COMPLEX SYSTEMS

OVERVIEW

The Vermont Complex Systems Center comprises a transdisciplinary group of faculty and their graduate students and postdocs who collaborate in analyzing, modeling, and understanding complex physical, biological, technological, and/or sociological systems. The Center sponsors an invited seminar series, a biweekly reading group, biweekly meetings of SCRAPS (Student Complexity Research And Pizza Seminar), research symposia, and TEDxUVM events. Most graduate students affiliated with the Center complete the 5-course Certificate of Graduate Study in Complex Systems as a complement to their graduate degrees across campus.

DEGREES

- Complex Systems CGS

FACULTY

Bagrow, James; Assistant Professor, Department of Mathematics & Statistics; PHD, Clarkson University
Bates, Jason H. T.; Interim Director, School of Engineering; Professor, Department of Medicine - Pulmonary; Research Professor, Department of Molecular Physiology and Biophysics; PHD, Otago University
Beckage, Brian; Associate Professor, Department of Plant Biology; PHD Duke University
Bongard, Joshua C.; Associate Professor, Department of Computer Science; PHD, University of Zurich
Danforth, Christopher M.; Associate Professor, Department of Mathematics and Statistics; PHD, University of Maryland College Park
Del Maestro, Adrian G; Assistant Professor, Department of Physics; PHD, Harvard University
Dodds, Peter S.; Professor, Department of Mathematics and Statistics; PHD, Massachusetts Institute of Technology
Dubief, Yves C.; Associate Professor, School of Engineering; PHD, Institut National Polytechnique de Grenoble; PHD, Insitut National Polytechnique de Grenoble
Dunlop, Mary J.; Assistant Professor, Department of Computer Science, Assistant Professor, Department of Engineering; PHD, California Institute of Technology
Eppstein, Margaret Jean; Professor, Department of Computer Science; PHD, University of Vermont
Garavan, Hugh P.; Associate Professor, Department of Psychiatry, Associate Professor, Department of Psychology; PHD, Bowling Green State University
Gibson, William Arch; Professor, Department of Economics; PHD University of California, Berkeley
Goodnight, Charles James; Professor, Department of Biology; PHD, University of Chicago
Hernandez, Eric; Assistant Professor, Department of Engineering; PHD, Northeastern University
Hines, Paul D.; Associate Professor, School of Engineering; PHD, Carnegie Mellon University
Koliba, Christopher J.; Professor, Department of Community Development and Applied Economics; PHD, Syracuse University
Ricketts, Taylor H; Director, Gund Institute, Professor, Rubenstein School of Environment and Natural Resources; PHD, Stanford University
Rizzo, Donna Marie; Professor, Department of Engineering; PHD, University of Vermont
Sansoz, Frederic P.; Associate Professor, Department of Engineering, Director, Department of Mechanical Engineering; PHD, Ecole des Mines
Zia, Asim; Assistant Professor, Department of Community Development and Applied Economics; PHD, Georgia Institute of Technology

Courses

CSYS 213. Systems & Synthetic Biology. 3 Credits.
Applying engineering tools to the design and analysis of biomolecular processes; gene regulatory networks; nonlinear dynamics in molecular biology; biological circuit design; biological signal processing. Prerequisite: Background required: Differential Equations, Linear Algebra, Programming. Cross-listed with: ME 213, EE 213.

CSYS 221. Deterministic Modls Oper Rsch. 3 Credits.
The linear programming problem. Simplex algorithm, dual problem, sensitivity analysis, goal programming. Dynamic programming and network problems. Prerequisites: MATH 122 or MATH 124; MATH 121 recommended. Cross-listed with: MATH 221.

CSYS 226. Civil Engineering Systems Anyl. 3 Credits.
Linear programming, dynamic programming, network analysis, simulation; applications to scheduling, resource allocation routing, and a variety of civil engineering problems. Pre/co-requisites: Senior/Graduate standing in CEE or Instructor permission. Cross-listed with: CE 226.

CSYS 245. Intelligent Transportation Sys. 3 Credits.
Introduction to Intelligent Transportation Systems (ITS), ITS user services, ITS applications, the National ITS architecture, ITS evaluation, and ITS standards. Pre/co-requisites: CE 140 or equivalent; Instructor permission. Cross-listed with: CE 245.

CSYS 251. Artificial Intelligence. 3 Credits.
Introduction to methods for realizing intelligent behavior in computers. Knowledge representation, planning, and learning. Selected applications such as natural language understanding and vision. Prerequisites: CS 103 or CS 123; CS 104 or CS 124; STAT 153 or equivalent. Cross-listed with: CS 251.

CSYS 253. Appl Time Series & Forecasting. 3 Credits.
Autoregressive moving average (Box-Jenkins) models, autocorrelation, partial correlation, differencing for nonstationarity, computer modeling. Forecasting, seasonal or cyclic variation, transfer function and intervention analysis, spectral analysis. Prerequisites: CE 211 or CE 225; or CE 141 or CE 143 with Instructor permission. Cross-listed with: STAT 253.

CSYS 256. Neural Computation. 3 Credits.
Introduction to artificial neural networks, their computational capabilities and limitations, and the algorithms used to train them. Statistical capacity, convergence theorems, backpropagation, reinforcement learning, generalization. Prerequisites: MATH 122 or MATH 124 or MATH 271; STAT 143 or STAT 153 or equivalent; CS 110. Cross-listed with: STAT 256, CS 256.

CSYS 266. Chaos,Fractals&Dynamical Syst. 3 Credits.
Discrete and continuous dynamical systems, Julia sets, the Mandelbrot set, period doubling, renormalization, Henon map, phase plane analysis and Lorenz equations. Co-requisite: MATH 271 or MATH 230 or Instructor permission. Cross-listed with: MATH 266.

CSYS 268. Mathematical Biology&Ecology. 3 Credits.
Mathematical modeling in the life sciences. Topics include population modeling, dynamics of infectious diseases, reaction kinetics, wave phenomena in biology, and biological pattern formation. Prerequisites: MATH 122 or MATH 124 or MATH 230 or Instructor permission. Cross-listed with: MATH 268.

CSYS 300. Principles of Complex Systems. 3 Credits.
Introduction to fundamental concepts of complex systems. Topics include: emergence, scaling phenomena and mechanisms, multi-scale systems, failure, robustness, collective social phenomena, complex networks. Students from all disciplines welcomed. Pre/co-requisites: calculus and statistics required; Linear algebra, differential equations, and computer programming recommended but not required. Cross-listed with: MATH 300.

CSYS 302. Modeling Complex Systems. 3 Credits.
Integrative breadth-first introduction to computational methods for modeling complex systems; numerical methods, cellular automata, agent-based computing, game theory, genetic algorithms, artificial neural networks, and complex networks. Pre/co-requisites: Computer programming in any language; calculus. Linear algebra recommended. Cross-listed with: CS 302.

CSYS 303. Complex Networks. 3 Credits.
Detailed exploration of distribution, transportation, small-world, scale-free, social, biological, organizational networks; generative mechanisms; measurement and statistics of network properties; network dynamics; contagion processes. Students from all disciplines welcomed. Pre/co-requisites: MATH 301/CSYS 301, calculus, and statistics required. Cross-listed with: MATH 303.

CSYS 312. Adv Bioengineering Systems. 3 Credits.
Advanced bioengineering design and analysis for current biomedical problems spanning molecular, cell, tissue, organ, and whole body systems including their interactions and emergent behaviors. Cross-listed with: ME 312.

CSYS 350. Multiscale Modeling. 3 Credits.
Computational modeling of the physics and dynamical behavior of matter composed of diverse length and time scales. Molecular simulation. Coarse-graining. Coupled atomistic/continuum methods. Cross-listed with: ME 350.

CSYS 352. Evolutionary Computation. 3 Credits.
Theory and practice of biologically-inspired search strategies including genetic algorithms, genetic programming, and evolution strategies. Applications include optimization, parameter estimation, and model identification. Significant project. Students from multiple disciplines encouraged. Pre/co-requisites: Familiarity with programming, probability, and statistics. Cross-listed with: BIOL 352, CS 352.

CSYS 355. Statistical Pattern Recogntn. 3 Credits.
Analysis of algorithms used for feature selection, density estimation, and pattern classification, including Bayes classifiers, maximum likelihood, nearest neighbors, kernels, discriminants, neural networks, and clustering. Prerequisite: STAT 241 or STAT 251 or Instructor permission. Cross-listed with: STAT 355, CS 355.

CSYS 359. Appld Artificial Neural Ntwrks. 1-3 Credits.
Introduction to articifial neural networks. A broad range of example algorithms are implemented in MATLAB. Research applications to real data are emphasized. Pre/co-requisites: STAT 223, CS 016/CE 011, or Instructor permission. Cross-listed with: CE 359.

CSYS 369. Applied Geostatistics. 3 Credits.
Introduction to the theory of regionalized variables, geostatistics (kriging techniques): special topics in multivariate analysis; Applications to real data subject to spatial variation are emphasized. Pre/co-requisites: STAT 223 or STAT 225; CS 016/CE 011 or Instructor permission. Cross-listed with: STAT 369.

CSYS 395. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.