MARYLAND APPLIED GRADUATE ENGINEERING

AI-based Software Systems (ENPM655)

Term: *Fall 2024*

Professor: Dr. Mikael Lindvall, Dr. Joshua Giltinan **Grader:** Sumedha Vadlamani
Office Phone: 301-575-6275   **Email:** Use ELMS' email
Email: Use ELMS' email   **Office Hours:** By appointment
Office Hours: TBD with Grader
Credits: 3
Course Dates: From Aug 27, 2024 - Dec 17, 2024
Course Times: Tuesdays 7:00pm-9:40pm
Classroom: BLD JMP Room 3101

Canvas/ELMS: https://umd.instructure.com/courses/1368670

Course Description

The goal of this new course is to address the important problem of specifying, developing, and testing software systems that are based on artificial intelligence (AI) components. Since such systems are often safety critical or must be dependable for other reasons, it is important that quality is built in throughout the software development life cycle.

It is important to note that the focus of the course is not on generic software engineering or on how to train neural networks, even though we will touch upon those topics. The core of the course is instead about how to specify, develop and test software systems that are based on or uses AI.

Data scientists are often great at building models with cutting edge techniques, but incorporating those models into functioning software products presents different engineering challenges. For example, data scientists may work with un-versioned notebooks on static data sets and focus on prediction accuracy while ignoring scalability, robustness, update latency, or operating cost.

Software engineers, in contrast are typically trained with clear specifications and tend to focus on code, but may not be aware of the difficulties of working with data and unreliable models. They have a large toolset for decision making and quality assurance, but may not know how to apply those to AI-enabled systems and their challenges.

This course discusses questions such as: To what degree can existing SE practices be used for building intelligent systems? To what degree are new practices needed?

This course adopts a software engineering perspective on building intelligent systems, focusing on what a software engineer can do to turn a machine learning idea into a scalable and reliable product.

The course will use software and systems engineering terminology and techniques (e.g., test coverage, architecture views, fault trees) and discuss challenges posed by using such techniques on machine learning/AI components.

The course will include one lecture on teaching/refreshing fundamentals of machine learning and AI to provide a basic understanding of relevant concepts (e.g., feature engineering, linear regression vs fault trees vs neural networks).

The course will also briefly cover design thinking and tradeoff analysis. It will focus primarily on practical approaches that can be used now and will feature hands-on practice with modern tools and infrastructure.

Required technology

Some assignments require access to a computer that runs Python, preferably Linux and/or MS Windows 10/11. For some in-class assignments students should bring a laptop to class. More information will be provided during the first lecture.

Method for communication outside the classroom

Email is preferred using canvas.

Important Dates

- See separate schedule

Due dates for Assignments will be provided during the first lecture and throughout the course.

Course attendance policy

Students must attend the following classes: Midterm, Final, Assignment presentations, Student presentations.

Course Topics

The following topics are planned to be covered; however, changes may occur:

- Introduction to AI-based Software Systems - Basic Principles and Technologies
    - Basic SE and AI-technologies
    - Tradeoffs among AI Techniques
- Collecting and specifying requirements for systems with an AI component
    - Requirements and Risks
- Designing robust systems with AI components
- Ensuring privacy and other forms of security in AI-enabled systems including legal frameworks for ethics and privacy such as GDPR.
- Software Components and Architecture of AI-enabled Systems
- Testing and Test Coverage Tools for AI-based systems
    - Unit testing data
    - Assuring quality of an AI-enabled system
    - Using test automation to test correctness an AI-enabled system
    - Evaluating correctness or usefulness of a system with an AI component
    - Detecting poor data quality, poor model quality, and data drift
- Reviewing systems with AI components
- How and where to deploy models, how and when to update models, and what telemetry to collect? How to design learning and evaluation infrastructure that scales?

Prerequisites

ENPM611 or instructor's permission

Learning Outcomes
After successfully completing this course you will be able to:

- Analyze tradeoffs for designing production systems with AI-components

- Analyze qualities beyond accuracy such as operation cost, latency, updateability, and explainability

- Implement production-quality systems that are robust to mistakes of AI components

- Design fault-tolerant and scalable data infrastructures for learning models, serving models, versioning, and experimentation

- Reason about how to ensure quality of the entire machine learning pipeline (it should be noted that some of the following topics are still open research questions) with test automation and other quality assurance techniques, including automated checks for data quality, data drift, feedback loops, and model quality.

- Build systems that can be tested in production and build deployment pipelines that allow careful rollouts and canary testing

- Consider privacy, fairness, and security when building complex AI-enabled systems

- Communicate effectively in teams with both software engineers and data analysts

Assignments include specific deliverables from in-class exercises, participation in the discussion board, and take-home assignments. More information will be provided in the first lecture and throughout the course.

Course Materials

Required Resources
- No text book is used in this course.

- Lectures are often based on published papers, which will be provided for references as necessary.

- Total Estimated costs of required course materials: $0.00.

Course Structure
This course includes both on-campus and online sections. To attend synchronously online, log into ELMS-Canvas at the time of the Section 0101 class Tuesdays at 7PM and select "Video Conference" from the left side menu. This will open a Zoom link to the live classroom.

For asynchronous online students, all lectures will be recorded and made available on ELMS-Canvas under "Panopto Recordings/Video Lectures" within 24 hours of the class time. Be sure to review the recorded lecture in a timely manner.

On-campus students come to class prepared to engage with the lecture and materials. Online students, be sure to log into Canvas regularly and participate in discussions and activities. Regardless of the section you are enrolled in, participation is expected.

Please note that F1 students enrolled in the on-campus section are required to attend in person. If you have a conflict on a particular day, please reach out to us in advance to discuss.

Communication Guidelines

Communicating with the Instructor
Our goal is to be readily available to you throughout the semester. Use ELMS' email system for course related topics and CC both instructors as well as the grader. Direct questions about assignments and lectures related to assignments to Joshua and CC Mikael and the grader. Please DO NOT email us using regular email regarding questions that are easily found in the first lecture slides, syllabus or on ELMS-Canvas (e.g., When is this assignment due? How much is it worth? etc.), but please DO reach out about personal, academic, and intellectual concerns/questions.

While we will do our best to respond to emails within 24 hours, you will more likely receive email responses from us on Week days from 4PM to 6PM EST.

Since we're using ELMS' email system "ENPM 655 (Section XXXX)" is automatically added to the subject line making it easy for us to see your email allowing us to respond quickly.

Additionally, please review These tips for 'How to email a Professor'. By following these guidelines, you will be ensured to receive a timely and courteous response.

Finally, if you need to discuss issues not appropriate for the classroom and/or an email, we can arrange to talk by phone, over Zoom, or in person. Send us an email asking for a meeting and we can set something up.

Announcements
We will send IMPORTANT messages, announcements, and updates through ELMS-Canvas. To ensure you receive this information in a timely fashion, make sure your email and announcement notifications (including changes in assignments and/or due dates) are enabled in ELMS-Canvas (How to change notification settings in CANVAS).

Log into our ELMs-Canvas course site at least once every 24-hour period to check your inbox and the Announcements page.

Names/Pronouns and Self-Identifications
The University of Maryland recognizes the importance of a diverse student body, and we are committed to fostering inclusive and equitable classroom environments. We invite you, if you wish, to tell us how you want to be referred to in this class, both in terms of your name and your pronouns (he/him, she/her, they/them, etc.). Keep in mind that the pronouns someone uses are not necessarily indicative of their gender identity. Visit trans.umd.edu to learn more.

Additionally, it is your choice whether to disclose how you identify in terms of your gender, race, class, sexuality, religion, and dis/ability, among all aspects of your identity (e.g., should it come up in classroom conversation about our experiences and perspectives) and should be self-identified, not presumed or imposed. We will do our best to address and refer to all students accordingly.

Communicating with your Peers
With a diversity of perspectives and experience, we may find ourselves in disagreement and/or debate with one another. As such, it is important that we agree to conduct ourselves in a professional manner and that we work together to foster and preserve a virtual classroom environment in which we can respectfully discuss and deliberate controversial questions. We encourage you to confidently exercise your right to free speech—bearing in mind, of course, that you will be expected to craft and defend arguments that support your position. Keep in mind, that free speech has its limit and this course is NOT the space for hate speech, harassment, and derogatory language. We will strive to create an atmosphere in which students feel comfortable voicing their argument without fear of being personally attacked, mocked, demeaned, or devalued.

Any behavior (including harassment, sexual harassment, and racially and/or culturally derogatory language) that threatens this atmosphere will not be tolerated. Please alert us immediately if you feel threatened, dismissed, or silenced at any point during our semester together and/or if your engagement in discussion has been in some way hindered by the learning environment.

Netiquette Policy
Netiquette is the social code of online classes. Students share a responsibility for the course's learning environment. Creating a cohesive online learning community requires learners to support and assist each other. To craft an open and interactive online learning environment, communication has to be conducted in a professional and courteous manner at all times, guided by common sense, collegiality and basic rules of etiquette.

Grading

Grading is calculated based on a sum of the weighted scores from (tentative):
Midterm (20%), Final (40%), Assignments (30%), Student Presentation (10%)

Final information about the grades will be provided during the first lecture. Students who score less than 70 out of 100 on the Midterm must discuss the situation with both Dr. Lindvall and Dr. Giltinan.

Grade Breakdown

Assignment	Percentage %
Midterm Exam	20%
Final Exam	40%
Individual Assignments	30%
Student Presentation	10%

Practice Quizzes (not formally graded)	**0%**
Total	**100%**

Course Assignments

Midterm and Final Exams
- Mid-term and final exams will be administered online, using the student's own laptop, in class and will be closed book and closed notes. Students must show their UMD student ID to the person administering the exam before taking it. Students in the online section need to arrange for proctoring.

Individual Assignments
- Assignments include specific deliverables from in-class exercises, participation in the discussion board, and take-home assignments. More information will be provided in the first lecture and throughout the course.

Participation & Engagement
- To facilitate stronger interactions and better understanding, in-class attendance or remote connection during class time is recommended.
- Students will learn the class material by attending lectures, independent study, and teamwork.
- Classes will incorporate active learning (e.g., hands on exercises) and will stimulate students' critical thinking.
- Students will participate in ELMS (Canvas) Discussions and are encouraged to post feedback and questions for the instructor.

Group Project Assignments
- Each student must fairly contribute to the group project(s). Individual project grades might be adjusted according to individual contribution.

Grading of Assignments
All assignments will be graded according to a predetermined set of criteria (i.e., rubric) which will be communicated to students before the assignment is submitted.

To progress satisfactorily in this class, students need to receive timely feedback. To that end, it is our intention to grade all assignments within 2 weeks of their final due date. If an assignment is taking longer than expected to grade, students will be informed of when they can expect to see their grade.

Grade Computation
All assessment scores will be posted on ELMS/Canvas page. If you would like to review any of your grades (including the exams), or have questions about how something was scored, please email us to schedule a time for us to meet and discuss.

It is expected that you will submit work by the deadline listed in the syllabus and/or on ELMS-Canvas. Late work will be penalized according to the late work policy described in the **Course Policies and Procedures** section below.

Grade Disputes: We are happy to discuss any of your grades with you, and if we have made a mistake, we will correct it. Any formal grade disputes must be submitted in writing and within one week of receiving the grade.

Final letter grades are assigned based on the percentage of total assessment points earned. To be fair to everyone we have to establish clear standards and apply them consistently, so please understand that being close to a cutoff is not the same as making the cut (89.99 ≠ 90.00). It would be unethical to make exceptions for some and not others.

Final Grade Cutoffs									
+	97.00%	+	87.00%	+	77.00%	+	67.00%	+	
A	94.00%	B	84.00%	C	74.00%	D	64.00%	F	<60.0%
-	90.00%	-	80.00%	-	70.00%	-	60.00%	-	

Course Schedule

Topic (Note, the list doesn't indicate exact order of lectures)	Deliverable
Introduction to the course Introduction to AI-based systems Introduction to Software Engineering	
Introduction to Software Engineering Challenges for ML	
Requirements Engineering for AI based systems	**Assignment 1**
Modeling of Autonomous Systems Modeling Basics	
Hidden Technical Debt in Machine Learning Systems	
MLOPS	**Assignment 2**
Testing of AI-based systems Testing of Autonomous Systems	**Assignment 3**
Quality Assurance of AI-based systems	

Data science, data security, privacy in AI-based systems	Assignment 4
AI with Parallel Computing - from an SE perspective?	

Note: This is a tentative schedule, and subject to change as necessary – monitor ELMS-Canvas for current deadlines. In the unlikely event of a prolonged university closing, or an extended absence from the university, adjustments to the course schedule, deadlines, and assignments will be made based on the duration of the closing and the specific dates missed.

Course Policies and Procedures

Use of Cell phones:
- Do not use your cellphone in class. If you have critical communication to attend to, please excuse yourself and return when you are ready.

Other course policies:
- Students must attend the following classes: Midterm, Final, student presentations, and assignment presentations.
- No make-up exams will be considered, except for very rare circumstances (officially excused absences). In that case, an equivalent (but not identical) assessment will be administered. The make-up for the final exam must be administered before the last exam day of the semester.
- Project groups for student presentations will be formed by the instructor or by students themselves.
- For project and assignment presentations, all group members must be present in class (either in College Park, or remotely, at their respective sites).
- No extra credit/make-up work will be offered.

Conduct
The University of Maryland's conduct policy indicates that course syllabi should refer to a webpage of course-related policies and procedures. For a complete list of graduate course related policies, visit the [Graduate School website](#). Below are course-specific policies and procedures which explain how these Graduate School policies will be implemented in this class.

Satisfactory Performance
The Graduate School expects students to take full responsibility for their academic work and academic progress. The student, to progress satisfactorily, must meet all the academic requirements of this course. Additionally, each student is expected to complete all readings and any preparatory work before each class session, come to class prepared to make substantive contributions to the learning experience, and to proactively communicate with the instructor when challenges or issues arise.

Questions about Assignments
Please ask all questions you may have about an assignment by 6:00 PM Sunday before the assignment is due. Any questions asked after that time may not be answered in time for you to make changes to your work.

Late Work Policy
Submissions for project deliverables will be made online, using ELMS (Canvas), by the date specified in ELMS. Late submissions are not accepted. Exceptions might be occasionally granted, if and only if permission is obtained from the instructor **before** the submission deadline.

Religious Observance
It is the student's responsibility to inform the instructor of any intended absences for religious observances in advance. Notice should be provided as soon as possible but no later than the end of the schedule adjustment period.

Academic Integrity
For this course, your assignments will be collected via Turnitin on ELMS/Canvas. We have chosen to use this tool because it can help you improve your scholarly writing and help us verify the integrity of student work. For information about Turnitin, how it works, and the feedback reports you may have access to, visit Turnitin Originality Checker for Students

The University's Code of Academic Integrity is designed to ensure that the principles of academic honesty and integrity are upheld. In accordance with this code, the University of Maryland does not tolerate academic dishonesty. Please ensure that you fully understand this code and its implications because all acts of academic dishonesty will be dealt with in accordance with the provisions of this code. All students are expected to adhere to this Code. It is your responsibility to read it and know what it says, so you can start your professional life on the right path. **As future professionals, your commitment to high ethical standards and honesty begins with your time at the University of Maryland.**

It is important to note that course assistance websites, such as CourseHero, or AI generated content are not permitted sources, unless the instructor explicitly gives permission. Material taken or copied from these sites can be deemed unauthorized material and a violation of academic integrity. These sites offer information that might be inaccurate or biased and most importantly, relying on restricted sources will hamper your learning process, particularly the critical thinking steps necessary for college-level assignments.

Additionally, students may naturally choose to use online forums for course-wide discussions (e.g., Group lists or chats) to discuss concepts in the course. However**, collaboration on graded assignments is strictly prohibited unless otherwise stated**. Examples of prohibited collaboration include: asking classmates for answers on quizzes or exams, asking for access codes to clicker polls, etc. Please visit the **Office of Graduate Studies' full list of campus-wide policies** and reach out if you have questions.

Finally, on each exam or assignment you must write out and sign the following pledge: *"I pledge on my honor that I have not given or received any unauthorized assistance on this exam/assignment."*

If you ever feel pressured to comply with someone else's academic integrity violation, please reach out to us straight away. Also, *if you are ever unclear* about acceptable levels of collaboration, *please ask*!

To help you avoid unintentional violations, *the following table* lists levels of collaboration that are acceptable for each graded exercise. Each assignment will contain more specific information regarding acceptable levels of collaboration.

	OPEN NOTES	USE BOOK	LEARN ONLINE	GATHER CONTENT With AI	ASK FRIENDS	WORK IN GROUPS
Homework Assignments	✓	✓	✓	---	---	✓
Practice Quizzes	✓	✓	✓	---	✓	---
Mid term and Final Exams	---	---	---	---	---	---

Course Evaluation
Please submit a course evaluation through Student Feedback on Course Experiences in order to help faculty and administrators improve teaching and learning at Maryland. All information submitted to Course Experiences is confidential. Campus will notify you when Student Feedback on Course Experiences is open for you to complete your evaluations at the end of the semester. Please go directly to the **Student Feedback on Course Experiences** to complete your evaluations. By completing all of your evaluations each semester, you will have the privilege of accessing through Testudo the evaluation reports for the thousands of courses for which 70% or more students submitted their evaluations.

Copyright Notice

Tips for Succeeding in this Course

1. **Participate.** We invite you to engage deeply, ask questions, and talk about the course content with your classmates. You can learn a great deal from discussing ideas and perspectives with your peers and professor. Participation can also help you articulate your thoughts and develop critical thinking skills.
2. **Manage your time.** Students are often very busy, and we understand that you have obligations outside of this class. However, students do best when they plan adequate time that is devoted to course work. Block your schedule and set aside plenty of time to complete assignments including extra time to handle any technology related problems.
3. **Login regularly.** We recommend that you log in to ELMS-Canvas several times a week to view announcements, discussion posts and replies to your posts. You may need to log in multiple times a day when group submissions are due.
4. **Do not fall behind.** This class moves at a quick pace and each week builds on the previous content. If you feel you are starting to fall behind, check in with the instructor as soon as possible so we can troubleshoot together. It will be hard to keep up with the course content if you fall behind in the pre-work or post-work.
5. **Use ELMS-Canvas notification settings.** Pro tip! Canvas ELMS-Canvas can ensure you receive timely notifications in your email or via text. Be sure to enable announcements to be sent instantly or daily.
6. **Ask for help if needed.** If you need help with ELMS-Canvas or other technology, IT Support. If you are struggling with a course concept, reach out to us and your classmates for support.

Student Resources and Services

Taking personal responsibility for your learning means acknowledging when your performance does not match your goals and doing something about it. We hope you will come talk to us so that we can help you find the right approach to success in this course, and We encourage you to visit the Counseling Center's Academic Resources to learn more about the wide range of resources available to you. Below are some additional resources and services commonly used by graduate students. For a more comprehensive list, please visit the Graduate School's Campus Resources Page.

Accessibility and Disability Services

The University of Maryland is committed to creating and maintaining a welcoming and inclusive educational, working, and living environment for people of all abilities. The University of Maryland is also committed to the principle that no qualified individual with a disability shall, on the basis of disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of the University, or be subjected to discrimination. The Accessibility & Disability Service (ADS) provides reasonable accommodations to qualified individuals to provide equal access to services, programs and activities. ADS cannot assist retroactively, so it is generally best to request accommodations several weeks before the semester begins or as soon as a disability becomes known. Any student who needs accommodations should contact us as soon as possible so that we have sufficient time to make arrangements.

For assistance in obtaining an accommodation, contact Accessibility and Disability Service at 301-314-7682, or email them at adsfrontdesk@umd.edu. Information about sharing your accommodations with instructors, note taking assistance and more is available from the Counseling Center.

Writing Center

Everyone can use some help sharpening their communication skills (and improving their grade) by visiting The Graduate School's Writing Center and schedule an appointment with them. Additionally, international graduate students may want to take advantage of the Graduate School's free English Editing for International Graduate Students (EEIGS) program.

Health Services

The University offers a variety of physical and mental health services to students. If you are feeling ill or need non-emergency medical attention, please visit the University Health Center.

If you feel it would be helpful to have someone to talk to, visit UMD's Counseling Center or one of the many other mental health resources on campus.

Notice of Mandatory Reporting

Notice of mandatory reporting of sexual assault, sexual harassment, interpersonal violence, and stalking: As a faculty member, We am designated as a "Responsible University Employee," and we must report all disclosures of sexual assault, sexual harassment, interpersonal violence, and stalking to UMD's Title IX Coordinator per University Policy on Sexual Harassment and Other Sexual Misconduct.

If you wish to speak with someone confidentially, please contact one of UMD's confidential resources, such as CARE to Stop Violence (located on the Ground Floor of the Health Center) at 301-741-3442 or the Counseling Center (located at the Shoemaker Building) at 301-314-7651.

You may also seek assistance or supportive measures from UMD's Title IX Coordinator, Angela Nastase, by calling 301-405-1142, or emailing titleIXcoordinator@umd.edu.
To view further information on the above, please visit the Office of Civil Rights and Sexual Misconduct's website at ocrsm.umd.edu.

Basic Needs Security
If you have difficulty affording groceries or accessing sufficient food to eat every day, or lack a safe and stable place to live, please visit UMD's Division of Student Affairs website for information about resources the campus offers you and let us know if we can help in any way.

Veteran Resources
UMD provides some additional supports to our student veterans. You can access those resources at the office of Veteran Student life and the Counseling Center. Veterans and active duty military personnel with special circumstances (e.g., upcoming deployments, drill requirements, disabilities) are welcome and encouraged to communicate these, in advance if possible, to the instructor.