CSDS 600: Deep Generative Models

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Case Western Reserve University

Semester: Fall 2023
Credit Hours: 3
Meeting Times: Mon, Wed: 5:30pm-6:45pm
Class Location: Olin 314

Office Hours: Mon, Wed: 6:45pm-7:45pm
Location: Zoom or Olin606
Teaching Assistant: TBD

Course Description

Generative models are widely used in many subfields of AI and Machine Learning. Recent advances in parameterizing these models using deep neural networks, combined with progress in stochastic optimization methods, have enabled scalable modeling of complex, high-dimensional data including images, text, and speech. In this course, we will study the probabilistic foundations and learning algorithms for deep generative models, including variational autoencoders, generative adversarial networks, normalizing flow models, and diffusion models. The course will also discuss application areas that have benefitted from deep generative models, including computer vision, speech and natural language processing, reliable machine learning, and inverse problem solving.

List of topics

- Autoregressive Models
- Variational Autoencoders
- Generative Adversarial Models
- Normalizing Flows
- Diffusion Models
- Evaluation of Generative Models
- Generative AI in domain-specific tasks: natural language processing, image editing, 3D vision

Course Prerequisites

Formal prerequisite:

- CSDS 340: Machine Learning for Big Data, or
- CSDS 440: Machine Learning

Required and Recommended Materials

Textbooks

No required textbook. One relevant textbook: "Deep Learning" by Ian Goodfellow, Yoshua Bengio, Aaron Courville.

Software

We will be using Python and Pytorch in this course to use, implement, and evaluate deep learning algorithms.

Course Expectations

Students are expected to attend and participate in lectures. Announcements, lecture notes, and assignments will be posted on the course website on Canvas. Unless otherwise specified, all assignments are to be submitted electronically on Canvas. If the Canvas website is inaccessible ***near the assignment deadline*** such that a student is unable to submit their completed assignment, they may email me with the completed assignment.

Students are expected to check their Case email address regularly. If there are any issues with a submitted assignment, for example, *I may send you a time-sensitive email allowing you to correct your assignment prior to solutions being uploaded.*

Contacting Me

I can be reached during office hours on Zoom (https://cwru.zoom.us/j/7764186669?pwd=cmYxcmFXS1RueXZXT0hVUXNJWkdrUT09) or in my office at Olin 606. If my scheduled office hours do not work for you, please email me to make an appointment for an alternate time. ***Questions regarding course content, e.g. clarifications to assignment instructions, should be posted to the discussion board on Canvas so that other students may also benefit.***

Grading Policy

Students' grades will be calculated according to the following components:

- *Homework assignments (30%):* A mix of conceptual, mathematical, and programming problems related to the material covered in lectures.
- *Mid-term exams (20%):* Take-home exams during the semester.
- *Paper Discussion (20%): A group of students discuss a recent advance in generative models or perform a literature survey on an area.*
- *Final Project (30%): A project using one (or more) types of the generative models discussed in the class on a topic of your choice.*

Late Assignments

Late assignments, either homework or case studies, will be accepted ***up to 24 hours after the assignment deadline with a 25% penalty***. After 24 hours, late assignments *will not be accepted* without my prior approval. Note that the exact time displayed in Canvas may not exactly match the time on your computer, and uploading your assignment may take some time, so ***I recommend you submit your assignments at least 15 minutes prior to the deadline!***

A student may request for an assignment or exam to be re-graded. The student must bring it to my attention *no later than 2 weeks after receiving the grade*. In all cases, the entire assignment or exam will be re-graded so that the revised grade may be either higher or lower than the initial grade.

Collaboration Policy

Unless an assignment explicitly states that you may work in groups (such as the case studies), all work turned in *must be your own individual work*. Students may share general ideas on assignments but not specific approaches to solving a particular problem. In particular, ***you must write your own solutions and code!*** You must be prepared to prove that your solutions are your own, by explaining it to me if asked. ***Students are not allowed to work together on exams.***

Letter Grades

There will be no fixed scale for assigning letter grades (e.g. 90% for A, 80% for B, etc.); instead, I identify clusters in the numeric grades and use gaps between clusters as thresholds between letter grades. Each student with a numeric grade in the same cluster will be assigned the same letter grade. This ensures that no student is only a few points away from getting a higher letter grade.

Accessibility

In accordance with federal law, if you have a documented disability, you may be eligible to request accommodations from Disability Resources. In order to be considered for accommodations, you must first register with the Disability Resources office. Please contact their office to register at 216.368.5230 or get more information on how to begin the process. Please keep in mind that accommodations are not retroactive.

Academic Integrity

Students at Case Western Reserve University are expected to uphold the highest ethical standards of academic conduct. Academic integrity addresses all forms of academic dishonesty, including cheating, plagiarism, misrepresentation, obstruction, and submitting without permission work to one course that was completed for another course. Please review the complete academic integrity policy. Any violation of the policy will be reported to the Dean of Undergraduate Studies and the Office of Student Conduct & Community Standards.

Unless otherwise specified (e.g. in a particular assignment problem), students are allowed to use code from the textbook and Canvas website in their assignments. If you are using code from another publicly available source (e.g. examples from the scikit-learn website), ***you must document this by adding a reference to your assignment submission***, such as a comment in your submitted code!

Course Schedule

Course schedule is tentative and subject to change. *There will be no final exam.*

Week	Date	Mon.	Wed.	HW/Exam
1	Aug 28 - Sept 1	Introduction	Autoregressive Models	
2	Sept 4 - 8	Labor Day Holiday	VAEs	
3	Sept 11 -15	VAEs	Normalizing Flows	
4	Sept 18 - 22	Normalizing Flows	GANs	HW 1 Due
5	Sept 25 - 29	GANs	Inversion issue in GANs	
6	Oct 2 - 6	Diffusion Models	Proposal Presentation	
7	Oct 9 - 13	Diffusion Models	Evaluation of Generative Models	HW 2 Due
8	Oct 16 - 20	Mid-term Exam (Take-home exam)	Paper Discussion	Mid-term Exam
9	Oct 23 - 27	Fall Break	Paper Discussion	
10	Oct 30 - Nov 3	Paper Discussion	Paper Discussion	

11	Nov 6 - 10	Paper Discussion	Paper Discussion	Paper Discussion Report Due
12	Nov 13 - 17	Generative AI with LLMs [*Guest*]	Generative AI with LLMs [*Guest*]	
13	Nov 20 - 24	Image Editing using Generative models	Generative models in 3D	
14	Nov 27 - Dec 1	Project presentations	Project presentations	
15	Dec 4 - 8	Project presentations	Project presentations	
	Dec 18	Final Report Due at 5am		