SUNY Polytechnic Institute ***Spring 2026***
CS 540 Artificial Intelligence

Instructor: *Dr. Jorge Novillo*
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Office Hours: Monday & Wednesday 12:00-2:00 p.m. Office or Virtual
Tuesday 2:30-4:30 p.m. Virtual
and/or by appointment

References: *Machine Learning Specialization, Prof. Andrew Ng, Coursera*
Mathematics for Machine Learning, Coursera
Audit [free] or Certificate [highly recommended]

Why Machines Learn – The Elegant Math Behind Modern AI
Anil Ananthanswamy, Dutton 2024 [under the hood - highly recommended]

Google AI Studio Pro (free to students - useful)

Overview: '*Reasoning is but reckoning*' *said Hobbes in 1651. Since then, philosophers have been grappling with the problem of modeling and mechanizing intelligence. With the advent of the Internet and Big Data as well as fast AI Chips, major strides have been made, and some aspects of these inquiries are now so well understood that they have become an engineering task. This course introduces some of the fundamental problems of Artificial Intelligence and the techniques to solve them. Emphasis on Machine Learning and the mathematics that enables it.*

Outline: *The first half is application-driven with code and intuition (MLS) and the second half formalizes those intuitions mathematically (MfML).*

Weeks 1–7: Machine Learning Specialization (concepts + practice) (MLS)
Weeks 8–14: Mathematics for Machine Learning and Data Science (MfML)

Week 1 – What is ML, linear regression

- *MLS Course 1 (Supervised ML: Regression and Classification), Week 1: supervised vs unsupervised, regression vs classification, univariate linear regression, cost, gradient descent.*

Week 2 – Multivariate regression, feature scaling

- *MLS C1 Week 2: multivariate linear regression, feature scaling, vectorization.*

Week 3 – Logistic regression, regularization

- *MLS C1 Week 3: logistic regression for classification, decision boundaries, overfitting, regularization.*

Week 4 – Trees, ensembles, practical issues

- *MLS Course 2 (Advanced Learning Algorithms), Week 1: decision trees; Week 2: tree ensembles (random forests, XGBoost).*

Week 5 – Neural networks as function approximators

- *MLS C2 Weeks 3–4: basic neural networks, training via gradient descent, intro to modern deep learning frameworks.*

Week 6 – Unsupervised learning, recommender systems

- *MLS Course 3 (Unsupervised Learning, Recommenders, RL), Weeks 1–2: k-means, anomaly detection; content-based/collaborative filtering recommenders.*

Week 7 – Intro RL + ML strategy, midterm

- *MLS C3 Week 3: basic RL ideas (bandits / simple MDP sense); Week 4: end-to-end ML case studies.*

Weeks 8–14: Mathematics for Machine Learning and Data Science (MfML)

Focus on: linear algebra foundations → calculus for optimization → probability/statistics for generalization, always tied back to models used in Weeks 1–7.

Week 8 – Linear algebra I: vectors, matrices, systems

- *MfML Course 1 (Linear Algebra), Weeks 1–2: systems of linear equations, matrices, rank, basic vector/matrix operations, linear transformations.*
    - *Prove or at least discuss conditions for uniqueness of the least-squares solution.*

Week 9 – Linear algebra II: eigenvalues, eigenvectors, SVD

- *MfML C1 Weeks 3–4: eigenvalues/eigenvectors, diagonalization, SVD; labs on eigen-based methods.*

Week 10 – Calculus for optimization

- *MfML Course 2 (Calculus for ML and DS), early weeks: partial derivatives, gradients, Jacobians, gradient descent interpretation.*

Week 11 – Multivariate calculus and constraints

- *MfML C2 later weeks: chain rule in multiple dimensions, Hessians, optimization landscapes; brief mention of constrained optimization / Lagrange multipliers if you like.*

Week 12 – Probability basics for ML

- *MfML Course 3 (Probability & Statistics for ML), Weeks 1–2: random variables, distributions, expectation, variance, covariance.*

Week 13 – Statistics: estimation, confidence, generalization

- *MfML C3 Weeks 3–4: parameter estimation, sampling, central limit theorem, confidence intervals.*

Week 14 – Synthesis and mini-projects

    - *Student-run mini-talks: "The math behind X" where X is linear regression, logistic regression, k-means, PCA, or a simple NN, tying together MLS and MfML tools.*
    - *Final exam or project presentations emphasizing both use and understanding of the math.*

Grading: Exams (70%), project (30%).