

Deep Generative Models (ESE 6450)

Fall Semester 2025

René Vidal

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Course Information: Administrative



Instructor: René Vidal
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Lectures:

Tuesday & Thursday 3:30pm-4:59pm
at AGH 105 (8/26 to 12/4)

Office Hours:

Thursday 5pm-5:45pm, AGH 615



TA: Tianjiao Ding
tjding@seas.upenn.edu



TA: Liangzu Peng
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TA: Kaleab A. Kinfu
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TA: Yuyan Ge
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TA: Tadipatri Uday Kiran Reddy
ukreddy@seas.upenn.edu



TA: Kostas Emmanouilidis
ekostas@seas.upenn.edu

Office Hours

- Professor René Vidal: Thursday 5pm-5:45pm, AGH 615
- TAs will rotate office hours every three weeks
 - Tianjiao and Uday: Wed 12-1pm. 09/03, 09/24, 10/15, 11/05
 - Liangzu and Kostas: Mon 2-3pm. 09/08, 10/29, 10/20, 11/10
 - Kaleab and Yuyan: Fri 9-10am. 09/19, 10/10, 10/31, 11/21
- Location: AGH 615
- TAs will hold extra office hours on the week that homework is due.
- For extra OHs with René, feel free to email Sonia Castro Rodríguez
soniacr@seas.upenn.edu

- <https://vidal-lab.github.io/dgm/>

Course Materials

Prerequisites

Students should be comfortable with **multivariate calculus**, **linear algebra**, **probability**, **statistics**, **information theory**, and **Python programming** to register for the course.

Basic knowledge of **machine learning** (e.g., ESE 4200, CIS 5190, or CIS 5200) would be very useful.

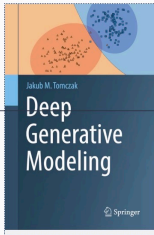
Reference Books

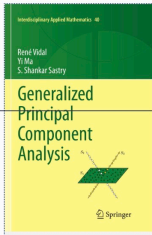
Generalized Principal Component Analysis
René Vidal, Yi Ma, Shankar Sastry

1st Edition ISBN: 978-0-387-87810-2

Deep Generative Modeling
Jakub M. Tomczak



1st Edition ISBN: 978-3-030-93157-5






Course Canvas


- Please check course Canvas for all materials:
 - <https://canvas.upenn.edu/courses/1880732>




Account




Dashboard




Courses




Calendar



Inbox



History



Help

BAN_ESE-6450-001 202530

Immersive Reader

202530 (Fall 2025)

Home

Syllabus

People

Course Materials @ Penn Libraries

Gradescope


Ed Discussion


Class Recordings

Assignments

Grades

ESE 6450-001 202530 Deep Generative Models



 DALLE 2024-08-26 15.16.34 - A vibrant and artistic representation of deep generative models for a website cover photo. The image should include a visually captivating display of .webp

ESE 6450-001: Deep Generative Models

Please see Course Website for further information. <https://vidal-lab.github.io/dgm/>

View Course Stream

View Course Calendar

View Course Notifications

To Do

Nothing for now

Course Information: Background

- Graduate-level course
- **Prerequisites:** Students should be comfortable with
 - **Linear algebra:** eigenvalue decomposition, singular value decomposition
 - **Multivariate calculus, optimization:** gradient, Hessian, first and second order conditions for minima/maxima, gradient descent, alternating minimization, Lagrange Multipliers
 - **Probability, statistics, information theory:** random variables, expectation, variance, covariance, maximum likelihood, expectation maximization, entropy, mutual information
 - **Programming:** Python
- Prior exposure to **machine learning** (e.g., ESE 4200, CIS 5190 or CIS 5200) is a plus.

Course Information: Books and Grading

- Text(s)/Required Materials:
 - Deep Generative Modeling, Jakub M. Tomczak, Springer Verlag, 2022 (<https://link-springer-com.proxy.library.upenn.edu/book/10.1007/978-3-030-93158-2>)
 - Generalized Principal Component Analysis, René Vidal, Yi Ma, Shankar Sastry, Springer Verlag, 2016 (<https://link-springer-com.proxy.library.upenn.edu/book/10.1007/978-0-387-87811-9>)
- Grading
 - Homework (60%): 3 mini-projects on different paradigms of generative models
 - Due roughly 3rd week of September, October, November
 - You will be given three (3) late days in total.
You can freely arrange them across all homework.
 - Project (40%): text-to-image generation and editing
 - In-person poster presentation on 12/2 or 12/4.
 - Report due 12/4.



Course Syllabus

- Introduction (Week 1)
 - History of AI, History of Generative Models (GMs), Advent of Deep GMs, Applications
- Background (Week 1, 2)
 - Basics of Linear Algebra, Probability, Statistics, Information Theory, and Optimization
 - Discriminative vs Generative Models
 - Taxonomy of Generative Models
 - Maximum Likelihood Estimation
- Latent Variable Models (Week 2, 3, 4)
 - Variational Inference and Expectation Maximization
 - Probabilistic Principal Component Analysis (PPCA)
 - Application of PPCA to Generating Images of Faces with Variable Lighting
 - Variational Auto-Encoders (VAEs)
 - Application of VAEs to Generating Images of Handwritten Digits

Course Syllabus

- Shallow Auto-regressive Models (Week 5, 6, 7, 8)
 - Markov Models & Hidden Markov Models (HMMs)
 - Application of HMMs to Generating Text
 - Linear Dynamical Systems (LDSs)
 - Application of LDSs to Generating Videos of Dynamic Textures
- Deep Auto-regressive Models (Week 8, 9, 10, 11, 12, 13)
 - Recursive Neural Networks (RNNs)
 - Application to Speech Synthesis (WaveNet) and Image Captioning (RNN + VAE)
 - Transformers (Transformer, Vision Transformer, Multimodal Transformers)
 - Application to Text Generation, and Text-to-Image Generation (DALLE: auto-regressive model + VAE)
 - Diffusion Models
 - Denoising Diffusion Probabilistic Models (DDPM)
 - Diffusion Models with Latent Variables
 - Implementation details (UNet, StyleGAN)
 - Applications to Image Inpainting, and Text-to-Image Generation (CLIP Guided Diffusion)

Course Syllabus

- Multimodal Models (Week 13, 14)
 - Vision-Language Models
 - ControlNet
 - Applications to Image Editing
- Project Presentations (Week 15)

Student Code of Conduct

- Read University Policy:
 - <https://grad.seas.upenn.edu/student-handbook/student-code-of-conduct/>
- You must not misrepresent someone else's work as your own. You can avoid this in two ways:
 - Do not use work (including code) from someone else (including AI assistants).
 - Give proper credit if you do use someone else's work (including AI assistants).
- Naturally, even if you give appropriate credit, you will only receive credit for your original work, so for this class you should stick with option #1.
- All cases of confirmed cheating/plagiarism will be reported to the Student Ethics Board.
- Homeworks are strictly individual unless stated otherwise.
- Project to be done in groups of up to four students.

Exit Quiz

- To improve our class, we will have exit quiz that survey your opinions and comments for the course.
 - They are not mandatory and won't count towards your grade.
- Due every end of the week.

Registration & Auditing

- Number of registered students: ~72
- Number of students in the waiting list: ~38
- Capacity of AGH 105: ~72
- I'm really sorry since a larger room is not available, we will not be able to accept auditing students. All students must be registered for credit.