Katz
Katz School
of Science and Health

MS in Artificial Intelligence

Course Descriptions

Artificial Intelligence

Prerequisites: Data Acquisition and Management; Computational Statistics and Probability
Artificial Intelligence (AI) is an interdisciplinary field, integrating knowledge and methods from computer science, mathematics, philosophy, psychology, economics, neuroscience, linguistics, and biology. Intelligent agents mimic cognitive functions to implement intelligent behaviors such as perception, reasoning, communication, and acting in symbolic and computational models. AI is used in a wide range of narrow applications, from medical diagnosis to speech recognition to bot control.

The autonomous single, multiple, and adversarial agents that students build in this course will support fully observable and partially observable decisions in both deterministic and stochastic environments. Topics covered include search, constraint satisfaction, Markov decision processes, planning, knowledge representation, reasoning under uncertainty, graphical models, and reinforcement learning. The techniques and technologies mastered here will provide the foundational knowledge for the ongoing study and application of AI in other applications across practice areas.

Computational Statistics and Probability

Arguably, most of data science is statistical learning, which requires strong foundational knowledge in probability and statistics. And applying computational methods such as direct simulation, shuffling, bootstrapping, and cross-validation to statistical problems is often more intuitive, and intuitive and can provide solutions where analytical methods would prove computationally intractable. This course introduces students to the statistical analysis of data using modern computational methods and software. Probability, descriptive statistics, inferential statistics and computation methods such as simulations sample distributions, shuffling, bootstrapping, and cross-validation will be covered.

Data Acquisition and Management

Data Acquisition and Management focuses on the data structures, data design patterns, algorithms, methods, and best practices for the pre-modeling phases of data science workflows, including problem formulation, gather, analyze, explore, model, and communicate, analytics programming focuses on the gather, analyze, and explore workflow steps. This comprises the “data wrangling” work which is where most data scientists spend the majority of their time. Because data science is iterative, this preparatory work informs the modeling phase. Often, the creation and validation of new models requires going back for additional data, different data transformations, and exploration of data distributions. In short, every effective data scientist needs to master analytics programming. Course topics include reading from or writing to databases, text files, and the web; shaping data into “tidy” data frames, exploratory data analysis, data imputations, feature engineering, and feature scaling.

Machine Learning

Prerequisites: Data Acquisition and Management; Computational Statistics and Probability

In classical programming, answers are obtained from rules and data. In machine learning, rules are obtained from data and answers. The widespread availability and sharing of data, and improvements in computing capacity, processing methods, and algorithms have given machine learning the power to deliver game-changing systems and technologies to organizations that compete on predictive, prescriptive, and/or autonomous analytics. In this course, we'll look at methods for using, tuning, and comparing machine learning algorithms, based on measures of performance, accuracy, and explainability. We'll also look at recent advances and trends in automated machine learning.

Neural Networks and Deep Learning

Prerequisites: Machine Learning

Data scientists have been able to leverage better algorithms on faster hardware optimized with graphical processing units to deliver improved performance and accuracy in whole classes of applications that had been previously commercially unviable. The biggest beneficiaries are applications that require unstructured data, such as audio and or video processing. Deep neural networks have also provided gains for other complex applications, from recommendation systems to natural language processing. This course builds on the concepts in machine learning to train multi-layered neural networks.

Numerical Methods

Algorithms in machine learning and neural networks are built upon a strong foundation of linear algebra. For example, modern recommendation systems may have sparse matrices with millions of users and millions of items; matrix factorization methods make the underlying calculations tractable say this course builds a foundation of linear algebra concepts such as matrices, determinants, vectors and eigen values. Then it deepens it into data science applications around network analysis and logistic algorithms. In addition, some multi-variate calculus and graph theory topics are covered.

Predictive Models

Prerequisites: Data Acquisition and Management; Computational Statistics and Probability

Predictive modeling answers the question, "What will happen next?" Linear regression and logistic regression are foundational predictive modeling methods, used to predict continuous and categorical output respectively. The main topics covered in this course include simple and multiple linear regression, variable selection and shrinkage methods, binary logistic regression, count regression, weighted least squares, robust regression, generalized least squares, multinomial logistic regression, generalized linear models, panel regression, and nonparametric regression.

Capstone for Artificial Intelligence and Machine Learning

The Capstone integrates prior coursework, research, colloquia, and professional experience, and provides the opportunity to synthesize theory with practice in an applied project, thesis, approved internship, or equivalent activity. Examples include developing an AI application or methodology, publishing a research paper at a peer-reviewed conference, or creating a startup company through YU's Innovation lab—though students may propose other related projects based on their interests.

The Capstone will include four components: a brief proposal and project schedule; the main deliverable (e.g. thesis, conference paper, working system with analysis/code/data); and a final presentation to the student and faculty body. Faculty will provide students with mentorship and feedback at each stage of the work.

Advanced Data Engineering

Prerequisites: Data Acquisition and Management

As both the volume and the velocity of data increase exponentially, problems in both commerce and research become increasingly reliant on environments with distributed data storage and data processing capabilities. This requires rethinking how our entire approach to distributed environments. This course provides students with the concepts, data structures, and algorithms needed to implement data science applications in distributed computing environments. In this course, we will implement and apply distributed algorithms, data frames, and streaming. You will also learn how to choose appropriate distributed algorithms based on the characteristics of the problem and the system.

Bayesian Methods

Prerequisites: Data Acquisition and Management; Computational Statistics and Probability

Bayesian inference provides powerful tools to model random variables. While Bayesian methods often yield the most accurate theoretical results, historically analytical complexity made it challenging to apply Bayesian methods against less trivial problems. Now, the confluence of more powerful computing resources and improved computational algorithms make Bayesian methods the best choice for tackling some of the most complex data science problems. Bayesian analysis is increasingly important in academic research, and research and is the preferred standard statistical analysis tool in data science practice. In this course, we'll build from Bayes' probability foundations to first applying Bayesian methods to infer binomial probabilities, then hierarchical models, and finally generalized linear models. We'll provide comparisons between frequentist approaches and Bayesian approaches. We'll build basic algorithms from scratch, as well as using high-performance Markov Chain Monte Carlo (MCMC) methods.

Complex Systems: Financial Time Series Analysis

Prerequisites: Data Acquisition and Management; Computational Statistics and Probability

Provides a rigorous introduction to modeling and prediction of financial time series. The goals are to learn basic characteristics of financial data, understand the application of financial econometric models, and gain experience in analyzing financial time series. We begin with the basic concepts of linear time series analysis such as stationarity and autocorrelation function, introduce regression models with time series errors, seasonality, unit-root non-stationarity, and long-memory processes. We provide methods of analysis in the presence of conditional heteroscedasticity and serial correlations of asset returns. The course introduces heavy-tailed distributions, and their application to financial risk management. In particular, we discuss modern valuations of credit risk. We introduce multivariate time series analysis and apply the concept of co-integration to investigate arbitrage opportunity in pairs trading. The course places great emphasis on empirical data analysis. We use real examples and exercises in R and Python are included. The course aims to broaden the horizons of students in applied mathematics and to provide conceptual background to students who are interested in a career in financial industry.

Data Visualization

Data scientists depend on data visualizations for their own exploratory analysis to support their modeling decisions--the mind can process visual information must faster than numbers. Data visualization is also important to inform—and often to persuade—other people about what can be inferred from the data.

These explanatory visualizations often require higher production values, interactivity, and guiding text. In this course, students apply the concepts, methods, and best practices of data visualization to create reproducible, code-based exploratory and explanatory data visualizations.

Natural Language Processing

Prerequisites: Machine Learning; Neural Networks and Deep Learning

Natural Language Processing lives at the intersection of machine learning, artificial intelligence, and linguistics. It is the key to unlocking vast amounts of human-generated, unstructured data. The increased availability of corpuses of text data, the wide availability of cheap distributed systems, improvements in neural network algorithms, and increased access to graphical processing units (GPUs) have improved the performance and accuracy of entire families of once computationally intractable problems, making these commercially feasible.

This course explores a series of text and voice processing use cases, including sentiment analysis and topic modeling. It is the key to unlocking vast amounts of human-generated, unstructured data. Along the way, students gain experience working with supervised and unsupervised methods using both machine learning algorithms and deep neural networks.

Product Studio

What is needed to convert a promising idea or research into a viable product or service? Bringing successful products to market is an experiential discipline that requires hands-on practice working through iterative workflow of a customer-driven product development lifecycle. In this course, students work with mentors to design products, develop customers, and create product development roadmaps. Students create and communicate hypotheses around customers, cost and revenue streams, activities, and value propositions. Agile project management, data-driven product design and customer feedback, and technical constraint identification are all covered.

Special Topics in Artificial Intelligence and Machine Learning

This course provides the opportunity to take on emerging theory, phenomena, and technologies in the field of artificial intelligence, machine learning, data science, and big data generally. This will be an advanced class, whether seminar style or project based.

Independent Study in Artificial Intelligence and Machine Learning

The course provides flexibility to learn more about a topic of interest outside of the formal course setting. The subject should be chosen in consultation with a faculty advisor who acts as the student's supervisor, and with the permission of the program director. The student is required to submit a course contract describing the course of study and its specific learning objectives.

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