# Theory and Practical Applications of AI Generative Modeling - CSYE 7380 01

SUMMER 2025

**Course Information**
Course Title: Theory and Practical Applications of AI Generative Modeling
Course Number: CSYE7380 19143
Term and Year: Spring 2025
Credit Hour: 4
CRN: 53375
Course Format: Traditional Instructional Method Boston Campus

**Instructor Information**
Full Name: Subrata Das
Email Address: s.das@northeastern.edu
Office Hours: Always via email

**Instructor Biography**
Dr. Subrata Das brings a wealth of experience as a principal and chief data scientist, lab manager, and technology consultant across various organizations, including Humana, EY/Nike, AdventHealth, Cimpress/Vistaprint, MIT Lincoln Labs, Charles River Analytics, and Xerox European Research Center. He also founded and led his start-up, Machine Analytics.

With over 25 years of experience, Subrata has researched and developed cutting-edge applications in Generative AI, machine and deep learning, computer vision, and NLP technologies. His professional mission remains focused on solving complex industrial challenges in the healthcare, surveillance, finance, and e-commerce sectors.

Subrata holds a PhD in AI and Databases from Heriot-Watt University in Edinburgh, UK, and completed a postdoctoral fellowship in AI at Imperial College London. He is a part-time faculty member at Northeastern University, where he teaches Generative AI, and has authored several books on AI and analytics, all available on Amazon.

**Teaching Assistant Information**
Full Name: Not assigned yet.
Email Address:N/A
Office Hours:N/A

**Course Prerequisites**
Graduate level INFO 6205 Minimum Grade of B

**Course Description**

A generative model of a problem provides a comprehensive probabilistic distribution of all relevant features or variables, defined over data points in a potentially high-dimensional space. It is referred to as "generative" because it can sample and generate synthetic data points, enabling it to handle missing information effectively.

The proposed advanced applied AI generative modeling course will go beyond focusing solely on Transformer-based language models, such as ChatGPT and Gemini. It will also cover generative image models (e.g., GANs and variational autoencoders) and generative models for structured data (e.g., Bayesian networks). This ensures that the course addresses generative modeling for the major data modalities: textual, visual, and structured relational data.

Students will have the opportunity to learn how to build such models for practical applications across various domains using Python and widely available libraries, including Keras/TensorFlow and PyTorch.

The course requires students to have a good foundation in advanced mathematics and statistics, as well as prior completion of a data science course. Additionally, students should be capable of reading and analyzing technical papers and articles, which will be provided as part of the coursework.

**Course Learning Outcomes**
This will help students become experts in applying popular tools for generative models, such as ChatGPT, Gemini, and DALL-E, to solve real-world problems. It will set students apart and give them a competitive edge in the job market.

**Required Tools and Course Textbooks.**
Python and machine and deep learning libraries in Scikit, Keras/TensorFlow, OpenAI, Hugging Face, and Pytorch, NLTK, Spacy, Gensim.

**Course Schedule/Topics Covered.**

| Week | Date | In Class Topic | Assignment Due |
|---|---|---|---|
| 1 | 01/06 | Generative Modeling – Introduction, Bayesian probability, Statistical distributions, Gradient Descent, Optimization function, Generative models for text, images, and structured data, Generative probabilistic models, word embeddings, Natural Language Processing (NLP) | 01/13 |
| 2 | 01/13 | Neural Networks, Convolutional Neural Network (CNN), Residual Networks (ResNet) | 01/27 |

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|---|---|---|---|
| **3** | **01/27** | **Generative Adversarial Network (GAN) introduction, Vanilla GAN, Min-Max optimizer, Conditional GAN (CGAN), Deep Convolutional GAN (DCGAN), CycleGAN** | **02/03** |
| **4** | **02/03** | **Large Language Modeling (LLM), ChatGPT and Gemini, Fine Tuning, Prompt Engineering, Zero and Few Shot, Chain of Thoughts Reasoning , Hallucination** | **02/10** |
| **5** | **02/10** | **Traditional ML for NLP - Naïve Bayesian Classifier (NBC), Latent Dirichlet Allocation (LDA), Latent Semantic Analysis (LSA)** | **02/17** |
| **6** | **02/17** | **Transformers, Bidirectional Encoder Representations from Transformers (BERT), Supervised, unsupervised, and reinforcement learning for Transformers** | **02/24** |
| **7** | **02/24** | **Midterm Project** | **03/10** |
| **8** | **03/03** | **SPRING BREAK – NO CLASSES** | |
| **9** | **03/10** | **Project Presentation** | |
| **10** | **03/17** | **Stacked Autoencoder, Variational Autoencoder (VAE), Vector Quantized VAE (VQVAE), Vector Quantized GAN (VQGAN)** | **03/24** |
| **11** | **03/24** | **Sequential models, RNN, LSTM, Autoregressive GAN, PixelCNN** | **03/31** |
| **12** | **03/31** | **Text to Image generation, Diffusion Models, U-Net, Caption generation, DALL-E** | **04/27** |
| **13** | **04/07** | **Final Project, Structured data generation, Bayesian Belief Networks (BN), Gaussian Mixture Model (GMM), Hidden Markov Model (HMM)** | **04/21** |
| **14** | **04/14** | **Quiz** | |
| **15** | **04/21** | **Project Presentation** | |

**Assignment Grading**

Please insert all assignment grades and weights for the course. Example below:

- Attendance – 5 %
- Assignment 1 – 9 (5% each): 45%
- Quiz 1 – 10%
- Midterm Project – 20%
- Final Project – 20%

**Grading Scale**

| | | | |
|---|---|---|---|
| | 87-89.9% B+ | 77-79.9% C+ | |
| 95-100% A | 84-86.9% B | 74-76.9% C | |
| 90-94.9% A- | 80-83.9%B- | 70-73.9% C- | 69.9% or below F |

**Attendance/Late Work Policy**

Attendance Policy

Students registered in MGEN courses (INFO, CSYE, and DAMG) are allowed **a maximum of 2 absences per course, with 3 or more absences resulting in an automatic 'F' for that course.** Students are expected to inform their instructors of any absences in advance of the class; if a student is sick long-term or experiences a medical issue that prevents class attendance, it is strongly encouraged that they speak with their Academic Advisor (coe-mgen-gradadvising@northeastern.edu) to learn more about the Medical Leave of Absence. Should a student anticipate being unable to attend 3 or more classes, they should discuss their situation with their Academic Advisor to explore other types of leave in accordance with the University's academic and global entry expectations. International students should review the Office of Global Services webpage to understand their visa compliance requirements.

Teaching Assistants (TAs) or Instructional Assistants (IAs) will be present at each class to collect student attendance.

Late Work Policy

Students must submit assignments by the deadline in the time zone noted in the syllabus. Students must communicate with the faculty prior to the deadline if they anticipate work will be submitted late. Work submitted late without prior communication with faculty will not be graded.

**End-of-Course Evaluation Surveys**

Your feedback regarding your educational experience in this class is particularly important to the College of Engineering. Your comments will make a difference in the future planning and presentation of our curriculum.

At the end of this course, please take the time to complete the evaluation survey at **https://neu.evaluationkit.com**. Your survey responses are **completely anonymous and confidential**. For courses 6 weeks in length or shorter, surveys will be open one week prior to the end of the courses; for courses greater than 6 weeks in length, surveys will be open for two weeks. An email will be sent to your Northeastern University Mail account notifying you when surveys are available.

**Academic Integrity**

A commitment to the principles of academic integrity is essential to the mission of Northeastern University. The promotion of independent and original scholarship ensures that students derive the most from their educational experience and their pursuit of knowledge. Academic dishonesty violates the most fundamental values of an intellectual community and undermines the achievements of the entire University.

As members of the academic community, students must become familiar with their rights and responsibilities. In each course, they are responsible for knowing the requirements and restrictions regarding research and writing, examinations of whatever kind, collaborative work, the use of study aids, the appropriateness of assistance, and other issues. Students are responsible for learning the conventions of documentation and acknowledgment of sources in their fields. Northeastern University expects students to complete all examinations, tests, papers, creative projects, and assignments of any kind

according to the highest ethical standards, as set forth either explicitly or implicitly in this Code or by the direction of instructors.

Go to http://www.northeastern.edu/osccr/academic-integrity-policy/ to access the full academic integrity policy.

**MGEN Student Feedback**
Students who would like to provide the MGEN unit with anonymous feedback on this particular course, Teaching Assistants, Instructional Assistants, professors, or to provide general feedback regarding their program, may do so using this survey: https://neu.co1.qualtrics.com/jfe/form/SV_cTlAbH7ZRaaw0Ki

**University Health and Counseling Services**
As a student enrolled in this course, you are fully responsible for assignments, work, and course materials as outlined in this syllabus and in the classroom. Over the course of the semester if you experience any health issues, please contact UHCS.

For more information, visit https://www.northeastern.edu/uhcs.

**Student Accommodations**
Northeastern University and the Disability Resource Center (DRC) are committed to providing disability services that enable students who qualify under Section 504 of the Rehabilitation Act and the Americans with Disabilities Act Amendments Act (ADAAA) to participate fully in the activities of the university. To receive accommodations through the DRC, students must provide appropriate documentation that demonstrates a current substantially limiting disability.

For more information, visit https://drc.sites.northeastern.edu.

**Library Services**
The Northeastern University Library is at the hub of campus intellectual life. Resources include over 900,000 print volumes, 206,500 e-books, and 70,225 electronic journals.

For more information and for education specific resources, visit https://library.northeastern.edu
Network Campus Library Services: Northeastern University Library Global Campus Portals

**24/7 Canvas Technical Help**
For immediate technical support for Canvas, call 617-373-4357 or email help@northeastern.edu

Canvas Student Resources: https://canvas.northeastern.edu/student-resources/

For assistance with my Northeastern e-mail, and basic technical support:
Visit ITS at https://its.northeastern.edu
Email: help@northeastern.edu
ITS Customer Service Desk: 617-373-4357

**Diversity and Inclusion**
Northeastern University is committed to equal opportunity, affirmative action, diversity, and social justice while building a climate of inclusion on and beyond campus. In the classroom, members of the University community work to cultivate an inclusive environment that denounces discrimination through innovation, collaboration, and an awareness of global perspectives on social justice.

Please visit http://www.northeastern.edu/oidi/ for complete information on Diversity and Inclusion

**Title IX**
*Title IX of the Education Amendments of 1972 protects individuals from sex or gender-based discrimination, including discrimination based on gender-identity, in educational programs and activities that receive federal financial assistance*.

Northeastern's Title IX Policy prohibits Prohibited Offenses, which are defined as sexual harassment, sexual assault, relationship or domestic violence, and stalking. The Title IX Policy applies to the entire community, including male, female, transgender students, faculty, and staff.

In case of an emergency, please call 911.

*Please visit **https://www.northeastern.edu/ouec** for a complete list of reporting options and resources both on- and off-campus*.