COMPLEX SYSTEMS AND DATA SCIENCE

https://www.uvm.edu/cems (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 MS 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 PhD 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 (http://catalogue.uvm.edu/graduate/complexsystemsdatascience/complexsystemsdatascienceamp/)

Complex Systems and Data Science CGS (http://catalogue.uvm.edu/graduate/complexsystemsdatascience/complexsystemsdatasciencecgs/)

Complex Systems and Data Science M.S. (http://catalogue.uvm.edu/graduate/complexsystemsdatascience/complexsystemsdatasciencessm/)

Complex Systems and Data Science Ph.D. (http://catalogue.uvm.edu/graduate/complexsystemsdatascience/complexsystemsdatasciencephd/)

FACULTY

Allgaier, Nicholas; Assistant Professor, Department of Psychiatry; Ph.D., University of Vermont
Bagrow, James; Associate Professor, Department of Mathematics and Statistics; Ph.D., Clarkson University
Bongard, Joshua C.; Professor, Department of Computer Science; Ph.D., University of Zurich
Danforth, Chris; Professor, Department of Mathematics and Statistics; Ph.D., University of Maryland College Park
Dodds, Peter Sheridan; Professor, Department of Computer Science; Ph.D., Massachusetts Institute of Technology
Galford, Gillian Laura; Research Assistant Professor, Rubenstein School of Environment and Natural Resources; Ph.D, Brown University
Garavan, Hugh P.; Professor, Department of Psychiatry; Ph.D, Bowling Green State University
Hébert-Dufresne, Laurent; Assistant Professor, Department of Computer Science; Ph.D, Université Laval, Québec, Canada
Mahoney, John Matthew; Assistant Professor, Department of Neurological Sciences; Ph.D, Dartmouth College
Niles, Meredith; Assistant Professor, Department of Nutrition and Food Sciences; Ph.D, University of California-Davis
Pespeni, Melissa H.; Assistant Professor, Department of Biology; Ph.D, Stanford University
Price, Matthew; Associate Professor, Department of Psychological Science; Ph.D, Georgia State University
Ricketts, Taylor H.; Professor, Rubenstein School of Environment and Natural Resources; Ph.D, Stanford University
Young, Jean-Gabriel; Research Assistant Professor, Department of Computer Science, Ph.D, Université Laval

Courses

CSYS 266. QR:Chaos,Fractals&Dynamcal Syst. 3 Credits.
Discrete and continuous dynamical systems, Julia sets, the Mandelbrot set, period doubling, renormalization, Henon map, phase plane analysis, and Lorenz equations. Prerequisite: MATH 122 or MATH 124. CS 020 or CS 021 recommended. Cross-listed with: MATH 266.

CSYS 287. QR: Data Science I 3 Credits.
Data harvesting, cleaning, and summarizing. Working with non-traditional, non-numeric data (social network, natural language textual data, etc.). Scientific visualization using static and interactive "infographics". A practical focus on real datasets, and developing good habits for rigorous and reproducible computational science. Project-based. Prerequisites: CS 020 or CS 021; STAT 141 or STAT 143 or STAT 211; CS 110 and MATH 122/124 recommended. Cross-listed with: CS 287, STAT 287.
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.

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 352. Evolutionary Computation. 3 Credits.

CSYS 354. Deep Learning. 3 Credits.

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. Prerequisites: STAT 223; CS 020 or CS 021; or Instructor permission. Cross-listed with: CE 369, STAT 369.

CSYS 387. Data Science II. 3 Credits.
Advanced data analysis, collection, and filtering; statistical modeling, monte carlo statistical methods, and in particular Bayesian data analysis, including necessary probabilistic background material; a practical focus on real datasets and developing good habits for rigorous and reproducible computational science. Prerequisite: STAT 287 or CS 287 or CSYS 287 or Instructor permission. Cross-listed with: CS 387, STAT 387.

CSYS 390. 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 391. Master's Thesis Research. 1-9 Credits.
Masters thesis research under the supervision of a graduate faculty member. Prerequisite: Instructor permission.

CSYS 392. Master's Project. 1-6 Credits.
Masters Project under the supervision of a graduate faculty member. Prerequisite: Instructor permission.

CSYS 393. 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 394. Independent Graduate 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 395. Advanced Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

CSYS 491. Doctoral Dissertation Research. 1-18 Credits.

CSYS 494. Independent Graduate 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 496. Advanced Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.