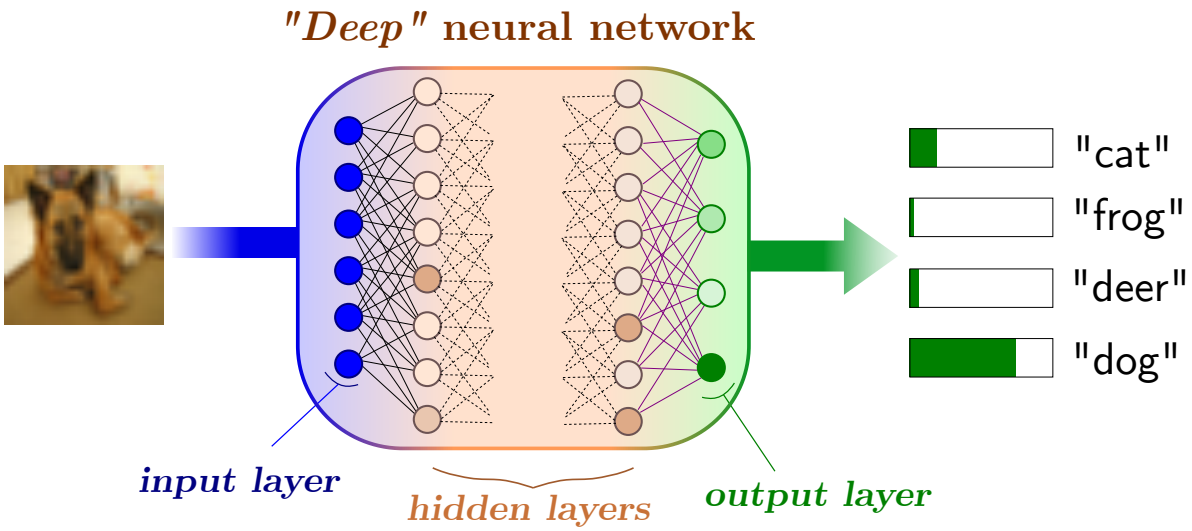
APM 598: **Introduction to deep neural networks**



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School of Mathematical and Statistical Sciences

Office hours: Tu,Th 1:30-2:30pm

Zoom link: `https://asu.zoom.us/j/9536528707`

Course Description

Introduction to neural networks, covering feedforward, convolutional, recurrent architectures and transformers. Topics include backpropagation, regularization, optimization techniques (stochastic gradient descent). Applications in data classification (image recognition), natural language processing, and image generation. Hands-on implementation using frameworks like PyTorch. A course in Linear Algebra, Calculus and basic programming skills (Python) are recommended prior to enrollment.

Course Objective

The goal of this course is to give a practical understanding of deep neural networks. We will use classification problems to illustrate and test different network architectures. After a brief introduction about machine learning, we first present how to train simple neural networks using stochastic gradient descent and backpropagation. Then, we focus

on Convolutional Neural Networks (CNN) for image classification and Recurrent Neural Networks for language modeling. It time allows, we will also discuss diffusion models and graph CNN.

Most of the examples and codes will be written in Python and deep neural networks will be implemented using Pytorch. However, students are welcome to use other frameworks such as TensorFlow.

The course is divided in four parts:

1) Brief review about machine learning and first training of a two-layer neural networks.

2) Convolutional Neural Networks (CNN) for image classification.

3) Natural Language Processing (NLP) with RNN and Transformer

4) (it time allows) Diffusion models, Graph convolutional networks

Expected Learning Outcomes

By the end of the course, students will:

- Implement simple deep learning models using frameworks like PyTorch.
- Analyze and evaluate different neural network architectures and their performance.
- Apply neural networks to solve real-world problems in various domains such as image processing, NLP, and data classification.

Assignment and Grade policies

- There will be **four homework** assignments, each covering a different part of the course. Each assignment will include an analytical component to test comprehension of the material, and a numerical component where students will implement and test various algorithms.
- **Final project**: A group or individual project that involves designing, training, and evaluating a deep neural network for a specific task. The final project can be presented as either a 30 minutes presentation or a 10 pages manuscript.

Assignment	**Percentage**
4 Homework assignment	50%
Final Project	50%
Total	100%

Grading scale

97.0 thru 100	=	A+
93.0 thru 96.9	=	A
90.0 thru 92.9	=	A-
87.0 thru 89.9	=	B+
83.0 thru 86.9	=	B
80.0 thru 82.9	=	B-
77.0 thru 79.9	=	C+
70.0 thru 76.9	=	C
60.0 thru 69.9	=	D (Not accepted by department)
Less than 60.0	=	E (Failure - no credit)

Readings, Activities, Special Materials

- **Textbooks**
  - A. Zhang, Z. Lipton, M. Li, A. Smola, *"Dive into Deep Learning"*
  - A. Géron, *"Hands-On Machine Learning with Scikit-Learn and TensorFlow"*
- **Activities**
  - In-class coding session (using notebooks)
- **Special Materials**
  - Students can require access to the Sol super-computer.

Tentative schedule

	Lectures	Topic
Intro. ML	lecture 1	Data/Model/Loss
	lecture 2	Minimizing the loss
	lecture 3	Overfitting, classification
	lecture 4	Linear classifier, stochastic gradient descent
	Notebook 1	MNIST
	lecture 5	Non-linear classifiers
	lecture 6	Multiperceptron
CNN	lecture 7	Intro. Convolutional Neural Networks
	lecture 8	Implementation CNN
	Notebook 2	CNN
	lecture 9	Overfitting
	Notebook 3	deep network CNN
NLP	lecture 10	Intro. Language modeling
	lecture 11	N-gram models
	lecture 12	Recurrent neural networks
	Notebook 4	n-gram and RNN
	lecture 13	Recurrent neural networks (LSTM)
	lecture 14	Word embeddings (1)
	lecture 15	Word embeddings (2)
	Notebook 5	Word embedding
	lecture 16	Attention mechanism
	lecture 17	Transformer
	lecture 18	Transformer and word embedding
	Notebook 6	Transformer
Extra	lecture 19	Intro. diffusion model
	lecture 20	Reverse diffusion
	lecture 21	Intro. Graphs
	lecture 22	Convolution/pooling on graphs

Instructor's General Policy

Regular attendance is expected. Students are expected to actively participate in discussions and activities, maintain a respectful and collaborative environment, and refrain from disruptive behavior, such as using devices for non-class activities during lectures.

Make-up Work Policy

Students who miss class due to valid reasons (such as illness, emergencies, or university-sanctioned events) are responsible for contacting the instructor as soon as possible to arrange make-up work. Make-up work must be completed within ten days after the student's return to class unless other arrangements have been made. It is the student's responsibility to review any missed material, and they are encouraged to collaborate with classmates and visit office hours for additional support.

Accommodation for Religious Practices

The university community should, in all its activities, be sensitive to the religious practices of the various religious faiths represented in its student body and employees. Faculty are asked to recognize the obligations of their students who may be participating in the observance of religious holidays. Students should notify faculty at the beginning of the semester about the need to be absent from class due to religious observances. For more information, visit https://public.powerdms.com/ASU/documents/1541225.

Missed Classes Due to University-Sanctioned Activities

Students who participate in university-sanctioned activities that require classes to be missed, shall be given opportunities to make up examinations and other graded in- class work. Normally, the made-up work will be due on the class day after the immediately after the absence. Absence from class or examinations due to university- sanctioned activities does not relieve students from responsibility for any part of the course work required during the period of the absence. For more information, visit:
https://public.powerdms.com/ASU/documents/1557490.

Academic Integrity/Anti-Plagiarism Policy

Plagiarism of any kind will not be tolerated. Students must take the exams independently without assistance from other students. Students may not submit papers written by persons other than themselves. Students must submit original work for this course and may not submit papers previously submitted to (an)other class(es). The ASU student academic integrity policy lists violations in detail. These violations fall into five broad areas that include but are not limited to: (1) Cheating on an academic evaluation or assignment; (2) Plagiarizing; (3) Academic deceit, such as fabricating data or information; (4) Aiding academic integrity policy violations and inappropriately collaborating; (5) Falsifying academic records. See https://provost.asu.edu/academic-integrity.

Disruptive, Threatening or Violent Behavior

In the classroom and out, students are required to conduct themselves in a manner that promotes an environment that is safe and conducive to learning and conducting other university-related business. All incidents and allegations of violent or threatening conduct by an ASU student will be reported to the ASU Police Department (ASU PD) and the Office of the Dean of Students. Such incidents will be dealt with in accordance with the policies and procedures described in Section 104-02 of the Student Services Manual, available at https://public.powerdms.com/ASU/documents/1560490.

Disability Accommodation

If you are a student with a disability and have need of assistance or special accommodations, contact Student Accessibility and Inclusive Learning Services (SAILS): https://eoss.asu.edu/accessibility. Students requesting accommodations for a disability must register with SAILS, and must submit appropriate documentation to the instructor from SAILS. For more information, please review the policy at: https://public.powerdms.com/ASU/documents/1560607.

Copyright

Students must refrain from uploading to any course shell, discussion board, or website used by the course instructor or other course forum, material that is not the student's original work, unless the students first comply with all applicable copyright laws; faculty members reserve the right to delete materials on the grounds of suspected copyright infringement. For more information, see the Computer, Internet, & Electronic Communications Policy at https://public.powerdms.com/ASU/documents/1540286.

Prohibition Against Discrimination, Harassment, and Retaliation

Title IX is a federal law that provides that no person be excluded on the basis of sex from participation in, be denied benefits of, or be subjected to discrimination under any education program or activity. Both Title IX and university policy make clear that sexual violence and harassment based on sex is prohibited. An individual who believes they have been subjected to sexual violence or harassed on the basis of sex can seek support, including counseling and academic support, from the university. If you or someone you know has been harassed on the basis of sex or sexually assaulted, you can find information and resources at http://sexualviolenceprevention.asu.edu/faqs.

As a mandated reporter, I am obligated to report any information I become aware of regarding alleged acts of sexual discrimination, including sexual violence and dating violence. ASU Counseling Services, https://eoss.asu.edu/counseling, is available if you wish to discuss any concerns confidentially and privately.