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/

Program of study: Required Common Core, Electives, and Tracks

Programs of study:

Requirements:

Total: 30 course credits, distributed as shown below.

Note: Courses marked with asterisks include individual and/or team projects.

12 credits: Common Core (4 courses) (Students must pass comprehensive exams in these areas)

- 3 credits: CSYS/Math 300 Principles of Complex Systems*
- 3 credits: CSYS/CS 302 Modeling Complex Systems*
- 3 credits: Stat 287 Data Science I*
- 3 credits: Stat 387 Data Science II*

Note: Stat 287 and Stat 387 have been run as special topics courses (287 in Spring 2014, 387 in Fall 2014) and are currently going through the standard approval mechanisms in the 2014–2015 school year.

9 Credits:

- 6 credits: Complex Systems and/or Data Science electives (see lists below)
- 3 credits: 1 advisor approved course.
  - Note: A Policy Systems Elective is recommended for students in the Energy Systems Track
  - Note: CS 124 Data Structure is required and is approved for graduate credit for those without a formal CS background unless candidates can establish competency in this area.

Capstone data project: Threaded throughout their courses, a desired central outcome of each Master's student's training will be their development of a data-intensive, high design portfolio of interactive online visualizations. Students will have many opportunities to work with faculty, researchers, institutions (e.g., Vermont Medical School), and corporations both local and national, on meaningful, important real-world data sets, drawn from engineering systems, neuroscience, society through the lens of social media, and more. Beyond being a key training mechanism, we envisage these portfolios—in the manner of, for example, a traditional engineering design or artist's set of works—will be instrumental in students achieving outstanding positions in their chosen fields.

Note on assessment: We will follow the Computer Science model where students receiving sufficiently high enough grades in their core courses (A- or above) will not be required to take oral exams. Those who fall below this mark will have oral exams involving three faculty organized by the Curriculum Committee.

9 Credits:

Either—Pure CSDS (no track specified):

- 3 additional Complex Systems and/or Data Science Electives (listed below).

Or—3 courses in one of the following Concentration Tracks:

- CSDS: Energy Systems
- CSDS: Policy Systems
- CSDS: Biomedical Systems
- CSDS: Evolutionary Robotics
- CSDS: Environmental Systems
- CSDS: Transportation Systems
- CSDS: Distributed Systems Track
- CSDS: Self-designed named disciplinary track (requires approval of the CSDS curr comm)

Note: We have identified and engaged with Domain Consultants to generate the elective course lists below. The Curriculum Committee will ensure that the track options remain current, and will communicate with Domain Consultants both annually and on an as-need basis.

Note: Tracks do not have to have candidates enrolled as the courses involved (see below) run on regular schedules already. We are simply providing tracks as possible options for students. We anticipate that more tracks may be added in the future, and that similarly some tracks may be removed.

Complex Systems and Data Science Electives:

- CSYS/Math 303 Complex Networks*
- CSYS/Math 266 Chaos, Fractals and Dynamical Systems
- CSYS/CS/Biol 352 Evolutionary Computation*

- CSYS/STAT/CE 369 Applied Geostatistics*
- CSYS/CE 359 Applied Artificial Neural Networks*
- CS 204 Database Systems
- CS 254 Machine Learning*
- CS 228 Human Computer Interaction*
- CS 332 Data Mining*
- Stat 330 Bayesian Statistics
- Stat 235 Categorical Data Analysis
- Stat 223 Multivariate Analysis
- Stat 225 Applied Regression Analysis
- Stat 229 Logistic Regression and Survival Analysis
- Other advanced Complex Systems and Data Science electives approved by the MS in CSDS Curriculum Committee (including special topics)

Concentration Track Electives:

Track Electives are considered relatively flexible and may be updated on a semester by semester basis, based on current course offerings and content and availability and may include special topics. Below we list recently taught courses that we believe would be appropriate for the various tracks (note: these lists may be modified after more discussions with domain experts in the various areas). Track electives applied toward the MS in CSDS must be approved by the CSDS graduate coordinator.

Energy Systems Track Electives: (domain consultants: Paul Hines, Mads Almassalkhi, and Jennie Stephens)

- EE 295 Smart Grid (currently undergoing course approval)
- EE 215 Electric Energy Systems Analysis
- ME 238 Energy Systems Engineering
- EE 395 Optimization in Engineering (taught previously as a special topic)
- CE 295 Reliability of Engineering Systems (taught previously as a special topic)
- EE 295 Optimization in Energy Systems (to be developed by Mads Almassalkhi)

- ENSC 285 Climate Change, Energy & Dev (being developed by Jennie Stephens)
- other approved advanced electives related to energy

Policy Systems Track Electives: (domain consultants: Chris Koliba and Asim Zia)

- PA 306 Policy Systems
- PA 308 Decision Making Models
- PA 317 Systems Analysis and Strategic Management
- PSYC 296 Behavioral Economics (Graduate course developed for IGERT)
- PA 311 Policy Analysis
- PA 302 Organizational Behavior and Change
- ENSC 285 Climate Change, Energy & Dev (being developed by Jennie Stephens)
- Other approved advanced electives related to policy

Biomedical Systems Track Electives: (domain consultants: Jason Bates, Mary Dunlop, Liz Chen)

- CSYS/ME 295 Systems and Synthetic Biology
- CSYS/ME 312 Advanced Bioengineering Systems
- CSYS/ME 350 Multi-Scale Modeling
- CTS 271 Intro Biomedical Informatics
- CTS 272 Applied Biomedical Informatics
- CTS 275 Informatics Practicum
- CS/MMG 231 Programming for Bioinformatics
- CS/MMG 232 Methods in Bioinformatics
- CTS 302 Quality in Health Care
- CSYS/MATH 268 Mathematical Biology & Ecology
- STAT/BIOS/MPBP 308 Biometrics & Applied Statistics
- STAT/BIOS 350 Advanced methods in biostatistics

- Other approved advanced electives in biomedical systems related areas

Evolutionary Robotics Track: (domain consultant: Josh Bongard)

- CS 206 Evolutionary Robotics* (Required for this track)
- CSYS/CS 352 Evolutionary Computation*
- CSYS/CE 359 Applied Artificial Neural Networks*
- Biol 271 Evolution
- ME 338: Advanced Dynamics
- Other approved advanced electives related to evolutionary robotics

Environmental Systems Track Electives: (domain consultants: Donna Rizzo and Taylor Ricketts)

- ENVS 295 Environmental Modeling and Systems Thinking (offered previously as special topic)
- CSYS/STAT/CE 369 Applied Geostatistics*
- NR 245 Integrating GIS & Statistics
- NR343 Fundamentals of Geographic Information Systems
- Geog 281 Advanced Topic: GIS & Remote Sensing
- Geog 287 Spatial Analysis
- CS 361 Wireless Sensor Network Applications (taught previously as a special topic)
- Other approved advanced electives related to the environment

Transportation Systems Track: (domain consultants: Lisa Aultman-Hall and Brian Lee)

- CE/TRC 312 Sustainability & Transportation
- CE/TRC 314 Risk/Behavior in Transportation
- TRC 316/NR 377 Land Use Policy and Economics
- CE 395 Transportation Demand Modeling (offered previously as a special topic)

- CE 245 Intelligent Transportation Systems
- Other approved advanced electives in transportation related courses

Distributed Systems Track: (domain consultant: Chris Skalka)

- CS 265 Computer Networks
- CS 266 Network Security & Cryptography
- CS 275 Mobile Apps and Wireless Devices
- CS 361 Wireless Sensor Network Applications (taught previously as a special topic)
- Other approved advanced electives in distributed systems

Two sample programs:

Example 1—Example Pure track for a hypothetical student with an undergraduate degree in Computer Science:

Fall, Year 1: Stat 287 Data Science I CSYS/Math 300 Principles of Complex Systems CSYS/CS/Biol 352 Evolutionary Computation
Spring, Year 1: CSYS/CS 302 Modeling Complex Systems CSYS/Math 303 Complex Networks CSYS/CE 359 Applied Artificial Neural Networks
Fall, Year 2: CS 204 Database Systems Stat 235 Categorical Data Analysis
Spring, Year 2: CS 332 Data Mining Stat 387 Data Science II

Example 2—Energy Systems track for student with a background in Electrical Engineering:

Fall, Year 1: Stat 287 Data Science I CSYS/Math 300 Principles of Complex Systems EE 295 Smart Grid (currently undergoing course approval)
Spring, Year 1: CSYS/CS 302 Modeling Complex Systems CSYS/Math 303 Complex Networks ENSC 285 Climate Change, Energy & Dev (being developed by Jennie Stephens)
Fall, Year 2: EE 2xx Optimization in Energy Systems (to be developed by Mads Almassalkhi) CSYS/CS/Biol 352 Evolutionary Computation
Spring, Year 2: CS 332 Data Mining Stat 387 Data Science II