GRADUATE STUDIES IN COMPUTATIONAL & DATA SCIENCES

* NEW! GRADUATE CERTIFICATE IN COMPUTATIONAL NEUROSCIENCE (NGP & MICDE)

* GRADUATE CERTIFICATE IN COMPUTATIONAL DISCOVERY & ENGINEERING

* PHD PROGRAM IN SCIENTIFIC COMPUTING (MICDE)

* GRADUATE CERTIFICATE IN DATA SCIENCE (MIDAS)

January 24 & 28, 2019
Overview of today’s session

- MICDE Overview and its educational programs

- MIDAS joint program

- Student Resources

- Questions for all Programs
UM Graduate Computational Science Training

www.MICDE.umich.edu

Ken Powell, Director of PhD in Scientific Computing
Krishna Garikipati, Director MICDE
Victoria Booth, Director, Cert. in Computational Neuroscience
Mariana Carrasco-Teja, Assistant Director MICDE
MICDE, created in 2013, is an initiative of the University of Michigan College of Engineering, College of Literature, Science and the Arts, and Advanced Research Computing

Our mission is to advance new paradigms of computational science, which cut across application domains, to enable the discoveries that will define society for the next decade and beyond.
Computational Science is the development and innovative use of mathematical/computational algorithms/models for research, science and engineering, data analysis and interpretation, product development, and forecasting.

It is now widely accepted as the third pillar of science, complementing theory and experimentation.

U-M offers several opportunities for specialization in this booming field, and engaging with other researchers in computational science.
MICDE today

Three Educational Programs:
- Ph.D. in Scientific Computing
- Graduate Certificates in CDE and in CN

Research Centers:
- Storage-Enabled Comp Sci.
- Data-driven Comp Phys.
- Software Infrastructure

>140 Affiliated Faculty
31 Departments
8 Schools/Colleges

Seminar series, Symposia, Faculty Workshops
Outreach and Industrial Engagement
Computational Science Research

- Neuroscience
- Blood flow
- Materials Science
- Mathematics
- Computer Architecture
- Physics
- Current Smoking Prevalence
- Hydrology
- Space and Climate
- Public Health
Computational Science Research

- Computational chemistry, biology
- Computational statistics, operations research, complex systems
- Computational business (analytics), finance, econometrics
- Computational social sciences (automated information extraction systems, social network analysis, social geographic information systems (GIS), complexity modeling, and social simulation models)
- ...
Educational Programs

- **Certificate programs:**
  - Open to all M.S. and Ph.D. students
  - *Lightweight* – recognition of exposure to/knowledge of field of computational science/neuroscience

- **PhD program:**
  - Offers opportunity for much deeper specialization in computational science
RACKHAM GRADUATE CERTIFICATE IN COMPUTATIONAL DISCOVERY & ENGINEERING

Krishna Garikipati, Director
Prof. Mechanical Engineering & Mathematics
Graduate Certificate in CDE

- Nine graduate credit-hours (3 courses) (methodology and application)
  - All courses w/ substantial computational content are allowed
  - If a course is not listed in our site, please ask us about it
  - One course can be double counted w/ other degree

- Attendance at MICDE Annual Symposium and MICDE Seminar Series
  - at least 7 seminars

- CDE-related non-credit experience
  - E.g., internship, research, another course, MDP
Graduate Certificate in CDE

- Established in 2013; 48 alumni
- 41 students currently enrolled [18 Depts., 4 schools/colleges]
Graduate Certificate in CDE

- To enroll
  - Talk with your advisor
  - Follow the procedures described at https://micde.umich.edu/certificate/application-procedures/
RACKHAM GRADUATE CERTIFICATE IN COMPUTATIONAL NEUROSCIENCE

Victoria Booth, Director
Prof. Mathematics & Anesthesiology
Organized by: the Neuroscience Graduate Program (NGP) and Michigan Institute of Computational Discovery and Engineering (MICDE)

Motivation: address the need for scientists trained in interdisciplinary experimental and computational neuroscience methods to lead modern efforts in understanding the brain by integrating experimental, quantitative modeling and engineering techniques

Purpose: provide formal interdisciplinary training in computational neuroscience methods to students in experimental neuroscience programs and in quantitative and engineering programs
Graduate Certificate in Computational Neuroscience

Curriculum

- Nine (9) credit hours in coursework
  - 3 credits in core computational neuroscience course:
    - MATH 568/BIOINF 568 Computational and Mathematical Neuroscience
    - BME 517 Neural Engineering
    - PSYCH 733 Advanced Neural Circuits
  - 3 credits in cross discipline course
  - 3 credits in advanced neuroscience or advanced quantitative course
    - May be within student’s home discipline
Graduate Certificate in Computational Neuroscience

Curriculum

- 3 credits in a **practicum** fulfilled by
  - formal rotation in cross-discipline lab
  - completion of an extended project for the core computational neuroscience course
  - additional coursework in the core computational neuroscience courses

- Required participation in the interdisciplinary **Neural Networks journal club** (alternate Fridays 10-11:30am in in the Biological Sciences Building (BSB) Rm 1010)
Graduate Certificate in Computational Neuroscience

Student Benefits

- Close collaboration of NGP and MICDE optimizes training for a broad spectrum of students across campus
- uniquely prepares students to participate in interdisciplinary team-based research in neuroscience
- Valuable for pursuing careers in technology fields related to neuroscience, neuroinformatics, and the brain
Enrollment

- To enroll
  - Talk with your PhD advisor/program director for MS
  - Follow the procedures described at micde.umich.edu/comput-neuro-certificate/application-procedures/
    - Fill the application form
    - Meet with program director
    - Complete Rackham online application
PHD IN SCIENTIFIC COMPUTING

Ken Powell, Director
Prof. Aerospace Engineering
Ph.D. in Scientific Computing

- Must be pursuing a PhD in a home department at U-M
- Thesis topic and committee composition must reflect an emphasis on scientific computing
- 18 credit hours
  - 3 courses (9 credits) in numerical methods and
  - 3 courses (9 credits) in computer science and computing applications outside home department
- One of the prelim questions must be related to scientific computing
- Meeting the requirements appends “and Scientific Computing” to their diploma (e.g. PhD in Aerospace Engineering and Scientific Computing)
Ph.D. in Scientific Computing

- Established in 1989
- Prior to 2015:
  - 85 degrees granted; ~15 students enrolled at any given time
Ph.D. in Scientific Computing

- By September 2018:
  - 81 students enrolled [22 Depts., 6 schools/colleges]
Ph.D. in Scientific Computing

- 108 alumni (23 on or after 2015)
Ph.D. in Scientific Computing

- Application Procedures:
  - Talk to your academic advisor about your interest
  - Send an email to Prof. Powell and Bonnie Bryant, program administrator at micde-phdapp@umich.edu to set up a meeting and finalize your planned courses.

Students are encouraged to apply to the program after having completed one term of doctoral work, but prior to being promoted to candidacy status.
UM Graduate Data Science Training
www.MIDAS.umich.edu
H.V. Jagadish, MIDAS Director
Ivo D. Dinov, PhD, MIDAS Associate Director, Education & Training
### Characteristics of Big Biomed Data

<table>
<thead>
<tr>
<th>BD Dimensions</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Harvesting and management of vast amounts of data</td>
</tr>
<tr>
<td>Complexity</td>
<td>Wranglers for dealing with heterogeneous data</td>
</tr>
<tr>
<td>Incongruency</td>
<td>Tools for data harmonization and aggregation</td>
</tr>
<tr>
<td>Multi-source</td>
<td>Transfer and joint modeling of disparate elements</td>
</tr>
<tr>
<td>Time</td>
<td>Techniques accounting for longitudinal patterns in the data</td>
</tr>
<tr>
<td>Multi-scale</td>
<td>Macro to meso to micro scale observations</td>
</tr>
<tr>
<td>Incomplete</td>
<td>Reliable management of missing data</td>
</tr>
</tbody>
</table>

**Example:** analyzing observational data of 1,000’s Parkinson’s disease patients based on 10,000’s signature biomarkers derived from multi-source imaging, genetics, clinical, physiologic, phenomics and demographic data elements.

Software developments, student training, service platforms and methodological advances associated with the Big Data Discovery Science all present existing opportunities for learners, educators, researchers, practitioners and policy makers.
Graduate Data Science Certificate

OVERVIEW

The overarching goal of the Graduate Data Science Certificate Program is to train a cadre of skillful data scientists with significant multidisciplinary knowledge, broad analytical skills and agile technological abilities. The program emphasizes the practice of modeling using modern technology to handle large, incongruent, and heterogeneous collections of data. The Graduate Certificate for Data Science is approved by the Rackham School for Graduate Studies.

The program provides interactive data-centered training and involves 9 credits of courses and 3 credits of experiential training that require a written report on data analytics. MIDAS faculty from different disciplines provide mentorship and advising and the Institute offers merit-based top-off scholarships for graduate students enrolled in the certificate program. The Graduate Data Science Certificate Program is open for enrollment on a rolling basis. U-M graduate students from any field are eligible to enroll. Merit-based top-off fellowships may be provided. Minority and underrepresented students are strongly encouraged to enroll and complete the program.

http://midas.umich.edu/certificate
Graduate Data Science Certificate

- Open to ALL registered UM graduate students
- Course Requirements:
  - 9 graduate credits - Algorithms & Applications (AA), Data Management (DM), Analysis Methods (AM)
  - 3+ practicum credits – approved Data Science-related experience
- Attendance:
  - MIDAS Annual Data Science Symposium
  - Weekly MIDAS Colloquial Series (1 year)

http://midas.umich.edu/certificate
## Graduate Data Science Certificate

### Prerequisites

<table>
<thead>
<tr>
<th>Prerequisites</th>
<th>Skills</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed Undergraduate Degree</td>
<td>Quantitative training and coding skills as described below</td>
<td>The DS certificate is a graduate program requiring a minimum level of quantitative skill</td>
</tr>
<tr>
<td>Quantitative Training</td>
<td>Undergraduate calculus, linear algebra and introduction to probability and statistics</td>
<td>These are the entry level skills required for most upper-level undergraduate and graduate courses in the program</td>
</tr>
<tr>
<td>Coding Experience</td>
<td>Exposure to software development or programming on the job or in the classroom</td>
<td>Most DS practitioners need substantial experience with Java, C/C++, HTML5, Python, PHP, SQL/DB</td>
</tr>
<tr>
<td>Motivation</td>
<td>Significant interest and motivation to pursue quantitative data analytic applications</td>
<td>Dedication for prolonged and sustained immersion into hands-on and methodological research</td>
</tr>
</tbody>
</table>

[http://midas.umich.edu/certificate](http://midas.umich.edu/certificate)
### Graduate Data Science Certificate Competencies

<table>
<thead>
<tr>
<th>Areas &amp; Applications</th>
<th>Competency</th>
<th>Expectation</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tools</td>
<td></td>
<td>Working knowledge of basic software tools (command-line, GUI based, or web-services)</td>
<td>Familiarity with statistical programming languages, e.g., R or SciKit/Python, and database querying languages, e.g., SQL or NoSQL</td>
</tr>
<tr>
<td>Algorithms</td>
<td></td>
<td>Knowledge of core principles of scientific computing, applications programming, API’s, algorithm complexity, and data structures</td>
<td>Best practices for scientific and application programming, efficient implementation of matrix linear algebra and graphics, elementary notions of computational complexity, user-friendly interfaces, string matching</td>
</tr>
<tr>
<td>Application Domain</td>
<td></td>
<td>Data analysis experience from at least one application area, either through coursework, internship, research project, etc.</td>
<td>Applied domain examples include: computational social sciences, health sciences, business and marketing, learning sciences, transportation sciences, engineering and physical sciences</td>
</tr>
</tbody>
</table>
## Graduate Data Science Certificate Competencies

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<tr>
<td>Data Management</td>
<td>Data validation &amp; Visualization</td>
<td>Curation, Exploratory Data Analysis (EDA) and visualization</td>
<td>Data provenance, validation, visualization - histograms, QQ plots, scatterplots (ggplot, Dashboard, D3.js)</td>
</tr>
<tr>
<td></td>
<td>Data Wrangling</td>
<td>Skills for data normalization, data cleaning, data aggregation, and data harmonization/registration</td>
<td>Data imperfections include missing values, inconsistent string formatting (‘2016-01-01’ vs. ‘01/01/2016’, PC/Mac/Lynux time vs. timestamps, structured vs. unstructured data)</td>
</tr>
<tr>
<td></td>
<td>Data Infrastructure</td>
<td>Handling databases, web-services, Data structures, SOAP protocols, ontologies, XML, Hadoop, multi-source data</td>
<td>JSON, streaming</td>
</tr>
</tbody>
</table>

[http://midas.umich.edu/certificate](http://midas.umich.edu/certificate)
## Graduate Data Science Certificate

### Competencies

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<tr>
<td><strong>Statistical Inference</strong></td>
<td></td>
<td>Basic understanding of bias and variance, principles of (non)parametric statistical inference, and (linear) modeling</td>
<td>Biological variability vs. technological noise, parametric (likelihood) vs non-parametric (rank order statistics) procedures, point vs. interval estimation, hypothesis testing, regression</td>
</tr>
<tr>
<td><strong>Study design &amp; diagnostics</strong></td>
<td></td>
<td>Design of experiments, power calculations and sample sizing, strength of evidence, p-values, FDR</td>
<td>Multistage testing, variance normalizing transforms, histogram equalization, goodness-of-fit tests, model overfitting, model reduction</td>
</tr>
<tr>
<td><strong>Machine Learning</strong></td>
<td></td>
<td>Dimensionality reduction, k-nearest Empirical risk minimization. Supervised, semi-supervised, and unsupervised learning. Transfer learning, active learning, reinforcement learning, multiview learning, instance learning</td>
<td></td>
</tr>
</tbody>
</table>

[http://midas.umich.edu/certificate](http://midas.umich.edu/certificate)
Contacts

- Prof. Ivo Dinov, Director: dinov@umich.edu
- Kristen Thornton, Graduate Coordinator: thorntok@umich.edu
- Moira Dowling, Project Manager: mdowling@umich.edu
- Alison Martin, Administrative Assistant: aalison@umich.edu
- MIDAS information: midas-contact@umich.edu
- www.MIDAS.umich.edu

http://midas.umich.edu/certificate
STUDENT RESOURCES
Advanced Research Computing
Student Resources

- **Student Clubs:**
  - Scientific Computing Student Club
  - Michigan Data Science Team
- **Seminar series and symposia**
- **Women in HPC chapter**
- **ARC-TS**
  - HPC Cluster, Data Science Clusters, storage
- **CSCAR**
  - Free consultations
  - Free workshops

- **MICDE programs student resources:**
  - $4K top-off fellowships
  - CAEN accounts for non-engineering students
Enrollment Deadlines: you may enroll at any time but...

- Certificates
  - To be considered for enrollment in Fall, students will need to apply by August 1\textsuperscript{st}
  - To be considered for enrollment in Winter, students will need to apply by December 1\textsuperscript{st}

- PhD
  - Should consider the time it takes to finish all requirements
What are my choices as a Master’s student?
Only the Certificates are available

What if the courses I’d like to count towards the certificate or degree are not listed on your website?
Contact us, we likely can accommodate you

As a PhD student, can I do both a Certificate and the Joint degree?
Only the Computational Neuroscience

How do I choose which to do?
The commitment for the Joint degree is greater: you need to do a prelim question on scientific computing, there are more courses required, and you need to take computer science. Choose which fits for you.
QUESTIONS?
More Questions?

Questions about the certificate in CDE or the PhD in Scientific Computing?
Go to micde.umich.edu/academic-programs
or email micde-contact@umich.edu

Questions about the certificate in Computational Neuroscience?
Go to micde.umich.edu/comput-neuro-certificate/
or email neuro-micde@umich.edu

Questions about the certificate in Data Science?
Go to midas.umich.edu/certificate or email midas-contact@umich.edu
Computational Science vs Data Science

**Computational Science**
- **MICDE**
  - Laws of Physics
    - Mathematical Models
      - PDEs
      - ODEs
    - Numerical Algorithms
    - Solutions
  - Simulation Data
    - Visualize Data

**Data Science**
- **MIDAS**
  - Big Data
    - Internet Data
    - Health Data
    - Population Data
    - Climate Data
    - Social Data
  - Algorithms
    - Patterns
    - Statistics
    - Smart Searches
  - Models
    - Conclusions