The Ohio State University
Department of Electrical and Computer Engineering

ECE 4300 — INTRODUCTION TO MACHINE LEARNING FOR ECE — Sp20

Instructor: Prof. Phil Schniter, 616 Dreese Labs, schniter.1@osu.edu

Assistant: Ms. PG Guan, guan.219@buckeyemail.osu.edu

Lectures: MWF 8:00–8:55am in Baker Systems 188

Office Hours: **TBD**

Prerequisites: Undergraduate in ECE Major
CSE 1222 or ENGR 1281 (Programming in C/C++)
Math 2568 (Linear Algebra)
Stats 3470 (Probability & Statistics for Engineers)

Materials: Instructor's notes (see http://carmen.osu.edu)

Optional: 1) G. James, D. Witten, T. Hastie, and R. Tibshirani, *An Introduction to Statistical Learning*, Springer, 2013. (Free at http://faculty.marshall.usc.edu/gareth-james/ISL/)
2) S. Raschka, *Python Machine Learning, 3rd Ed.*, Packt Publishing Ltd, 2019. ($5 at https://www.packtpub.com/)
3) A. Géron, *Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow*, O'Reilly, 2019.
4) J. VanderPlas, *Python Data Science Handbook*, O'Reilly, 2017. (Free at https://jakevdp.github.io/PythonDataScienceHandbook/)
5) E. Stevens and L. Antiga, *Deep Learning with PyTorch*, Manning, 2020. (Free at https://www.manning.com/books/deep-learning-with-pytorch)

Course Goals: Formulate and solve linear regression problems.
Formulate and solve linear classification problems using logistic regression.
Formulate and solve clustering problems using k-means.
Understand over-fitting, cross-validation, model-order selection, feature selection, neural networks, ensemble methods, PCA.
Gain experience with optimization and probabilistic models.
Implement basic machine-learning tasks in Python/sklearn/PyTorch.

Grading:

Homework and labs	40%
Midterm exams	2× 20%
Final project	20%

Homework: Homework and Python labs will be assigned and collected on a regular basis. Assignments and due dates will be posted on Carmen. Late homework will receive no credit unless an exception is made in advance.

Exams/Project: The exams will be closed-book a few pages of handwritten notes allowed. The tentative midterm exam dates are **2/19/19** and **4/17/19**. A final project will also be assigned. (Details will be provided.)

Collaboration: Because the purpose of homework and labs is to improve your understanding of course material, discussions on homework and related course material among students *are permitted*. However, all submitted written work must be your own. Absolutely no collaboration of any kind is allowed on the exams.

Misconduct: Academic integrity is essential to maintaining an environment that fosters excellence in teaching, research, and other educational and scholarly activities. Thus, The Ohio State University and the Committee on Academic Misconduct (COAM) expect that all students have read and understand the University's Code of Student Conduct, and that all students will complete all academic and scholarly assignments with fairness and honesty. Students must recognize that failure to follow the rules and guidelines established in the University's Code of Student Conduct and this syllabus may constitute "Academic Misconduct."

The Ohio State University's Code of Student Conduct (Section 3335-23-04) defines academic misconduct as: "Any activity that tends to compromise the academic integrity of the University, or subvert the educational process." Examples of academic misconduct include (but are not limited to) plagiarism, collusion (unauthorized collaboration), copying the work of another student, and possession of unauthorized materials during an examination. Ignorance of the University's Code of Student Conduct is never considered an "excuse" for academic misconduct, so I recommend that you review the Code of Student Conduct and, specifically, the sections dealing with academic misconduct.

If I suspect that a student has committed academic misconduct in this course, I am obligated by University Rules to report my suspicions to the Committee on Academic Misconduct. If COAM determines that you have violated the University's Code of Student Conduct (i.e., committed academic misconduct), the sanctions for the misconduct could include a failing grade in this course and suspension or dismissal from the University.

If you have any questions about the above policy or what constitutes academic misconduct in this course, please contact me.

Other sources of information on academic misconduct (integrity) to which you can refer include:

- Academic Misconduct Information for Students
  (https://oaa.osu.edu/academic-integrity-and-misconduct/student-misconduct)
- Eight Cardinal Rules of Academic Integrity
  (https://www.northwestern.edu/provost/policies/academic-integrity/cardinal-rules.html)

Disabilities: Students with disabilities that have been certified by the Office for Disability Services will be appropriately accommodated, and should inform the instructor as soon as possible of their needs. The Office for Disability Services is located in 098 Baker Hall, 113 W. 12th Ave.; telephone 292-3307, TDD 292-0901; `https://slds.osu.edu`.

Tentative Outline

Topic	Lectures
Introduction to Machine Learning Examples of ML problems (e.g., digit recognition, face detection, spam detection, stock prediction). Typical ML problems: classification, regression, clustering.	1
Linear Regression Scatterplots, sample mean/variance/covariance/corr-coef, residual sum-of-squares. Review of linear algebra and multivariable calculus. Matrix representation of linear regression, standardization. Zeroing gradient, least-squares solution. Sample covariance matrices. Polynomial regression. Python: loading data, scatterplots, arrays, sklearn.	5
Model-Order Selection, Feature Selection, LASSO Underfitting, overfitting, bias-variance tradeoff, cross-validation. Ridge regression, LASSO, coefficient path. ML and MAP estimation. Exhaustive and greedy feature selection. Python: polynomial fitting, LASSO, applying to data.	6
Optimization Cost function, gradient, Taylor approximation, stationary points, gradient descent, stepsize, convergence, Armijo rule, convexity. Python: training logistic regression.	3
Linear Classification Binary linear classifier, perfect separability. Logistic model, likelihood function, maximum likelihood estimation. Feature transformations. Multinomial logistic, softmax. Geometry of the linear classification boundary, maximum-margin classification, support vector classifier, hinge loss, support vector machine, kernel trick, RBF kernel. Python: implementing logistic regression, SVM, applying to data.	6
Neural Networks Two-stage feedforward networks. Activation functions: sigmoid, ReLU. Minibatch training, SGD, back-propagation, computation graph. Deep networks, ImageNet. 2D convolution, convolutional layers, dense layers, subsampling, pooling, tensors, backpropagation, GPUs, batch-norm, dropout, data augmentation, transfer learning, AlexNet, VGG, Inception, ResNet. Pytorch: MNIST, Image classification.	8
Ensemble Methods Intuitions, bagging, pasting, random feature selection, decision trees, top-down induction, homogeneity, random forests, boosting, Adaboost, gradient boosting, Python.	2
Principal Components Analysis Dimensionality reduction, orthogonal projection, PCA, sample covariance, eigenvectors/values, Eckart-Young, SVD Python: eigenfaces, face recognition.	2
Clustering Clustering, K-means, Lloyd's alg, K-means++, confusion matrix, non-negative matrix factorization. Gaussian-mixture models, EM algorithm. Python: Bag-of-words, TF-IDF, topic modeling, color quantization.	3
Midterms and Review	5