural second course after the CS 603 (Managerial Decision Making) course. Although the major emphasis in CS 603 is on understanding the heuristics and biases in individual and group decisions; the emphasis of this course is to integrate the heuristic and bias assumptions in computational models of aggregate behavior. Here, the emphasis is on highlighting the fact that computational models and techniques do allow modelers to capture the dynamics of several social systems at the aggregate level. Also, such models allow researchers to study the influence of certain policy assumptions at the aggregate level and improve the assumption based upon real-world observations. Programming models that capture the dynamics of social systems is an essential component of this course.

Course Outline: Modeling of social systems is often necessary to understand the system as well as to understand the costs and benefits of different policy interventions in the system. Good policies rely on sound modeling approaches that capture the dynamics of important social systems. For example, a policy decision to use a certain vaccine for a disease would need inputs from models that predict the number of lives saved due to the vaccine, the rate of contagion, and the rate of recovery with and without the vaccine. This course will introduce students of various backgrounds to statistical and system-dynamic approaches to modeling the behavior of simple and complex social systems.

Modules:

Module 1: Learning in Complex Systems (4 hours)
Policy Resistance, Counterintuitive Behavior of Social Systems; Learning and feedback process; Barriers in Learning; Requirements for Learning in Complex Systems; Virtues and Pitfalls of Virtual Worlds; Importance of simulation.

Module 2: The Modeling Process (8 hours)
Purpose of Modeling; Steps in the Modeling Process; Problem Articulation; Formulating a Dynamic Hypothesis; Formulating a Simulation Model; Testing; Policy Design and Evaluation; Causal Loop Diagrams; Fundamental Modes of Dynamic Behavior; Dynamics of Stocks and Flows: First-order Systems, Positive Feedback and Exponential Growth, Multiple-Loop Systems, Nonlinear First-Order Systems.

Module 3: Applications of Modeling Process (6 hours)
Modeling S-Shaped Growth; Modeling Epidemics (e.g., Modeling the HIV/AIDS Epidemic); Modeling Innovation Diffusion: Modeling New Ideas and New Products (The Bass Diffusion Model).

Module 4: Feedback Delays (8 hours)
Duration and Dynamics of Delays; Defining Delays; Material Delays: Structure and Behavior; Information Delays: Structure and Behavior; Response to Variable Delay Times; Estimating the Duration and Distribution of Delays; Examples: Forecasting Semiconductor Demand.

Module 5: Modeling Decision Making (8 hours)
Principles for Modeling Decision Making; Formulating Rate Equations; Common Pitfalls; Human Decision Making: Bounded Rationality or Rational Expectations; Cognitive Limitations; Individual and Organizational Responses to Bounded Rationality; Intended Rationality; Case Study: Modeling High-Tech Growth Firms.

Module 6: Validation and Model Testing (8 hours)

Difficulties in Validation and Verification; Questions Model Users Should Ask: Types of Data, Documentation, Replicability, Protective versus Reflective Modeling; Model Testing in Practice (Boundary Adequacy Tests, Structure Assessment Tests, Dimensional Consistency, Parameter Assessment, Extreme Condition Tests)

Text Book:

John D Sterman. Business Dynamics: Systems Thinking and Modeling for a Complex World. McGraw-Hill/Irwin. 2000. ISBN: 007238915X

Reference Books:

Donella H. Meadows. Thinking in Systems: A Primer (Paperback). Chelsea Green Publishing.2008.

John Morecroft. Strategic Modelling and Business Dynamics: A Feedback Systems Approach. John Wiley & Sons. 2007.