COMPLEX SYSTEMS AND DATA SCIENCE

https://www.uvm.edu/cems

OVERVIEW

The College of Engineering and Mathematical Sciences provides an educational program in Complex Systems and Data Science (CSDS) that includes education offerings at three levels:

1. A 5-course Graduate Certificate in Complex Systems that may be taken by any graduate student at UVM to augment their degree.
2. An M.S. in CSDS which is a 2-year degree with optional disciplinary tracks, and which UVM undergraduates may initiate through an Accelerated Master's Program.
3. A Ph.D. in CSDS which will allow students to fully develop a deep portfolio of published research, thereby opening the door to high level research positions in, for example, government, industry, or academia.

The educational program naturally complements UVM's undergraduate degree in Data Science but also thematically connects with many fields across the university.

The program's overall goal is to help students become protean data scientists with eminently transferable skills. Students are provided with a broad training in computational and theoretical techniques for (1) describing and understanding complex natural and sociotechnical systems, enabling them to then, as possible, (2) predict, control, manage, and create such systems. Students will be trained in: Industry standard methods of data acquisition, storage, manipulation, and curation; visualization techniques, with a focus on building high quality web-based applications; finding complex patterns and correlations through, for example, machine learning and data mining; powerful ways of hypothesizing, searching for, and extracting explanatory, mechanistic stories underlying complex systems—not just how to use black box techniques; combining the formulation of mechanistic models (e.g., toy physics models) with genetic programming.

DEGREES

Complex Systems and Data Science AMP

Complex Systems and Data Science CGS

Complex Systems and Data Science M.S.

Complex Systems and Data Science Ph.D.

FACULTY

Allgaier, Nicholas; Assistant Professor, Department of Psychiatry; Ph.D., University of Vermont
Bagrow, James; Associate Professor, Department of Mathematics and Statistics; PHD, Clarkson University
Bongard, Joshua C.; Professor, Department of Computer Science; PHD, University of Zurich
Cheney, Nicholas A.; Assistant Professor, Department of Computer Science; PHD, Cornell University
Danforth, Chris; Professor, Department of Mathematics and Statistics; PHD, University of Maryland College Park
Dodds, Peter Sheridan; Professor, Department of Computer Science; PHD, Massachusetts Institute of Technology
Galford, Gillian Laura; Research Associate Professor, Rubenstein School of Environment and Natural Resources; PHD, Brown University
Garavan, Hugh P.; Professor, Department of Psychiatry; PHD, Bowling Green State University
Harp, Randall; Associate Professor, Department of Philosophy; PHD, Stanford University
Hébert-Dufresne, Laurent; Associate Professor, Department of Computer Science; PHD, Université Laval, Québec, Canada
Lovato, Juniper; Research Assistant Professor, Department of Computer Science; PhD, University of Vermont
Niles, Meredith; Associate Professor, Department of Nutrition and Food Sciences; PHD, University of California-Davis
Patania, Alice; Assistant Professor, Department of Mathematics and Statistics; PHD, Politecnico di Torino
Pespeni, Melissa H.; Assistant Professor, Department of Biology; PHD, Stanford University
Price, Matthew; Associate Professor, Department of Psychological Science; PHD, Georgia State University
Ricketts, Taylor H.; Professor, Rubenstein School of Environment and Natural Resources; PHD, Stanford University
Rizzo, Donna Marie; Professor, Department of Civil and Environmental Engineering; PHD, University of Vermont
Wshah, Safwan; Associate Professor, Department of Computer Science; PHD, State University of New York at Buffalo
Young, Jean-Gabriel; Assistant Professor, Department of Computer Science, PHD, Université Laval

Courses

CSYS 5766. Gr Chaos,Fractals&Dynmcal Syst. 3 Credits.
Discrete and continuous dynamical systems, Julia sets, the Mandelbrot set, period doubling, renormalization, Henon map, phase plane analysis, and Lorenz equations. Credit not awarded for both CSYS 5766 and MATH 3766. Prerequisite: Graduate student or Instructor permission. Cross-listed with: MATH 5766.

CSYS 5870. Data Science I - Experience. 3 Credits.
Data harvesting, cleaning, and summarizing; working with non-traditional, non-numeric data (social network, natural language textual data, etc.); scientific visualization; advanced data pipelines with a practical focus on real datasets and developing good habits for rigorous and reproducible computational science; Project-based. Credit not awarded for both CSYS 5870 and CS 3870. Prerequisites: Knowledge of CS 1210 and either STAT 1410 or STAT 2430 required; knowledge of CS 2100 and MATH 2522 or MATH 2544 recommended; Graduate student or Instructor permission. Cross-listed with: STAT 5870, CS 5870.

CSYS 5990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

CSYS 5993. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CSYS 6020. Modeling Complex Systems I. 3 Credits.
Integrative breadth-first introduction to computational methods for modeling complex systems; dynamical systems, numerical methods, cellular automata, agent-based computing, game theory, genetic algorithms, artificial neural networks, and complex networks. Semester team-based project. Pre/Co-requisites: Computer programming in any language; calculus, linear algebra recommended. Cross-listed with: CS 6020.

CSYS 6021. Modeling Complex Systems II. 3 Credits.
Deep dive in state-of-the-art mathematical and computational methods for modeling complex systems; model theory, branching processes, probability generating functions, message passing, master equations, event-driven simulations, Gillespie algorithms, composition-rejection algorithms. Prerequisites: CS 6020 or CSYS 6020. Cross-listed with: CS 6021.

CSYS 6391. Master's Thesis Research. 1-18 Credits.
Master's thesis research under the supervision of a graduate faculty member. Prerequisite: Instructor permission.

CSYS 6392. Master's Project Research. 1-6 Credits.
Masters project under the supervision of a graduate faculty member. Prerequisite: Instructor permission.

CSYS 6520. 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, statistics. Cross-listed with: CS 6520.

CSYS 6540. Deep Learning. 3 Credits.
Introduction to Deep Learning algorithms and applications, including basic neural networks, convolutional neural networks, recurrent neural networks, deep unsupervised learning, generative adversarial networks and deep reinforcement learning. Includes a semester team-based project. Prerequisite: CS 3540. Cross-listed with: CS 6540.

CSYS 6701. Principles of Complex Systms 1. 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, statistics required; linear algebra, differential equations, computer programming recommended. Cross-listed with: MATH 6701.

CSYS 6713. Principles of Complex Systms 2. 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: Calculus, statistics required. Cross-listed with: MATH 6713.

CSYS 6990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

CSYS 6991. Internship. 1-18 Credits.
On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

CSYS 6993. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CSYS 6995. Graduate Independent Research. 1-18 Credits.
Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CSYS 7491. Doctoral Dissertation Research. 1-18 Credits.
Research for the Doctoral Dissertation.

CSYS 7980. 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. Prerequisites: Programming skills (such as in Python or Matlab) and content knowledge of multivariate statistics (such as STAT 5230) are assumed. Cross-listed with: CEE 7980, STAT 7980.

CSYS 7990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

CSYS 7995. Graduate Independent Research. 1-18 Credits.
Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.