Units: 4

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Office Hours: TBD

TA / Grader: TBD

Lecture: Monday, Wednesday, 4:00 – 5:50 PM in DMC 157

Discussion/Lab: TBD

Prereq: EE151L Introduction to Programming for Electrical Engineers
Or one of BME 210, CE 108, CHE 305, CSCI 103, ISE 150, ITP 115, ITP 165, ITP 168
(or equivalent proficiency, e.g., C++, Matlab, Python)
E141L Applied Linear Algebra for Engineering (or MATH 225 or MATH 235)
EE364 Probability and Statistics for EE/CS (or MATH 407)

Useful, but not required: EE301L

Other Requirements: Basic computer skills (e.g., plotting, Python or Matlab or other).

Grading:
30% Homework
10% Quiz 1
10% Quiz 2
20% Midterm Exam
30% Final Project

Learning Objectives: Upon successful completion of this course a student will

- Be able to identify machine learning according to the taxonomy of supervised, unsupervised, reinforcement learning, etc.
- Apply methods of linear and nonlinear methods of regression or classification to data sets
- Apply principle component analysis to datasets and determine a reasonable amount of dimensionality reduction
- Select appropriate methods of optimization to train machine learning systems
- Apply data engineering concepts, such as cleaning, labeling, augmentation, to design and improve data sets for machine learning applications
• Be able to use Python-based machine learning tools, such as scikit-learn, Tensorflow, PyTorch to design machine learning solutions and evaluate the associated performance

Exam Dates:
• Quiz 1: TBD
• Quiz 2: TBD
• Midterm Exam: TBD
• Final Project Presentation/Report: Wednesday, May 1, 4:30 – 6:30 (university final exam slot)

Textbooks:
• Required Textbooks:

• Optional Textbooks:
  – Michael Nielsen, *Neural Networks and Deep Learning*
  – Tensorflow online documentation and examples
Course Outline

1. Introduction and Motivation [Watt Chapters 1 and 2]
   (a) ML definitions, problem statements, and tools
   (b) Global/Local Optimization, Curse of Dimensionality
   (c) Comparison to inference methods based on statistical models
   (d) Applications of ML

2. Overview of Optimization Methods [Watt Chapters 2.1-2.5, 3.1-3.5, 4.1, 4.3]
   (a) Global/Local Optimization, Curse of Dimensionality
   (b) Zero order methods
   (c) Gradient decent
   (d) Second order methods
   (e) Autograd tools in Python

3. Regression [Watt Chapters 3.1-3.5, 5.1-5.2, 5.6]
   (a) Linear regression
   (b) Linear regression review from EE364 and EE141L
   (c) Multiple-output regression
   (d) Alternative loss functions

4. Introduction to Data Engineering [Watt Chapters 11.1-4, 11.7-11.8, 11.10]
   (a) Over-fitting
   (b) Under-fitting
   (c) Regularization
   (d) Cross-validation
   (e) augmentation
   (f) Data formats and common data sets.

5. Classification [Watt Chapters 6.1-6.4, 7.1-7.4, 7.6]
   (a) Linear regression for 2-class classification
   (b) Logistic regression and the perceptron
   (c) Cross-entropy loss
   (d) Multi-class classification
   (e) Example: digital modulation classification

QUIZ 1

   (a) Sufficient statistics and features
   (b) Principle Component Analysis
(c) K-mean clustering
(d) Example: common features in audio signal processing

   (a) Nonlinear regression
   (b) Nonlinear classifiers

8. Introduction to Kernel Machine [Watt Chapter 12 ]
   (a) Universal approximation property
   (b) Kernel trick
   (c) Optimization and learning methods

QUIZ 2

9. Introduction to Neural Networks [Watt Chapter 13, Neilson ]
   (a) Multilayer perceptions (MLPs)
   (b) Activation functions
   (c) Backpropogation learning

    (a) Regression trees
    (b) Classification trees
    (c) Random forests

11. Deep Learning (Neural Networks) [Slides, Tensorflow tutorials/docs ]
    (a) Optimizers
    (b) Regularizers
    (c) Training and evaluation of MLPs in TensorFlow

MIDTERM

12. Convolutional Neural Networks [Slides, Tensorflow tutorials/docs ]
    (a) CNN architectures and conventions
    (b) Applications to computer vision problems

13. Recurrent Neural Networks [Slides, Tensorflow tutorials/docs ]
    (a) RNN architectures and conventions
    (b) Applications to nonlinear filtering

14. Attention mechanisms [Slides, Tensorflow tutorials/docs ]
    (a) Attention as an alternative to state
    (b) Introduction to transformers
(c) Example capabilities of Large Language Models (LLMs)

15. Selected Advanced Topics (time allowing) [Slides, Tensorflow tutorials/docs]

(a) Introduction to reinforcement learning
(b) Introduction to generative models (GANs, diffusion)
(c) Example capabilities of text-to-image systems and deep fakes
Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism: presenting someone else’s ideas as your own, either verbatim or recast in your own words is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct.

Support Systems:

Student Health Counseling Services – (213) 740-7711, 24/7 on call. Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline – 1 (800) 273-8255, 24/7 on call suicidepreventionlifeline.org Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) – (213) 740-4900, 24/7 on call Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) and Title IX – (213) 740-5086 Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support – (213) 740-2421 Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

The Office of Disability Services and Programs – (213) 740-0776 Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy – (213) 821-4710 Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC – (213) 740-2101 Information on events, programs and training, the Provost’s Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000, 24/7 on call Emergency assistance and
avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be
continued if an officially declared emergency makes travel to campus infeasible.

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emergency assistance or information.