MicroMasters A series of credit-eligible courses recognized by industry.

MicroMaster in Artificial Intelligence

Earn a MicroMasters Credential in Artificial Intelligence from Columbia University to launch your career in computer science and design the future.

Gain expertise in one of the most fascinating and fastest growing areas of computer science through an innovative online program that covers fascinating and compelling topics in the field of Artificial Intelligence and its applications. This MicroMasters Program from Columbia University will give you a rigorous, advanced, professional, graduate-level foundation in Artificial Intelligence. The program represents 25% of the coursework toward a Masters degree in Computer Science at Columbia

What is a MicroMasters Program Program?

Developed to advance a career and born from Master's programs of leading universities, MicroMasters programs are a series of higher-level courses recognized by companies for real job relevancy, and may accelerate a Master's degree.

Modules to complete the MicroMasters program:

Artificial Intelligence (AI)

Learn the fundamentals of Artificial Intelligence (AI), and apply them. Design intelligent agents to solve real-world problems including, search, games, machine learning, logic, and constraint satisfaction problems.

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

About this course

What do self-driving cars, face recognition, web search, industrial robots, missile guidance, and tumor detection have in common?

They are all complex real world problems being solved with applications of intelligence (AI).

This course will provide a broad understanding of the basic techniques for building intelligent computer systems and an understanding of how AI is applied to problems.

You will learn about the history of AI, intelligent agents, state-space problem representations, uninformed and heuristic search, game playing, logical agents, and constraint satisfaction problems.

Hands on experience will be gained by building a basic search agent. Adversarial search will be explored through the creation of a game and an introduction to machine learning includes work on linear regression.

What you'll learn

- Introduction to Artificial Intelligence and intelligent agents, history of Artificial Intelligence
- Building intelligent agents (search, games, logic, constraint satisfaction problems)
- Machine Learning algorithms
- Applications of AI (Natural Language Processing, Robotics/Vision)
- Solving real AI problems through programming with Python

Course Syllabus

Week 1: Introduction to AI, history of AI, course logistics
Week 2: Intelligent agents, uninformed search
Week 3: Heuristic search, A* algorithm
Week 4: Adversarial search, games
Week 5: Constraint Satisfaction Problems
Week 6: Machine Learning: Basic concepts, linear models, perceptron, K nearest neighbors
Week 7: Machine Learning: advanced models, neural networks, SVMs, decision trees and unsupervised learning
Week 8: Markov decision processes and reinforcement learning
Week 9: Logical Agent, propositional logic and first order logic
Week 10: AI applications (NLP)
Week 11: AI applications (Vision/Robotics)
Week 12: Review and Conclusion

Machine Learning

Master the essentials of machine learning and algorithms to help improve learning from data without human intervention.

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

About this course

Machine Learning is the basis for the most exciting careers in data analysis today. You'll learn the models and methods and apply them to real world situations ranging from identifying trending news topics, to building recommendation engines, ranking sports teams and plotting the path of movie zombies.

Major perspectives covered include:

- probabilistic versus non-probabilistic modeling
- supervised versus unsupervised learning

Topics include: classification and regression, clustering methods, sequential models, matrix factorization, topic modeling and model selection.

Methods include: linear and logistic regression, support vector machines, tree classifiers, boosting, maximum likelihood and MAP inference, EM algorithm, hidden Markov models, Kalman filters, k-means, Gaussian mixture models, among others.

In the first half of the course we will cover supervised learning techniques for regression and classification. In this framework, we possess an output or response that we wish to predict based on a set of inputs. We will discuss several fundamental methods for performing this task and algorithms for their optimization. Our approach will be more practically motivated, meaning we will fully develop a mathematical understanding of the respective algorithms, but we will only briefly touch on abstract learning theory.

In the second half of the course we shift to unsupervised learning techniques. In these problems the end goal less clear-cut than predicting an output based on a corresponding input. We will cover three fundamental problems of unsupervised learning: data clustering, matrix factorization, and sequential models for orderdependent data. Some applications of these models include object recommendation and topic modeling.

What you'll learn

- Supervised learning techniques for regression and classification
- Unsupervised learning techniques for data modeling and analysis
- Probabilistic versus non-probabilistic viewpoints
- Optimization and inference algorithms for model learning

Course Syllabus

Week 1: maximum likelihood estimation, linear regression, least squares
Week 2: ridge regression, bias-variance, Bayes rule, maximum a posteriori inference
Week 3: Bayesian linear regression, sparsity, subset selection for linear regression
Week 4: nearest neighbor classification, Bayes classifiers, linear classifiers, perceptron
Week 5: logistic regression, Laplace approximation, kernel methods, Gaussian processes
Week 6: maximum margin, support vector machines, trees, random forests, boosting
Week 7: clustering, k-means, EM algorithm, missing data
Week 8: mixtures of Gaussians, matrix factorization
Week 9: non-negative matrix factorization, latent factor models, PCA and variations
Week 10: Markov models, hidden Markov models
Week 11: continuous state-space models, association analysis
Week 12: model selection, next steps

Robotics

Learn the core techniques for representing robots that perform physical tasks in the real world.

Columbia University in the City of New York

About this course

We think of Robotics as the science of building devices that physically interact with their environment. The most useful robots do it precisely, powerfully, repeatedly, tirelessly, fast, or some combinations of these. The most interesting robots maybe even do it intelligently. This course will cover the fundamentals of robotics, focusing on both the mind and the body.

We will learn about two core robot classes: kinematic chains (robot arms) and mobile bases. For both robot types, we will introduce methods to reason about 3-dimensional space and relationships between coordinate frames. For robot arms, we will use these to model the task of delivering a payload to a specified location. For mobile robots, we will introduce concepts for autonomous navigation in the presence of obstacles.

Class projects will make use of ROS - the open-source Robot Operating System (www.ros.org) widely used in both research and industry. Computer requirements for working on the projects will include a computer set up with Ubuntu Linux and high bandwidth internet access for downloading and installing ROS packages.

What you'll learn

- Represent 2D and 3D spatial relationships, homogeneous coordinates
- Manipulate robot arms: kinematic chains, forward and inverse kinematics, differential kinematics
- Program and navigate mobile robots: robot and map representations, motion planning
- Plan complete robot systems
- Develop present and future applications for robots

Course Syllabus

Week 1

- Introduction to Robotics
- Homogenous coordinates and transform representations

Week 2

- Kinematic chains
- Forward kinematics

Week 3

- Inverse kinematics: analytical methods

Week 4

- Differential kinematics: Jacobian computation, singular configurations

Week 5

- Configuration space operation

Week 6

- Mobile robots
- Differential drive kinematics

Week 7

- Motion planning in robotics

Animation and CGI Motion

Learn the science behind movie animation from the Director of Columbia's Computer Graphics Group.

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

About this course

How do you create realistic animations? It's key to the success of animated films to insure audiences believe in characters.

This course will show you how to create lifelike animations focusing on the technical aspects of CGI animation and also give you a glimpse into how studios approach the art of physically-based animation.

You will learn the fundamental concepts of physical simulation, including:

1. integration of ordinary differential equations such as those needed to predict the motion of a dress in the wind.
2. formulation of models for physical phenomena such as crumpling sheet metal and flowing water.
3. treatment of discontinuities such as fractures and collisions.
4. simulation of liquids and solids in both Lagrangian and Eulerian coordinates.
5. artistic control of physically-based animations.

These concepts will be put into practice in the programming assignments spanning:

- Discretizing and integrating Newton's equations of motion
- Constrained Lagrangian Mechanics
- Collisions, contact, and friction: detection and response
- Continuum mechanics
- Finite elements
- Rigid body simulation
- Thin shell and cloth simulation
- Elastic rod and hair simulation

- Fluid simulation
- Control of physical simulations

What you'll learn

- To code your own physics simulator to master the fundamental algorithms for creating lifelike animations clothing, hair, liquids, rigid bodies and more!
- Temporal integration of the equations of motion
- Formulation of mathematical models for mechanical systems
- Numerical methods for treating contact and impact
- Lagrangian and Eulerian representations of continua control of physical models

Course Syllabus

The coursework will focus on seven themes. Each theme is divided into weekly assignments, or "milestones." Each milestone will include successful implementation of new technical features, and an artistic scene that demonstrates these features.

Theme 01: Mass-spring systems, in which you will implement point masses, gravity, springs, dampers, time integrators (explicit Euler, symplectic Euler, linearized implicit Euler).

Theme 02: Collision handling, in which you will implement detection against fixed obstacles (discs, half-planes, polygonal objects), response against fixed obstacles (using reflection with a coefficient of restitution, and penalty methods), advanced pairwise detection between polygonal objects, and broad-phase accelerations using spatial hashing and hierarchical bounding volumes.

Theme 03: Rigid bodies, in which you will implement computations of center of mass and moment of intertia for polygonal objects, time integration for rigid bodies, and contact with fixed obstacles.

Theme 04: Elastica, in which you will implement the constant strain finite element, a discrete bending force for polygonal objects, and plastic and viscous flow.

Theme 05: Control, in which you will implement a controller for balance and locomotion of an under actuated character.

Theme 06: Fluids, in which you will implement a fast and stable fluid simulation including advection, convection, and viscocity, in an Eulerian framework.

Theme 07: Project, in which you are the boss.