GRADUATE STUDIES IN COMPUTATIONAL & DATA SCIENCES

* GRADUATE CERTIFICATE IN COMPUTATIONAL DISCOVERY & ENGINEERING

* PH.D. IN SCIENTIFIC COMPUTING

* GRADUATE CERTIFICATE IN COMPUTATIONAL NEUROSCIENCE (NGP & MICDE)

* GRADUATE CERTIFICATE IN DATA SCIENCE (MIDAS)

August 20, 2020
Overview of today’s session

- MICDE Overview and its educational programs

- MIDAS
  - Student Resources
  - Questions for all Programs

Graduate Certificate in Computational Discovery and Engineering

Graduate Certificate in Computational Neuroscience

Ph.D. in Scientific Computing

Graduate Certificate in Data Science
Today’s Presenters

Krishna Garikipati
Director, MICDE
Professor of Mechanical Engineering, Mathematics

Mariana Carrasco-Teja
Associate Director, MICDE
Assistant Research Scientist

Victoria Booth
Director, Graduate Certificate in Computational Neuroscience
Professor of Mathematics, Anesthesiology

Trisha Fountain
Education Program Manager, MIDAS

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Associate Director, MIDAS
Director, SOCR
Professor, Nursing, Computational Medicine & Bioinformatics, Human Behavior and Biological Sciences

Kristen Thornton
ECE PhD Graduate Coordinator, College of Engineering

Ken Powell
Director, Ph.D. in Scientific Computing
Professor, Aerospace Engineering
MICHIGAN INSTITUTE FOR COMPUTATIONAL DISCOVERY & ENGINEERING

UM Graduate Computational Science Training
www.MICDE.umich.edu

Krishna Garikipati, Director MICDE
Victoria Booth, Director, Cert. in Computational Neuroscience
Ken Powell, Director, Ph.D. in Scientific Computing
Mariana Carrasco-Teja, Associate 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

Engineering
Medical School

>150 Affiliated Faculty
8 Schools/Colleges

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

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

Seminar series, Symposia, Faculty Workshops

Outreach and Industrial Engagement
Computational Science Research

Acoustics

Blood flow

Materials Science

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 on our site, please ask us about it
  - One course can be double counted w/ other degree

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

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

- Established in 2013
- Currently: 44 students enrolled [23 Depts., 8 schools/colleges]
- 82 alumni [23 Depts, 6 school/colleges]

Current Enrollment & Recruitment

- 66% CoE
- 23% LSA
- 11% Other
Graduate Certificate in CDE

- To enroll
  - Talk with your advisor
  - Follow the procedures described at https://micde.umich.edu/certificate/

INFORMATION FOR PROSPECTIVE STUDENTS

There are four fundamental requirements for earning a graduate certificate in computational discovery and engineering:

1. Nine graduate credit hours of coursework in approved courses, a non-exhaustive list can be found here. These courses are designated either Methodology or Applications — at least six course-hours must be in classes in Methodology. (Up to three credits can be double-counted with another Rackham degree.)

2. A CDE-related experience approved by the CDE Program Committee. This can take the form of non-credit activity like an internship, practicum or professional project equivalent to a three credit-hour course, or additional coursework of at least three credits from the approved course list. Master students can participate in the Multidisciplinary Design Program to fulfill this requirement. To find out more about this option, please visit https://mdp.engin.umich.edu/micde/.

3. Attendance at the MICDE Annual Symposium, which will provide graduate students an opportunity to present the results of their research in talks and poster sessions. All students are required to attend at least once; Ph.D. students are encouraged to make a poster presentation.

4. Regular attendance at the MICDE Seminar Series, which brings internationally known CDE scientists to campus. Students are required to attend at least 7 seminars.
RACKHAM GRADUATE CERTIFICATE IN COMPUTATIONAL NEUROSCIENCE

Victoria Booth, Director
Prof. Mathematics & Anesthesiology
Motivation and Purpose

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
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
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 one of the following journal clubs:
  - **Neural Networks Journal Club** (alternate Fridays 10-11:30am, held virtually)
  - **Neural Engineering Journal Club** (Thurs. at 9:00 am)
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
To enroll

- Talk with your PhD advisor/program director for MS
- Follow the procedures described at https://micde.umich.edu/comput-neuro-certificate/
  - Fill the pre-application form (on MICDE's website)
  - Meet with program director
  - Complete Rackham application form
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 methodology 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; roughly 19 departments
Ph.D. in Scientific Computing

- Currently 171 students enrolled; 33 different departments

51% CoE
37% LSA
8% SPH/MED
4% Other
Ph.D. in Scientific Computing

- 134 alumni
- 49 alumni since 2015

![Bar chart showing the number of alumni per year from before 2015 to 2020. The chart indicates that the majority of alumni graduated before 2015, with a significant drop after 2015.]
Ph.D. in Scientific Computing

Application Procedures:

- Talk to your academic advisor about your interest

Students are encouraged to apply to the program after having completed one term of doctoral work, but prior to being promoted to candidacy status.
MICHIGAN INSTITUTE FOR DATA SCIENCE (MIDAS)

UM Graduate Data Science Training

www.MIDAS.umich.edu

Ivo D. Dinov, PhD
Associate Director, MIDAS
## 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-varying</td>
<td>Analyzing longitudinal patterns require specialized approaches</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.
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.

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

- Open to ALL registered UM graduate students – rolling enrollment
- Course Requirements:
  - 9 graduate credits in Algorithms & Applications, Data Management, and Analysis Methods
  - 3+ practicum credits – approved Data Science-related experience
- Attendance:
  - MIDAS Annual Data Science Symposium
  - MIDAS Seminar Series (1 year), could view past seminars online

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

Core Proficiencies

- Algorithms & Applications: core data science principles, assumptions, applications
- Data Management: basic protocols for data management, processing, computation, information extraction & visualization
- Analysis Methods: hands-on experience, modeling tools and analytics, real project setting

https://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>Some 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>Some 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>

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

<table>
<thead>
<tr>
<th>Areas</th>
<th>Competency</th>
<th>Expectation</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tools</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>
<td></td>
</tr>
<tr>
<td>I. Algorithms &amp; Applications</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>
<td></td>
</tr>
<tr>
<td>Application Domain</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>
<td></td>
</tr>
</tbody>
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[https://midas.umich.edu/certificate](https://midas.umich.edu/certificate)
## Graduate Data Science Certificate Competencies

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<tr>
<td><strong>II. Data Management</strong></td>
<td>Data validation &amp; Visualization</td>
<td>Curation, Exploratory Data Analysis (EDA) and visualization</td>
</tr>
<tr>
<td></td>
<td>Data Wrangling</td>
<td>Skills for data normalization, data cleaning, data aggregation, and data harmonization/registration</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>
</tr>
</tbody>
</table>

**Notes:**
- Data provenance, validation, visualization - histograms, QQ plots, scatterplots (ggplot, Dashboard, D3.js)
- 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)

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

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<tr>
<td>Statistical Inference</td>
<td>III. Analysis</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>Study design &amp; diagnostics</td>
<td>Methods</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>
</tbody>
</table>

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

Contacts

- Prof. Ivo Dinov, Director: dinov@umich.edu
- Kristen Thornton, Graduate Coordinator: thorntok@umich.edu
- Trisha Fountain, Education Program Manager: tvfount@umich.edu
- www.MIDAS.umich.edu

https://midas.umich.edu/certificate
STUDENT RESOURCES
Did you Know about these Student Resources?

- **Student Clubs:**
  - Scientific Computing Student Club
  - Michigan Data Science Team

- **Seminar/Webinar series and symposia**

- **Virtual Hackathons**

- **ARC-TS**
  - HPC Cluster, Data Science Clusters, storage, **Data Science Consulting**

- **CSCAR**
  - Free consultations
  - Free workshops

- **MICDE programs student resources:**
  - $4K top-off fellowships
  - CAEN accounts for non-engineering students
Events and Activities Fall 2020

- MICDE Workshop on Resilient Cities through Computation – October 9, 2020
  - Student Hackathon
- 2020 MIDAS Symposium – Nov 10 & 11, 2020
- MIDAS & MICDE Webinar series
- Many more virtual events
**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\(^{st}\)
  - To be considered for enrollment in Winter, students will need to apply by December 1\(^{st}\)

*NOTE THAT THIS DEADLINES ONLY MATTER IF YOU PLAN TO GRADUATE THAT SAME TERM*

- **PhD**
  - Should consider the time it takes to finish all requirements

- **International Masters and Ph.D. Students**
  - The $500 fee for entry is one time payment to your home department
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 at micde-contact@umich.edu, or midas-contact@umich.edu. We likely can accommodate you

How do I choose which to do?
It depends on your interests and background

Is there a fee to apply?
Yes. As of October 2019 there is a $10 non-refundable fee to apply to all certificate programs.
Should I wait to be enrolled to start taking classes towards the programs?
No, Rackham allows you to use courses that you have taken at U-M within the past 5 years to fulfill the certificate(s) or the PhD requirements.

Just make sure:
- They are graduate level courses (most 400 level, and 500 and above)
- You didn’t use those credits to fulfill an undergraduate requirement
- The course(s) is/are approved for the given program (or seek approval before taking it)

Can I join the program if I am not enrolled at the University of Michigan?
- No, only students enrolled in a graduate program at U-M can join these programs
Questions about the certificate in CDE or the PhD in Scientific Computing?

micde.umich.edu/academic-programs or email micde-contact@umich.edu

Questions about the certificate in Computational Neuroscience?

micde.umich.edu/comput-neuro-certificate/ or email neuro-micde@umich.edu

Questions about the certificate in Data Science?

midas.umich.edu/certificate or email midas-contact@umich.edu
Do you have questions about specific MICDE and MIDAS programs?

Check your email for links to break out rooms where you can ask questions within a smaller group. Rooms will close on the hour.
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
Smart Searches

Statistics

Models

Conclusions