MATH 6370

Special topics: Computational and Data-driven methods for the study of living systems
Independent study course
Term: Fall 2023
Instructor: Dr. Anass Bouchnita
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Instructor office: Bell Hall 202
Time and location: One hour meetings per week, to be specified later according to student and instructor availability
Office hours: Thursdays 1-3 p.m., in person.

Prerequisites
The course assumes that you have already taken basic knowledge of ordinary differential equations, numerical analysis, and programming.

Course description
In biomedical research, computer simulations are increasingly used to substitute for the often costly, impractical, and sometimes unethical in vivo and in vitro experiments. Mathematical modeling has played pivotal roles in generating novel testable hypotheses for experiments, enhancing our understanding of key mechanisms, optimizing treatments, planning randomized clinical trials, and forecasting epidemic trajectories. Multiscale modeling strives to integrate data and knowledge across diverse scales of space and time. However, this method can be expensive and typically demands access to significant computational resources. Conversely, purely data-driven methods like machine learning demand far less in terms of computational power. Yet, they have their own limitations, such as reduced interpretability and challenges related to the curse of dimensionality.

The development, calibration, implementation, and simulation of mathematical models are increasingly becoming essential skills in biomedical research. This course is designed to introduce the student to the fundamentals of mathematical modeling and its diverse applications in biology and medicine. The student will be guided through the process of numerical simulations, from model implementation and simulation execution to post-processing results. Additionally, the course will highlight trending topics and the open questions in computational and mathematical biology research.

Learning objectives
This course aims to achieve the following learning objectives:
● Learn how to describe biological systems using computational and data-driven models
● Implement multiscale models using appropriate numerical methods
- Simulate biological models, post-process and visualize outputs, and interpret the results
- Become familiar with the challenges, successes and milestones in the computational and mathematical biology research

**Learning modules**

The course progress will be tracked through weekly meetings. In each meeting, we will discuss the latest things that were read in the previous week. We will also discuss the progress made in the implementation of the project. Then, new reading materials and tasks will be assigned for the upcoming meeting. In addition to the meetings, assessment will also be made through four presentations, one review paper, and one project implementation.

**Table 1**: Tentative schedule of the course modules and examinations. The schedule is subject to change depending on the achievement of the learning outcomes. Any changes will be announced through e-mail or over Blackboard.

<table>
<thead>
<tr>
<th>Week</th>
<th>Content</th>
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<tbody>
<tr>
<td>Aug 28 - Aug 30</td>
<td>Computational and data-driven methods for modeling multicellular systems I</td>
</tr>
<tr>
<td>Sep 4 - Sep 6</td>
<td>Computational and data-driven methods for modeling multicellular systems II</td>
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<tr>
<td>Sep 11 - Sep 13</td>
<td>Interactions between multiscale modeling and machine learning</td>
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<td>Sep 18 - Sep 20</td>
<td>Computational oncology I: ODE and PDE models</td>
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<td>Sep 25 - Sep 27</td>
<td>Computational oncology II: Hybrid models</td>
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<td>Oct 2 - Oct 4</td>
<td>Viral infections I: continuous models</td>
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<tr>
<td>Oct 9 - Oct 11</td>
<td>Viral infections II: hybrid models</td>
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<tr>
<td>Oct 16 - Oct 18</td>
<td>Machine learning in biomedical research II: basics and applications</td>
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<tr>
<td>Oct 23 - Oct 25</td>
<td>Machine learning in biomedical research II: ethics and perspectives</td>
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<tr>
<td>Oct 30 - Nov 1</td>
<td>Infectious diseases I: continuous models</td>
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<tr>
<td>Nov 6 - Nov 8</td>
<td>Infectious diseases II: immuno-epidemiological models</td>
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<tr>
<td>Nov 13 - Nov 15</td>
<td>Pharmacokinetics - Pharmacodynamics modeling</td>
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<td>Nov 20 - Nov 22</td>
<td>Phenotype-structured models</td>
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<td>Nov 27 - Nov 29</td>
<td>Developmental biology</td>
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<tr>
<td>Dec 4 - Dec 6</td>
<td>Project presentation - perspectives</td>
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Required materials

Reading material will be uploaded on Blackboard before each week.

Course assignments and grading

The final grade will be calculated based on weekly discussions, the four presentations, the review paper and the final project. The grade will be calculated based on the final score as follows:

1000-800 = A; 800-600 = B; 600-400 = C; 400-200 = D; 200 and Below = F

The final score will be calculated as the weighted sum of the grades obtained in the following tests:

- 150 Points: Weekly meetings
- 150 Points: Presentations
- 300 Points: Review paper
- 400 Points: Final project

Technology requirements

Course contents will be delivered via the Blackboard learning management system. Communication between students and the instructor will be mediated by the Blackboard discussion board or using UTEP email accounts. The student must have the last version of a stable browser like Google Chrome or Mozilla Firefox to explore Blackboard. If you still encounter any difficulties, update your browser, clear your cache, or use a different browser. The Blackboard software will be used for quizzes, surveys, announcements, and additional course material. ADA students are advised to use word-processing software like Microsoft Office programs which is available for free via the UTEP Microsoft Office Portal. In addition, please reach out at the beginning of the course to accommodate the course for you. A tutorial for this software is available upon notice.

Given the computational nature of the course, computers with at least Core 2 duo and 8gb of RAM are required. The following software is also necessary for the completing of the learning activities:

- Word and powerpoint for preparing reports, presentations, and papers.
- Python interpreter and C++ compiler (MinGW and Code::Blocks or GCC for example).
- ParaView for visualization.

IMPORTANT: If you encounter technical difficulties beyond your scope of troubleshooting, please contact the UTEP Help Desk as they are trained specifically in assisting with the technological needs of students. Please do not contact me for this type of assistance. The Help Desk is much better equipped than I am to assist you!
Course communication

This is an in-person course, we will use the following communication channels to stay in contact:

**Office Hours:** My office hours will be held during the following time: Thursdays: 1-3 p.m. Mountain Time in person, by appointment.

**Email:** UTEP e-mail can be used if you have any inquiries regarding the course. I will attempt to answer within 24-48 hours. In the case the question requires a discussion, it is better to come to see me during office hours.

**Netiquette**

Online communication can be challenging because of the lack of body language and immediate feedback. Therefore, it is essential to follow some netiquette (network etiquette) guidelines to keep a positive and productive environment in the classroom. Failure to comply with these guidelines may result in disciplinary action.

- Communication should reflect polite consideration of others’ ideas.
- Respect and courtesy must be provided to classmates and to the instructor at all times. No harassment or inappropriate postings will be tolerated.
- When reacting to someone else’s message, address the ideas, not the person. Post only what anyone would comfortably state in a face-to-face situation.
- Blackboard is not a public internet venue; all postings to it should be considered private and confidential. Whatever is posted in these online spaces is intended for classmates and the instructor only. Please do not copy documents and paste them to a publicly accessible website, blog, or other space.

**Attendance and participation**

Attendance is necessary to complete the quizzes and exams with a satisfactory grade. Further, students are expected to read the reading material and work through the examples covered in class. Attendance and participation are explicitly taken into the final grade. Students are expected to attend class and arrive on time. Absent students are responsible to find out the material and lab activities that need to be made up. Absences due to illness or other emergencies can be justified with appropriate documentation. Participation in the class covers asking questions and participating in class discussions.

**Excused absences and drop policy**

I will not drop you from the course. However, if you feel that you are unable to complete the course successfully, please let me know and then contact the Registrar’s Office to initiate the drop process before the class drop deadline. If you do not, you are at risk of receiving an “F” for the course.
Accommodations policy

The University is committed to providing reasonable accommodations and auxiliary services to students, staff, faculty, job applicants, applicants for admissions, and other beneficiaries of University programs, services and activities with documented disabilities in order to provide them with equal opportunities to participate in programs, services, and activities in compliance with sections 503 and 504 of the Rehabilitation Act of 1973, as amended, and the Americans with Disabilities Act (ADA) of 1990 and the Americans with Disabilities Act Amendments Act (ADAAA) of 2008. Reasonable accommodations will be made unless it is determined that doing so would cause undue hardship for the University. Students requesting accommodation based on a disability must register with the UTEP Center for Accommodations and Support Services (CASS). Contact the Center for Accommodations and Support Services at 915-747-5148, email them at cass@utep.edu, or apply for accommodations online via the CASS portal.

Scholastic integrity

Academic dishonesty is prohibited and is considered a violation of the UTEP Handbook of Operating Procedures. It includes, but is not limited to, cheating, plagiarism, and collusion. Cheating may involve copying from or providing information to another student, possessing unauthorized materials during a test, or falsifying research data on laboratory reports. Plagiarism occurs when someone intentionally or knowingly represents the words or ideas of another as one's own. Collusion involves collaborating with another person to commit any academically dishonest act. Any act of academic dishonesty attempted by a UTEP student is unacceptable and will not be tolerated. All suspected violations of academic integrity at The University of Texas at El Paso must be reported to the Office of Student Conduct and Conflict Resolution (OSCCR) for possible disciplinary action. To learn more, please visit HOOP: Student Conduct and Discipline.

Copyright statement and course materials

All materials used in this course are protected by copyright law. The course materials are only for the use of students currently enrolled in this course and only for the purpose of this course. They may not be further disseminated.

Course resources

UTEP provides a variety of student services and support:

Technology Resources

Help Desk: Students experiencing technological challenges (email, Blackboard, iClicker, etc.) can submit a ticket to the UTEP Helpdesk for assistance. Contact the Helpdesk via phone, email, chat, website, or in person if on campus.
Academic Resources

**UTEP Library:** Access a wide range of resources including online, full-text access to thousands of journals and eBooks plus reference service and librarian assistance for enrolled students.

**Math Tutoring Center (MaRCS):** Ask a tutor for help and explore other available math resources.

Individual Resources

**Military Student Success Center:** Assists personnel in any branch of service to reach their educational goals.

**Center for Accommodations and Support Services:** Assists students with ADA-related accommodations for coursework, housing, and internships. Counseling and Psychological Services: Provides a variety of counseling services including individual, couples, and group sessions as well as career and disability assessments.