Georgia Institute of Technology

Course Syllabus: CS7643 Deep Learning

Fall 2021

Delivery: 100% Web-Based on Canvas, with submissions on Canvas/Gradescope

Dates course will run: August 23, 2021 – December 16, 2021

Instructor Information

Dr. Kira Zsolt

Email: zkira@gatech.edu

General Course Information

Description

Deep learning is a sub-field of machine learning that focuses on learning complex, hierarchical feature representations from raw data. The dominant method for achieving this, artificial neural networks, has revolutionized the processing of data (e.g. images, videos, text, and audio) as well as decision-making tasks (e.g. game-playing). Its success has enabled a tremendous amount of practical commercial applications and has had a significant impact on society.

In this course, students will learn the fundamental principles, underlying mathematics, and implementation details of deep learning. This includes the concepts and methods used to optimize these highly parameterized models (gradient descent and backpropagation, and more generally computation graphs), the modules that make them up (linear, convolution, and pooling layers, activation functions, etc.), and common neural network architectures (convolutional neural networks, recurrent neural networks, etc.). Applications ranging from computer vision to natural language processing and decision-making (reinforcement learning) will be demonstrated. Through in-depth programming assignments, students will learn how to implement these fundamental building blocks as well as how to put them together using a popular deep learning library, PyTorch. In the final project, students will apply what they have learned to real-world scenarios by exploring these concepts with a problem that they are passionate about.

Pre- &/or Co-Requisites

It is recommended that students have a strong mathematical background (linear algebra, calculus especially taking partial derivatives, and probabilities & statistics) and at least an introductory course in Machine Learning (e.g. equivalent to CS 7641). This should **not** be your first ML class, and self-study (e.g. online Coursera/Udacity courses) do not count. **Strong** programming skills (specifically Python) are necessary to complete the assignments.

Course Objectives

- Describe the major differences between deep learning and other types of machine learning algorithms.
- Explain the fundamental methods involved in deep learning, including the underlying optimization concepts (gradient descent and backpropagation), typical modules they consist of, and how they can be combined to solve real-world problems.

- Differentiate between the major types of neural network architectures (multi-layered perceptrons, convolutional neural networks, recurrent neural networks, etc.) and what types of problems each is appropriate for.
- Select or design neural network architectures for new data problems based on their requirements and problem characteristics and analyze their performance.
- Describe some of the latest research being conducted in the field and open problems that are yet to be solved.

Course Materials

Course Text

Deep Learning, by Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press. Available **online**.

Additional Materials/Resources

All additional reading materials will be available via PDF on Canvas.

Course Website and Other Classroom Management Tools

All course materials and videos are located on Canvas.

Course Requirements, Assignments & Grading

Assignment Distribution and Grading Scale

Assignments	Weight
On-Boarding Quiz	(required to verify identity using proctoring software)
Assignments (4)	55%
Quizzes (equally weighted)	20%
Final Project (including proposal)	20%
Class Participation (Graded Discussions & Ed Discussions Participation)	5%

Grading Scale

Your final grade will be assigned as a letter grade, with ***at least*** the following grades (i.e., 90 or greater will definitely be an A).

A	90-100%
B	80-89%
C	70-79%
D	60-69%
F	0-59%

Assignment Due Dates

All assignments are due at the day posted on Canvas, and at 11:59:00pm AOE on the date posted unless otherwise noted. All assignments are due relative to Anywhere on Earth (AOE). We will not accept assignments submitted late due to time zone issues. You should update your canvas to account for AOE if you are in a different time zone. There are no exceptions.

Every homework deliverable and project deliverable will have a 48-hour **grace period** during which no penalty will apply. This is intended to allow you time to verify that your submission has been submitted (we recommend you re-download it and look it over to make sure all questions/deliverables have been answered). Canvas will show your submission as late, but you do not have to ask for this grace period. **Deliverables after the grace period will receive a grade of 0.** There is no grace period for taking quizzes or finishing discussions.

Project

The project will be a group project, with 3-4 members recommended (instructor permission is needed for less than two or more than five, and a strong justification will be needed for approval). The class project is meant for students to (1) gain experience implementing deep models and (2) try Deep Learning on problems that interest them. The amount of effort should be at the level of one homework assignment per group member (2-4 people per group). A PDF write-up describing the project in a self-contained manner will be the sole deliverable. Your final write-up will be structured like a paper from a computer vision conference (CVPR, ECCV, ICCV, etc.). We will release this template as well as rubric. Additionally, we will allow people to upload additional code, videos and other supplementary material similar to code upload for assignments. While the PDF may link to supplementary material, external documents and code, such resources may or may not be used to evaluate the project. The final PDF should completely address all of the points in the rubric that will be released.

Late and Make-up Work Policy

There will be no make-up work provided for missed assignments. Of course, emergencies (illness, family emergencies) will happen. In those instances, please contact the Dean of Students office. The Dean of Students is equipped to verify emergencies and pass confirmation on to all your classes. For consistency, we ask all students to do this in the event of an emergency. Do not send any personal/medical information to the instructor or TAs; all such information should go through the Dean of Students.

Technology Requirements and Skills

Computer Hardware and Software

- High-speed Internet connection
- Laptop or desktop computer with a minimum of a 2 GHz processor and 4 GB of RAM
- CUDA compatible GPU is helpful for assignments but not necessary.
- UNIX-like OS experience is recommended (Linux/iOS)
- Windows/Linux for PC computers OR Mac iOS for Apple computers.
- Complete Microsoft Office Suite or comparable and ability to use Adobe PDF software (install, download, open and convert)
- Mozilla Firefox, Chrome browser, and/or Safari browsers (Chrome required for on-boarding quiz)

Canvas

This class will use Canvas to deliver course materials to online students. ALL course materials and quiz/discussion assessments will take place on this platform. Gradescope will be used for submission of assignments and the project.

Proctoring Information

In order to verify the identity of all GT online students, all online students are *required* to complete the onboarding quiz that uses Honorlock. Honorlock is utilized for student identity verification and to ensure academic integrity. Honorlock provides student identity verification via facial and ID photos. You may also be asked to scan the room around you. The onboarding quiz will be a practice quiz that will not affect your grade in the course. You can take the onboarding quiz as many times as you want. All potential violations are reviewed by a human. The Honorlock support team is available 24/7. While Honorlock will not require you to create an account, download software, or schedule an appointment in advance, you will need Google Chrome and download the Honorlock Chrome Extension. Information on how to access Honorlock and additional resources are provided below. You can also access Honorlock support at https://honorlock.com/support/.

Course Policies, Expectations & Guidelines

Communication Policy

You are responsible for knowing the following information:

1. Anything posted to this syllabus
2. Anything emailed directly to you by the teaching team (including announcements via Ed Discussions), 24 hours after receiving such an email or post.

Because Ed Discussions announcements are emailed to you as well, you need only to check your Georgia Tech email once every 24 hours to remain up to date on new information during the semester. Georgia Tech generally recommends students to check their Georgia Tech email once every 24 hours. So, if an announcement or message is time sensitive, you will not be responsible for the contents of the announcement until 24 hours after it has been sent.

Online Student Conduct and (N)etiquette

Communicating appropriately in the online classroom can be challenging. All communication, whether by email, Ed Discussions, Canvas, or otherwise, must be professional and respectful. In order to minimize this challenge, it is important to remember several points of **"internet etiquette"** that will smooth communication for both students and instructors

1. *Read first, Write later*. Read the ENTIRE set of posts/comments on a discussion board before posting your reply, in order to prevent repeating commentary or asking questions that have already been answered.
2. *Avoid language that may come across as strong or offensive*. Language can be easily misinterpreted in written electronic communication. Review email and discussion board posts BEFORE submitting. Humor and sarcasm may be easily misinterpreted by your reader(s). Try to be as matter of fact and as professional as possible.
3. *Follow the language rules of the Internet*. Do not write using all capital letters, because it will appear as shouting. Also, the use of emoticons can be helpful when used to convey nonverbal feelings. 😊
4. *Consider the privacy of others*. Ask permission prior to giving out a classmate's email address or other information.
5. *Keep attachments small*. If it is necessary to send pictures, change the size to an acceptable 250kb or less (one free, web-based tool to try is picresize.com).
6. *No inappropriate material*. Do not forward virus warnings, chain letters, jokes, etc. to classmates or instructors. The sharing of pornographic material is forbidden.

NOTE: The instructor reserves the right to remove posts that are not collegial in nature and/or do not meet the Online Student Conduct and Etiquette guidelines listed above.

University Use of Electronic Email

A university-assigned student e-mail account is the official university means of communication with all students at Georgia Institute of Technology. Students are responsible for all information sent to them via their university-assigned e-mail account. If a student chooses to forward information in their university e-mail account, he or she is responsible for all information, including attachments, sent to any other e-mail account. To stay current with university information, students are expected to check their official university e-mail account and other electronic communications on a frequent and consistent basis. Recognizing that some communications may be time-critical, the university recommends that electronic communications be checked minimally twice a week.

Plagiarism & Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. All students enrolled at Georgia Tech, and all its campuses, are to perform their academic work according to standards set by faculty members, departments, schools and colleges of the university; and cheating and plagiarism constitute fraudulent misrepresentation for which no credit can be given and for which appropriate sanctions are warranted and will be applied. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/.

You are encouraged to discuss problems and papers with others as long as this does not involve the copying of code or solutions. After discussions, all materials that are part of a submission should be

wholly your own. Any public material that you use (open-source software, help from a textbook, or substantial help from a friend, etc.) should be acknowledged explicitly in anything you submit to us. If you have any doubts about whether something is legal or not, please do check with the class Instructor or the TA. Further, do NOT post any solutions to the assignments on github or other public venues.

We will actively check for cheating, and any act of dishonesty will result in a Fail grade. Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Student-Faculty Expectations Agreement

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See http://www.catalog.gatech.edu/rules/22/ for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Subject to Change Statement

The syllabus and course schedule may be subject to change. Changes will be communicated via the Canvas announcement tool. It is the responsibility of students to check Ed Discussions, email messages, and course announcements to stay current in their online courses.

Course Schedule

Week/Dates	Modules/Lessons	Deliverables
1 **August 23**	Module 1: Introduction to Neural Networks Go through Welcome/Getting Started Lesson 1: Linear Classifiers and Gradient Descent Readings: • DL book: Linear Algebra background • DL book: Probability background • DL book: ML Background • LeCun et al., Nature '15 • Shannon, 1956	
2 **August 30**	Lesson 2: Neural Networks Readings: • DL book: Deep Feedforward Nets • Matrix calculus for deep learning • Automatic Differentiation Survey, Baydin et al.	Quiz #1: Linear Classifiers and Gradient Descent (Lesson 1) and Neural Networks (Lesson 2) **Due Sept. 5 11:59pm AOE (no grace period)**
3 **September 6**	Lesson 3: Optimization of Deep Neural Networks Readings: • DL book: Regularization for DL • DL book: Optimization for Training Deep Models	Assignment 1 **Due Sept. 12 11:59pm AOE (grace period until Sept. 14)**
4 **September 13**	Lesson 4: Data Wrangling Module 2: Convolutional Neural Networks Lesson 5: Convolution and Pooling Layers Readings: • Preprocessing for deep learning: from covariance matrix to image whitening • cs231n on preprocessing • DL book: Convolutional Networks • **Optional:** Khetarpal, Khimya, et al. Re-evaluate: Reproducibility in evaluating reinforcement learning algorithms." (2018). See related blog post	Quiz #2: Optimization of Deep Neural Networks (Lesson 3), Data Wrangling (Lesson 4), and Convolution and Pooling Layers (Lesson 5) **Due Sept. 19 11:59pm AOE (no grace period)** Graded Discussion 1: Initial responses should be posted by **Sept 14 11:59pm AOE (no grace period)** Graded Discussion 1: Closes **Sept 19 11:59pm AOE (no grace period)**

Week/Dates	Modules/Lessons	Deliverables
5 **September 20**	Lesson 6: Convolutional Neural Network Architectures	
6 **September 27**	Lesson 7: Visualization Lesson 8: PyTorch and Scalable Training Readings: • Understanding Neural Networks Through Deep Visualization • Grad-CAM: Visual Explanations from Deep Networks via Gradient-based Localization	Assignment 2 **Due Oct. 3 11:59pm AOE (grace period until Oct. 5)**
7 **October 4**	Lesson 9: Advanced Computer Vision Architectures Lesson 10: Bias and Fairness Readings: • Fully Convolutional Networks for Semantic Segmentation	Quiz #3: Convolutional Neural Network Architectures (Lesson 6), Visualization (Lesson 7), Advanced Computer Vision Architectures (Lesson 9), and Bias and Fairness (Lesson 10) **Due Oct 10 11:59pm AOE (no grace period)** Graded Discussion 2: Initial responses should be posted by **Oct 8 11:59pm AOE (no grace period)**
8 **October 11**	Module 3: Structured Neural Representations Lesson 11: Introduction to Structured Representations Lesson 12: Language Models Readings: • DL Book: Sequential Modeling and Recurrent Neural Networks (RNNs)	Assignment 3 **Due Oct 17 11:59pm AOE (grace period until Oct. 19)** Graded Discussion 2: Closes **Oct 13 11:59pm AOE (no grace period)**
9 **October 18**	Lesson 13: Embeddings Readings: • word2vec tutorial • word2vec paper • StarSpace paper	Project Proposal **Due Oct 24 11:59pm AOE (grace period until Oct. 26)** Quiz #4: Structured Representations (Lesson 11). Language Models (Lesson 12, and Embeddings (Lesson 13) **Due Oct 24 11:59pm AOE (no grace period)**

Week/Dates	Modules/Lessons	Deliverables
10 **October 25**	Lesson 14: Neural Attention Models Readings: • Attention is all you need • BERT Paper • The Illustrated Transformer	(Oct. 30 Withdrawal Deadline)
11 **November 1**	Lesson 15: Neural Machine Translation Lesson 16: Advanced Topics	Quiz #5: Neural Attention Models (Lesson 14), Neural Machine Translation (Lesson 15), and Advanced Topics (Lesson 16) **Due Nov. 7 11:59pm AOE (no grace period)** Assignment 4 Due **Nov. 7 11:59pm AOE (grace period until Nov. 9)**
12 **November 8**	Module 4: Advanced Topics Lesson 17: Deep Reinforcement Learning Readings: • MDP Notes (courtesy Byron Boots) • Notes on Q-learning (courtesy Byron Boots) • Policy iteration notes (courtesy Byron Boots) • Policy gradient notes (courtesy Byron Boots)	
13 **November 15**	Lesson 18: Unsupervised and Semi-Supervised Learning	Graded Discussion 3: Initial responses should be posted by **Nov 11 11:59pm AOE (no grace period)** Graded Discussion 3: Closes **Nov 16 11:59pm AOE (no grace period)** Quiz #6: Deep Reinforcement Learning (Lesson 17) and Unsupervised and Semi-Supervised Learning (Lesson 18) **Due Nov. 21 11:59pm AOE (no grace period)**
14 **November 22**	Lesson 19: Generative Models Readings:	Quiz #7: Generative Models (Lesson 19) Due **Nov. 28 11:59pm AOE (no grace period)**

Week/Dates	Modules/Lessons	Deliverables
	• Tutorial on Variational Autoencoder • NIPS 2016 Tutorial: Generative Adversarial Networks	
15 **November 29**	Wrap-Up	Final Project Due **Dec. 13th 11:59pm** AOE Graded Discussion 4: Initial responses should be posted by **Dec 11 11:59pm AOE (no grace period)** Graded Discussion 4: Closes **Dec 16 11:59pm AOE (no grace period)**