The Vermont Complex Systems Center
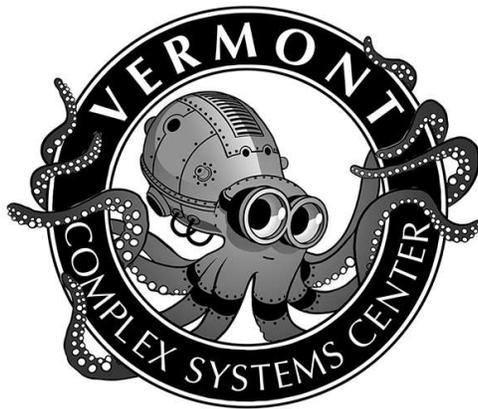
The University of Vermont

Master of Science in
Complex Systems and Data Science
(MS in CSDS)
http://uvm.edu/complexsystems/masters/

Synopsis of Program

Nutshell: The MS in CSDS is a two year degree with optional disciplinary tracks. The program will also provide an Accelerated Master's Program for undergraduates majoring in Computer Science, Mathematics, Statistics, and other disciplines if approved.

Objectives: The MS in CSDS will help students become protean data scientists with eminently transferable skills by delivering a comprehensive training in computational and theoretical techniques for (1) describing and understanding complex natural and sociotechnical systems, thereby enabling them to play roles in (2) predicting, controlling, managing, and creating such systems.

Administrative home: The MS in CSDS is housed within the College of Engineering and Mathematical Sciences at the University of Vermont and is overseen by the Vermont Complex Systems Center's Curriculum Committee.

Motivation: Almost all scientific fields have now moved from data scarce to (at least in part) data rich, and sophisticated analyses have been made possible by the advent of distributed computing and storage, with accompanying advances in algorithms and theory. Our 2011 TEDx event "Big Data, Big Stories" reflects our early framing of the importance that all modern scientists and engineers be able to gather, manage, describe, and find quantitative stories in very large-scale data sets.

As Big Data has become a common thread across disparate disciplines, so too have methods for contending with the many difficulties presented by large-scale data analysis. We now expect students from all fields to obtain mastery in, for example, the programming language Python and the visualization toolkit D3. As educators, we are in a position where we are effectively required to present these methods to students, re-imagining and adding to our existing curricula, and we are excited to do so.

Over the last 8 years, we have collectively built new sophisticated core courses around the science of complex systems and complex networks and the allied and emerging field of data science. These courses form the backbone of our successful and growing Graduate Certificate in Complex Systems. Many of our courses are highly innovative in their use of the web for lecture materials, video, and interactive visualizations, and have resulted in many student-led, peer-reviewed journal publications, as well as outstanding positions for students leaving UVM, in both industry and academia.

Director: Peter Dodds, Director of Complex Systems Center, Professor, Department of Mathematics and Statistics.

Curriculum Committee for MS in CSDS:

- Peter Dodds, Director of Complex Systems Center, Professor, Department of Mathematics and Statistics.

- Maggie Eppstein, Chair of Complex Systems Curriculum Committee, Chair and Professor of Department of Computer Science.

- Jeff Buzas, Chair and Professor, Department of Mathematics and Statistics.

- James Bagrow, Assistant Professor, Mathematics and Statistics.

- Josh Bongard, Associate Director of Complex Systems Center, Associate Professor, Department of Computer Science.

- Chris Danforth, Associate Director of Complex Systems Center. Associate Professor, Department of Mathematics and Statistics.

Intended training outcomes:

Students will be trained in:
1. Industry standard methods of data acquisition, storage, manipulation, and curation;
2. Visualization techniques, with a particular focus on building high quality web-based applications;
3. Finding complex patterns and correlations through, for example, machine learning and data mining;
4. Powerful ways of hypothesizing, searching for, and extracting explanatory, mechanistic stories underlying complex systems. For example, combining the formulation of mechanistic models (e.g., toy physics models) with genetic programming (e.g., through Eureqa).

Throughout the MS in CSDS program, students will be challenged to create defensible arguments for their findings, with warnings against the many potential pitfalls associated with exploring large-scale data sets.

We will train students with black box and white box techniques for modeling and creating complex systems. Central to our certificate is providing an understanding of mechanistic and algorithmic explanations, grounded in the traditions of statistical physics and dynamical systems. Indeed, it is this synthesis of broad traditions of statistical physics and computer science that we believe sets us apart from programs based more squarely in only one of these areas.

Data scientists and engineers need to be able to communicate their findings—their stories—at all scales, and visualization is an essential skill. In their capstone course (Data Science II), Master's students will be required to create at least one major online visualization project based on existing data.

Prerequisites for admission: We aim to serve students coming from a wide variety of backgrounds and therefore deliberately keep the prerequisites to a minimum. Students must have a Bachelor's degree in a relevant field and prior coursework in computer programming, calculus, probability, and statistics. Linear algebra is highly recommended but not required. Please note that some electives may have additional prerequisites. General GRE scores are required.

Accelerated MS admission: The College of Engineering and Mathematical Sciences (CEMS) will offer an Accelerated Master's Program (AMP) admission to this program for exceptional undergraduate students majoring in Data Science, Computer Science, Mathematics, or Statistics, which enables them to complete both a bachelor's and master's degree within a five-year period.

Students accepted into the AMP may apply up to 6 credits of their undergraduate Computer Science courses at the 200- level taken at UVM toward a Master's degree. These courses must be approved in advance by the Graduate Committee. The student must complete any additional requirements for taking these courses for graduate credit.

With permission of the Graduate Committee and the Graduate College, students may apply 3 credits taken at the graduate level prior to completing their undergraduate degree to this MS, as long as these courses are not also counted toward their undergraduate degree.

Only courses taken after the admission to AMP can be counted toward a graduate degree. So students need to apply early (before the second semseter of the junior year) to have time to plan two courses that can be used toward their graduate (MS) degree.

Mechanism for advising students:

Advising will be divided up among members of the MS in CSDS Curriculum Committee, with support from the Domain Consultants for students selecting specialized tracks. Primary goals of advising will be to ensure candidates are successfully navigating the program, to hear and respond to their feedback on their experiences, and to help them move successfully into the next part of their careers post graduation. Director Dodds will oversee advising with support from the Complex Systems Center's operations manager Andrea Elledge.

Incoming students will be given a full group advising session at the start of their first year and second year.

For tracks, Domain Consultants will advise students on their (three) course choices. In the case that a specific track does become sufficiently popular, the Curriculum Committee will work with the Domain Consultants to provide a satisfactory advising structure.

When there are students in a track advised by domain consultants, those consultants will attend at least one of the curriculum committee meetings each year. In addition, the curriculum committee and all domain consultants will meet together prior to the launch of the program and annually thereafter to ensure broad understanding of the curriculum and other program components.

As the MS evolves, the Committee will continually evaluate course selections made by students, and develop guides highlighting commonly chosen paths (for both students and advisers).

The Curriculum Committee will meet twice per semester regarding advising and student performance and placement (more often for all matters as needed), and establish a record of best practices.

We will help students connect with each other across years through both courses, meetings, and social events, affording a student-to-student mechanism for advising and mentoring.