Instructor: **Prof. Tanu Malik**
Course: **Designing End-to-End ML Systems** Fall 2026

1 Overview

Machine learning systems are both complex and unique. Complex because they must balance both performance and accuracy. Unique because they're data dependent, with data varying wildly from one use case to the next. In this course we will learn why and how to build systems that learn from data. We will learn that it requires more than understanding algorithms—it demands expertise spanning data pipelines, model development, optimization for deployment constraints, and operational practices. We will acquaint ourselves with both compute and data issues arising in managing a large ML pipeline. The course will be project-based.

1.1 Course Objectives

The objective is to transition students from "using models" to "engineering systems." By the end, students will have built a complete end-to-end ML pipeline and optimized it for real-world deployment constraints.

1. Comprehend the need for Machine Learning Systems and why ML system is beyond the model.
2. Trace the end-to-end ML pipeline from data to deployment. Identify throughput, I/O, memory allocations, FLOPs bottlenecks at each pipeline stage.
3. Experiment with batching strategies for inference (static, dynamic, continuous). Calculate the throughput-latency tradeoff for a given SLA.
4. Quantify the impact of data quality and quantization on model performance
5. Comprehend model drift (data drift, concept drift) and explain why it matters for production systems. Design a monitoring pipeline that detects drift before accuracy degrades.

2 Instructor Information

Instructor: Prof. Tanu Malik
Office: Naka 311, EECS
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3 Prerequisites

If you are not sure that you have satisfied the prerequisites, speak to the instructor before the second lecture. Prerequisite Courses:

- This is a programming heavy course. Expertise with Python is a must. Significant expertise in handling infrastructure, debugging, and being able to learn at an abstract level.
- Familiarity with basic probability theory and linear algebra.
- Student must have taken some introduction class on data science or be willing to take it along with the course.

4 Weekly Schedule

The tentative weekly schedule is as follows:

Weeks	**Description**	Assignments
Aug 26th	Introduction to ML Systems	
Sept 2nd	Types of ML Systems	Lab 1-3 (Hello + Cloud) due Sept 6th
Sept 9th	ML Workflows	Lab 4 (ML Pipeline) due Sept 13th
Sept 16th	Data Engineering	Lab 5 (Data Platforms) due Sept 20th
Sept 23rd	Model Development and Frameworks	Lab 6 (Persistent) due Sept 27th
Sept 30th	Model Training	Lab 7 (Training at scale) due Oct 4th
Oct 7th	Midterm-1 and Project Presentations	–
Oct 14th	Optimization Principles	Lab 8 (Experiment Tracking) due Oct 18th
Oct 21st	Data Selection	Lab 9 (Cluster+Ray) due Oct 25th
Oct 28th	Model Compression and Benchmarking	Lab 10 (Model Optimizations) due Nov 1st
Nov 4th	Model Deployment	Lab 11 (serving on edge devices) due Nov 8th
Nov 11th	Model Serving	Lab 12 (System optimizations) due Nov 15th
Nov 18th	Midterm-2 and Project Presentations	–
Dec 2nd	LLMs	Lab 13/14 (Offline + Online) due Dec 6th
Dec 9th	Agentic AI	Lab 15 (Closing the loop) due Dec 13th
Dec 16th	Final Project Presentations	MS3-Final Project due

5 Assessment

- Assignments (5 Quizzes, 5 Reflections, Labs): 25%
- Midterm: 30%
- Final Project: 40%
- Participation: 5%

The grade boundaries used for the class are as follows:

Letter Grade	Percentage >=
A+	95
A	92
A-	90
B+	88
B	84
B-	80
C+	77
C	73
C-	70
D	60
F	Below 60

6 TextBook

The course will take material from several text books.

- Janapa Reddi, V. (2026). Introduction to machine learning systems (Vol. 1: Foundations). The MIT Press. https://mlsysbook.ai/vol1/
- Huyen, C. (2022). Designing machine learning systems: An iterative process for production-ready applications. O'Reilly Media.
- Russell, S., and Norvig, P. (2020). Artificial intelligence: A modern approach (4th ed.). Pearson.
- Zhang, A., Lipton, Z. C., Li, M., and Smola, A. J. (2023). Dive into deep learning. Cambridge University Press. https://d2l.ai

7 Course Policies

7.1 Course-related Expectations

1. Students are expected to do the Labs on a weekly basis as the lectures proceed. Lecture discussions, Lab assignments and course project are the core delivery mechanism for the course material. Throughout the semester, lecture topics will often be interlaced with quizzes and discussions to gauge comprehension of topics and to survey attendance. Since only the best of 5 will be chosen, these participation events cannot be made up when missed, resulting in a zero (0) grade.

2. Exceptions will be made to the above policies for only the following conditions: a) illness that is documented by a medical professional; b) pre-absence email notification to the instructor regarding illness, family related matters, career related matters. WARNING: information technology related problems/failures/challenges are not appropriate excuses for late work. As a student in a senior-level Computer Science course, it is expected that you are capable of mitigating the risks associated with using technology to complete assignments!

7.2 Communication Expectations

1. The subject of your email must contain the course number 'CS'. If not, there is no guarantee of response.

2. You may address me as Professor, Prof. Malik, Dr. Malik, or simply Tanu.

3. All electronic interactions are an extension of the classroom and should be treated as such. While disagreement can be part of the discourse, online communication should remain respectful and appropriate rather than demeaning and/or unprofessional.

7.3 Homework Expectations

The course has weekly Lab. All Labs are an individual effort. We will assess your understanding of these Labs via in-class exercises and quizzes.

Each Lab must be submitted by end of the week. No late submission is allowed unless there are acute circumstances, which have been communicated in a timely manner. This being a fast-paced course, the stated timeline is for your benefit. If you fall behind for whatever reason, recovering the grade will be nearly impossible.

The course material and homework sequences are designed to build upon each other; providing the student with a complete understanding of the various techniques to solve problems. Each homework builds upon the concepts and lessons of the previous homeworks, and therefore they are each critical to the progression of the class.

8 University Policies

8.1 AI and the Learning Environment

Unless stated permissible as part of the question, students who use ChatGPT and similar tools for solving problem assignments without permission, or who use them in improper ways, are not only harming themselves but also violating the academic integrity rules of the University.

8.2 Academic Integrity

Academic integrity is fundamental to the activities and principles of a university. All members of the academic community must be confident that each person's work has been responsibly and honorably acquired, developed, and presented. Any effort to gain an advantage not given to all students is dishonest whether or not the effort is successful. The academic community regards breaches of the academic integrity rules as extremely serious matters. Sanctions for such a breach may include academic sanctions from the instructor, including failing the course for any violation, to disciplinary sanctions ranging from probation to expulsion. When in doubt about plagiarism, paraphrasing, quoting, collaboration, or any other form of cheating, consult the course instructor or the Office of Academic Integrity.

Students are expected to adhere to this honor pledge on all graded work whether or not they are explicitly asked in advance to do so: "I strive to uphold the University values of respect, responsibility, discovery, and excellence. On my honor, I pledge that I have neither given nor received unauthorized assistance on this work." All exercises and projects are designed and intended to be an individual effort, collaborative implementation or copying will result in a zero (0) on the exercise for all students involved. Students found to have exhibited academic dishonesty in the execution of programming exercises or projects in this course will be reported to the Office of Academic Integrity.

8.3 Academic Inquiry, Course Discussion and Privacy

When students record something that happens in a course (a lecture, class discussions, meetings, etc.) it has an impact on the rights of the people captured in that recording. For example, the instructor and the University may have rights to the intellectual property contained in that recording. At the same time, another student who may have been recorded has the right to privacy. In order to protect these rights, MU employs a policy (called "Executive Order No. 38") to govern both situations you may encounter while taking a course – when an instructor allows recordings and when they do not. In this class, students may not make audio or video recordings of course activity, except students permitted to record as an accommodation undersection 240.040 of the Collected Rules. Students who violate this policy are subject to discipline in accordance with provisions of section 200.020 of the Collected Rules and Regulations of the University of Missouri pertaining to student conduct matters.

8.4 FERPA

The Family Educational Rights and Privacy Act (FERPA) of 1974 is a federal law designed to protect the privacy of educational records; to establish the rights of students to inspect and review their education records; and to provide guidelines for the correction of inaccurate and misleading data through informal and formal hearings. The law applies to any individual who is or has been in attendance at an institution and regarding whom the institution maintains educational records. Once students have matriculated to the University of Missouri, i.e. enrolled in course work, FERPA rights transfer to the student, regardless of the student's age. Students can enable certain individuals to have access to their education records by signing a FERPA waiver. The consent must specify records to be disclosed, state the purpose of the disclosure and identify the party or class of parties to whom the disclosure must be made.

8.5 Intellectual Pluralism

The University community welcomes intellectual diversity and respects student rights. Students who have questions or concerns regarding the atmosphere in this class (including respect for diverse opinions) may contact the departmental chair or divisional director, the Office of Academic Integrity, or the MU Equity Office.

8.6 Mental Health

The University of Missouri is committed to supporting student well-being through an integrated network of care, with a wide range of services to help students succeed. The MU Counseling Center offers professional mental health care, and can help you find the best approach to treatment based on your needs. Call to make an appointment at 573-882-6601. Any student in crisis may call or go to the MU Counseling Center between 8:00-5:00 M-F. After hours phone support is available at 573-882-6601. Visit our website at https://wellbeing.missouri.edu/ to take an online mental health screening, find out about workshops and resources that can help you thrive, or learn how to support a friend.

8.7 Netiquette

Your instructor and fellow students wish to foster a safe online learning environment. All opinions and experiences, no matter how different or controversial they may be perceived, must be respected in the tolerant spirit of academic discourse. You are encouraged to comment, question, or critique an idea but you are not to attack an individual. Our differences, some of which are outlined in the University's nondiscrimination statement, will add richness to this learning experience. Please consider that sarcasm and humor can be misconstrued in online interactions and generate unintended disruptions. Working as a community of learners, we can build a polite and respectful course ambiance.

8.8 Religious Holidays & Accommodations

Many religious faiths are represented in the student body. The University of Missouri does not restrict student free exercise of religion, unless 1) the restriction is in the form of a rule of general applicability, and does not discriminate against religion or among religions; and 2) it can be demonstrated that the application of the restriction is essential to furthering a compelling university interest, and is not unduly restrictive considering the relevant circumstance. The policy of the University attempts to strike a reasonable balance between accommodating the religious practice of students and meeting academic needs and standards.

Consult IDE's Guide to Religions for the form that can be used to notify an instructor of an absence associated with religious practice. Students are expected to notify their instructor(s) by completing and submitting this form in a manner that is consistent with the procedure outlined in the university's policy on student religious accommodation. Providing false information regarding sincerely held religious practice is a violation of the university's Standard of Conduct and will not be tolerated.

8.9 Nondiscrimination Policy (Prohibited Discrimination)

The University of Missouri does not discriminate on the basis of race, color, national origin, ancestry, religion, sex* (including gender), pregnancy, sexual orientation, gender identity, gender expression, age, disability, protected veteran status, and any other status protected by applicable state or federal law. Discrimination includes any form of unequal treatment such as denial of opportunities, harassment, and violence. *Sex discrimination includes rape, sexual assault, sexual harassment, unwanted touching, stalking, dating/domestic violence, stalking, and sexual exploitation. Retaliation for making or supporting a report of discrimination or harassment is also prohibited.

If you experience discrimination or sexual violence, you are encouraged (but not required) to report the incident to the MU Office for Civil Rights & Title IX. Learn more about your rights and options at civilrights.missouri.edu or call 573-882-3880. You also may make an anonymous report online. If you are a survivor, or someone concerned about a survivor, and need immediate information on what to do, see RSVP Resources page. Both the Office for Civil Rights & Title IX and the RSVP Center can provide assistance to students who need help with academics, housing, or other issues.

In the event that you choose to write or speak about having experienced any of these forms of prohibited discrimination or harassment, Mizzou policies require that, as your instructor, I share this information with the MU Office for Civil Rights & Title IX. They will contact you to offer information about re-sources, as well as your rights and options as a member of our campus community.

8.10 Students with Disabilities

The goal of the University of Missouri is to ensure an inclusive learning environment for all students. The University of Missouri Disability Center provides services and accommodations for students to participate fully in the learning experience and to experience equitable evaluation of their performance. Students (including online students) with a documented disability can contact the Disability Center to establish an Accommodation Plan. Documented disabilities include hearing, vision, mobility, learning and attention, psychological health, and physical health. Students' accommodations are implemented with the in-put of students to maximize the learning experiences. The MU Disability Center keeps information about a student's disability confidential.

Please notify me of your eligibility for accommodations as soon as possible. Additionally, if there are aspects of the course that present as barriers, such as inaccessible course content (e.g., learning assessments, PowerPoints, non-captioned videos, images, tables, PDFs) or if you need an immediate accommodation due to an injury, please contact me or the Disability Center as soon as possible