

IE 7374 Machine Learning Operations (MLOps)

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| Course Overview | In this dynamic and comprehensive program, we delve into the exciting world of MLOps, where machine learning meets the operational demands of real-world applications. Designed to equip you with the essential skills and knowledge needed to bridge the gap between data science and production environments, this course will explore the entire MLOps lifecycle. From model development and training to deployment, monitoring, and scaling, you'll gain hands-on experience with cutting-edge tools and best practices. Whether you're a data scientist looking to deploy your models effectively or an IT professional aiming to integrate AI solutions into your organization, this course will empower you to drive innovation and efficiency in the rapidly evolving field of machine learning operations. |
| Prerequisites | IE - 7300, CS – 6400 with minimum grades of B-. Proficiency with Python programming. Experience with TensorFlow. |
| Objectives | Understand MLOps fundamentals and its role in AI development. Master end-to-end ML pipeline setup. Containerize ML models for efficient deployment. Explore automated model training, tuning, and version control. Learn CI/CD for ML to ensure seamless deployment. Proficiently monitor and scale ML systems in production. Acquire knowledge of MLOps best practices and tools. Apply MLOps principles to real-world projects. Foster effective collaboration among teams. Prepare for a career in MLOps or enhance data engineering skills. Manage ML models at scale and address challenges. Stay updated with the latest MLOps trends and innovations. |
| Textbooks | TBD |
| Syllabus | Scoping 1.1: Introduction to MLOps Scoping 1.2: Defining MLOps Objectives and Requirements 1.3: Identifying Stakeholders and Roles 1.4: Creating a MLOps Project Plan 1.5: Managing Scope Changes in MLOps Data 2.1: Data Preparation and Exploration 2.2: Data Versioning and Management 2.3: Data Quality and Validation in MLOps 2.4: Data Privacy and Compliance 2.5: Data Pipelines and Workflow Automation |

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| | <p>Model Development</p> <p>3.1: Building and Training ML Models 3.2: Model Versioning and Experiment Tracking 3.3: Model Evaluation and Validation 3.4: Hyperparameter Tuning 3.5: Model Documentation and Interpretability</p> <p>Deployment</p> <p>4.1: Containerization for Model Deployment 4.2: Orchestrating ML Deployments with Kubernetes 4.3: Deploying ML Models in Cloud Environments 4.4: Continuous Integration and Continuous Deployment (CI/CD) for ML 4.5: A/B Testing and Canary Deployments</p> <p>Monitoring</p> <p>5.1: Model Monitoring and Alerting 5.2: Scaling ML Systems in Production 5.3: Performance Optimization and Cost Management 5.4: Security and Compliance in Model Deployment 5.5: Feedback Loops and Model Iteration</p> |
| Homework | Homeworks and reading assignments will be posted weekly |
| Project Schedule | Project - Posting Date Second week of the semester and due date is the week before classes end. |
| Course Evaluation | HomeWorks - 25% Reading assignments - 10% Final Project - 60% Attendance – 5% |
| Software | <p>Jira: Jira is a versatile project management and issue tracking tool that facilitates task management, progress tracking, and team collaboration.</p> <p>Python >= 3.8</p> <p>TensorFlow >= 2.12, TFX, TFDV, TFMA: TensorFlow, along with TFX (TensorFlow Extended), TFDV (TensorFlow Data Validation), and TFMA (TensorFlow Model Analysis), serves as the backbone for machine learning model development, validation, and analysis.</p> <p>Airflow, DataFlow, Dask, GCP: Apache Airflow is used for workflow automation, DataFlow is part of Google Cloud Platform (GCP) for data processing, Dask is used for parallel computing, and GCP provides cloud services for various MLOps tasks.</p> <p>Logging, MLflow, Logstash: Logging tools, including Logstash, are crucial for tracking events and errors in MLOps systems. MLflow is employed for experiment tracking and model management.</p> |

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| | <p>FastPAI: FastPAI is an open-source platform designed to simplify and expedite the deployment of AI and ML models in production environments.</p> <p>GitHub, Git-Actions, Kubernetes, Docker, DVC: GitHub and Git-Actions are essential for version control and continuous integration/continuous deployment (CI/CD). Kubernetes and Docker facilitate containerization and orchestration of ML applications, and DVC (Data Version Control) is used for managing large datasets.</p> <p>Facet, Feast: Facet is a data visualization tool that aids in exploring and comprehending data, while Feast is an open-source feature store for managing and serving features to machine learning models.</p> <p>Elasticsearch, Kibana: Elasticsearch is a distributed, RESTful search and analytics engine used for indexing and searching large volumes of data. Kibana is an open-source data visualization and exploration tool that integrates seamlessly with Elasticsearch for data analysis and visualization.</p> <p>These software tools and platforms are integral components of the MLOps ecosystem, providing a comprehensive toolkit for various stages of the machine learning operations lifecycle. Students will gain hands-on experience with these tools throughout the course.</p> |
| <p>What to expect</p> | <p>Weekly Reading: Prepare for an intellectually stimulating journey as this course delves deep into the realm of MLOps. Expect a substantial amount of reading and assignments. Each week, teams will be assigned a curated selection of articles and academic papers related to the course topics. These readings will form the foundation of your understanding and will serve as catalysts for insightful discussions. Moreover, teams will be randomly chosen to deliver summary presentations, encouraging active engagement and knowledge sharing among peers.</p> <p>Weekly Labs: Get ready for hands-on learning experiences that will solidify your grasp of the course material. Following almost every class, we'll conduct practical labs that allow you to interact directly with the software and applications mentioned in the course. These labs will provide a platform for you to apply theoretical concepts to real-world scenarios, fostering practical skills and a deeper comprehension of the tools at your disposal.</p> <p>Project Preparation: The pinnacle of your learning journey in this course is the final project. It will serve as the primary assessment tool for your grades. Each team is expected to embark on the development of an end-to-end ML software project, broken down into multiple steps throughout the semester. After each chapter, teams will be required to apply the knowledge and software tools covered in the corresponding lessons to their project. This iterative approach ensures a continuous integration of theoretical and practical skills.</p> <p>Jira Ticketing System: Prepare to adopt industry-standard project planning and collaboration practices. We will utilize the Jira ticketing system extensively in this course. Jira will enable us to implement agile methodologies for project management, ensuring that your teams effectively plan, track progress, and collaborate on your projects. This real-world tool</p> |

will provide invaluable experience in project organization and execution, mirroring industry practices and enhancing your overall skill set.

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| Grading | A | 100 - 94 |
| | A- | 94 - 88 |
| | B+ | 88 - 82 |
| | B | 82 - 76 |
| | B- | 76 - 70 |
| | C+ | 70 - 64 |
| | C | 64 - 58 |
| | C- | 58 - 52 |
| | F | < 52 |
| Evaluation Policy | <ol style="list-style-type: none"> 1. Unless otherwise specified, all homeworks and assignments are due for submission at 11:59 pm on the day they are due. Late submission of homework will receive penalty. For two-day delay, grade will be cut by 10%. Beyond two days past the deadline, the submission will not be accepted. 2. Discussion between students for homeworks and projects is not permissible. Each submission must be an outcome of individual effort. | |
| Academic Honesty | <p>Plagiarism, cheating, and any form of unauthorized collaboration will not be tolerated and will be handled in accordance with University policies described in the Student Handbook. Penalties for cheating and plagiarism may include but not limited to, zero credit on the work, student placed on probation, submission of judicial findings in the students' permanent record, and jeopardy of the students' status in the Engineering Program. Acts of academic dishonesty will be referred to OSCCR (Office of Student Conduct and Conflict Resolution). Visit http://www.northeastern.edu/osccr/academic-integrity-policy/ for additional information on Northeastern University academic integrity policy.</p> | |
| Student Accommodations | <p>Northeastern University and the Disability Resource Center (DRC) are committed to providing disability services that enable students who qualify under Section 504 of the Rehabilitation Act and the Americans with Disabilities Act Amendments Act (ADAAA) to participate fully in the activities of the university. To receive accommodations through the DRC, students must provide appropriate documentation that demonstrates a current substantially limiting disability.</p> <p>For more information, visit http://www.northeastern.edu/drc/getting-started-with-the-drc/.</p> | |

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| Diversity and Inclusion | <p>Northeastern University is committed to equal opportunity, affirmative action, diversity and social justice while building a climate of inclusion on and beyond campus. In the classroom, members of the University community work to cultivate an inclusive environment that denounces discrimination through innovation, collaboration and an awareness of global perspectives on social justice. It is my intention that students from all backgrounds and perspectives will be well served by this course, and that the diversity that students bring to this class will be viewed as an asset. I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, socioeconomic background, family education level, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class. Your suggestions are encouraged and appreciated.</p> <p>Please visit http://www.northeastern.edu/oidi/ for complete information on Diversity and Inclusion.</p> |
| TITLE IX | <p>Title IX of the Education Amendments of 1972 protects individuals from sex or gender-based discrimination, including discrimination based on gender-identity, in educational programs and activities that receive federal financial assistance.</p> <p>Northeastern’ s Title IX Policy prohibits Prohibited Offenses, which are defined as sexual harassment, sexual assault, relationship or domestic violence, and stalking. The Title IX Policy applies to the entire community, including male, female, transgender students, faculty and staff.</p> <p>In case of an emergency, please call 911.</p> <p>Please visit www.northeastern.edu/titleix for a complete list of reporting options and resources both on- and off-campus</p> |
| Contact | <p>Email: r.mohammadi@northeastern.edu TA Contact: TBD</p> |