Overview of today’s session

- MICDE Overview and its educational programs
  - Graduate Certificate in Computational Discovery and Engineering
  - Graduate Certificate in Computational Neuroscience
  - Ph.D. in Scientific Computing
  - Graduate Certificate in Data Science
- MIDAS
  - Student Resources
  - Questions for all Programs
Programs’ Leadership

**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

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

**Ivo Dinov**
Associate Director, MIDAS
Director, SOCR
Professor, Computational Medicine & Bioinformatics, Human Behavior and Biological Sciences

**Jing Liu**
Managing Director, MIDAS

**JoAnne Kerr**
Interim PhD in Scientific Computing coordinator, MICDE
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
Computational Science is an interdisciplinary field that uses mathematical modeling and advanced computing to understand and solve complex problems.

Computational scientists develop models and simulations to understand physical and natural systems.
#ComputationalScience Everywhere!

- Chemistry, biology, kinesiology,
- Operations research, complex systems
- Business, finance, economics
- Computational social sciences

Acoustics

Blood flow

Computer Architecture

Physics

Hydrology

Space and Climate

Public Health

Materials Science

Mathematics
MICDE

MICDE’s mission is to advance new paradigms of **computational science** by building an interdisciplinary, computationally oriented, community of researchers at U-M.

MICDE was created in 2013 as an initiative of the College of Engineering, College of Literature, Science and the Arts, and the Office of Research.

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

Three Educational Programs:

- Ph.D. in Scientific Computing
- Graduate Certificates in CDE and in CN

- Kinesiology
- Pharmacy
- Medicine
- Information
- Engineering
- Lit., Sci. & the Arts
- Public Health
- Environment & Sustainability
- Education

>150 Affiliated Faculty

9 Schools/Colleges

Seminar series, Symposia, Faculty Workshops

Outreach and Industrial Engagement

> 200 students
RACKHAM GRADUATE CERTIFICATE IN COMPUTATIONAL DISCOVERY & ENGINEERING

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

OVERVIEW

Training to conduct computationally intensive research, and get ready to function effectively in interdisciplinary research and product development settings that employ high-performance computing.

- Nine graduate credit-hours (3 courses) (methodology and applications)
  - Courses w/ substantial computational content are allowed
- 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: 36 students enrolled | 97 alumni (14 in AY2020)
- 27 Depts., 8 schools/colleges

67 % CoE
25 % LSA
8 % 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**

**Academic Requirements Application Deadlines How to apply - Rackham Students How to apply - non-Rackham 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
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 the interdisciplinary **Neural Networks journal club** (alternate Fridays 10-11:30am, held virtually)
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
Current Enrollment

- Enrollment started in 2019
- Currently 7 students enrolled:
  - 2 Biomedical Engineering
  - 2 Psychology
  - 2 Mathematics
  - 1 Physics
- 1 alumni
Enrollment Process

- 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 application form
    - Meet with program director
    - Complete Rackham application form

Graduate Certificate in Computational Neuroscience
PHD IN SCIENTIFIC COMPUTING

Ken Powell, Director
Prof. Aerospace Engineering
This program is intended for students who will make extensive use of large-scale computation, computational methods, or algorithms for advanced computer architectures in their doctoral studies.

A firm knowledge of the scientific discipline is essential

Thesis topic and committee composition must reflect an emphasis on scientific computing
Ph.D. in Scientific Computing

Requirements:

- Must be pursuing a PhD in a home department at U-M
- 18 credit hours
  - 3 courses (9 credits) in methodologies 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 (other options available)
- 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 | Currently ~150 students enrolled

Ay20 | Ay19
- 47% | 51% CoE
- 40% | 37% LSA
- 8% | 8% SPH/MED
- 5% | 4% Other
Ph.D. in Scientific Computing

- 174 alumni (89 since 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.

1. Talk to your academic advisor about your interest. Your advisor must approve your enrollment in the program.
2. Complete this Course Audit form.
3. After the Program Administrator checks your Audit Form, they will contact you to schedule a meeting with the program director, Ken Powell, Arthur Thurnau Professor of Aerospace Engineering. During the meeting, the program administrator and Prof. Powell, will finalize your planned courses to meet the program requirements.
4. After your meeting with the program’s director, you must complete the Rackham’s Application form and submit it to micde-phdapp@umich.edu. You are not considered an “Enrolled Student” if you don’t complete this step.
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.
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 – 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 Seminar Series (1 term – 1 cr)

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><strong>I. Algorithms</strong>&lt;br&gt;<strong>&amp; Applications</strong>&lt;br&gt;<strong>Tools</strong>&lt;br&gt;<strong>Algorithms</strong>&lt;br&gt;<strong>Application Domain</strong></td>
<td>Working knowledge of basic software tools (command-line, GUI based, or web-services)</td>
<td>Knowledge of core principles of scientific computing, applications programming, API’s, algorithm complexity, and data structures</td>
<td>Data analysis experience from at least one application area, either through coursework, internship, research project, etc.</td>
</tr>
<tr>
<td></td>
<td>Familiarity with statistical programming languages, e.g., R or SciKit/Python, and database querying languages, e.g., SQL or NoSQL</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>Applied domain examples include: computational social sciences, health sciences, business and marketing, learning sciences, transportation sciences, engineering and physical sciences</td>
</tr>
</tbody>
</table>

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

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<th>Areas</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>II. Data Management</strong></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>Data validation &amp; Visualization</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>Data Wrangling</td>
<td>Handling databases, web-services, Data structures, SOAP protocols, ontologies, XML, Hadoop, multi-source data</td>
<td>JSON, streaming</td>
</tr>
</tbody>
</table>

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

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</thead>
<tbody>
<tr>
<td>III. Analysis</td>
<td>Statistical Inference</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></td>
<td>Study design &amp; diagnostics</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](http://midas.umich.edu/certificate)
Biomedical Informatics & Data Science Training Program (BIDS-TP)

- DS Certificate students who work on any aspect of data-intensive bioinformatics can apply for 2-year:
  - BIDS-fellowships (fully funded)
  - **BIDS-Traineeships** (no-funding)

Nominations/Applications for the cohort starting in Fall 2022 reviews in Winter/Spring 2022.

[https://bids-tp.umich.edu/](https://bids-tp.umich.edu/)
Graduate Data Science Certificate

Contacts

- Prof. Ivo Dinov, Director: dinov@umich.edu
- Kristen Thornton, Graduate Coordinator: thorntok@umich.edu
- www.MIDAS.umich.edu
- midas-contact@umich.edu

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

- Seminar/Webinar series and symposia
  - Scientific Computing Students’ webinar series
- Hackathons
- CSCAR - Free consultations and workshops

**MIDAS Student Resources:**
- Student Leadership Board
- Experiential Learning projects
- Data for Social Good projects

**MICDE programs student resources:**
- $4K top-off fellowships
- CAEN accounts for non-engineering students
Did you Know about these Student Resources?

- Advanced Research Computing
  - HPC Cluster, Data Science Clusters, storage, consulting
  - Computing Package:
    - 80,000 CPU Hours of HPC
    - 10 TB of replicated, HP Storage
    - 100 TB of archived storage
  - Allocations for Coursework
    - 1TB of big data per course
    - 100 CPU hours per student

arc.umich.edu/umrcp/
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

- International Masters and Ph.D. Students
  - The $500 fee for entry is one time payment to your home department
FAQ

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.
Questions?

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?

**RIGHT NOW**: breakout rooms with program directors

**TOMORROW 9/30 @ 3:00 pm:**
- Outdoor, in person information session with program directors
- Ingalls Mall Canopy, south of Rackham building
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