MET CS 788:

Generative AI

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Who is this course for?

1. Are you good at Python, or can write some python script? Are you willing to learn how to code in Keras, TensorFlow and PyTorch on your own?

2. Did you pass, CS 555 or CS 677 **and** CS 688 or CS 699, or do you have a back ground in ML?

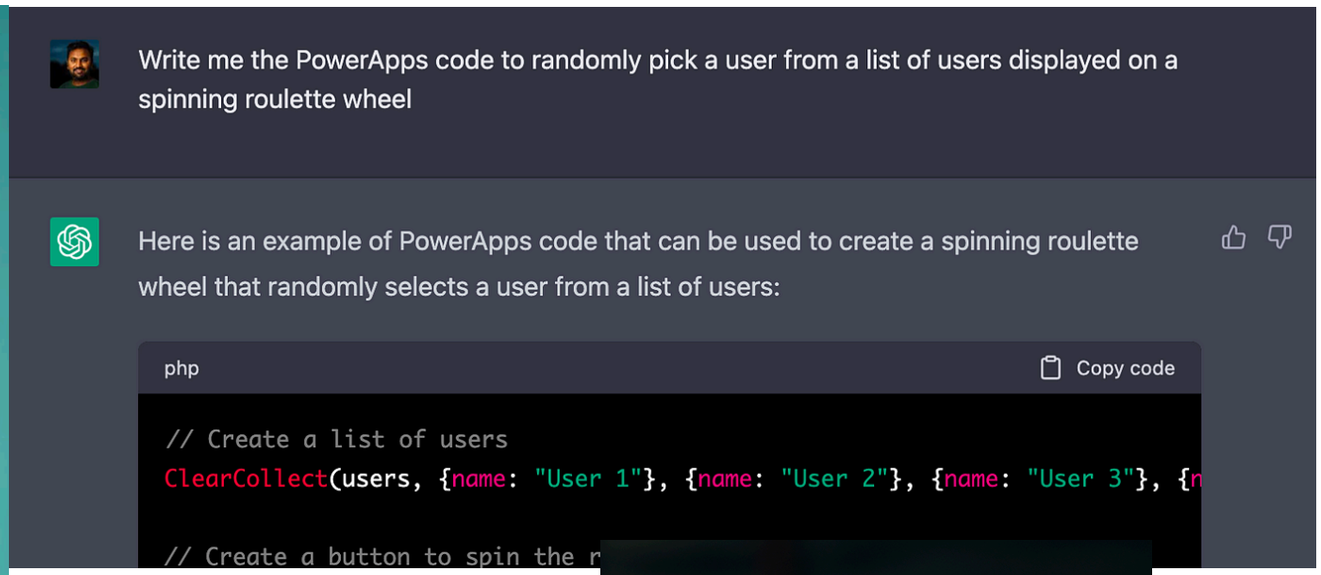
3. You should seek to be a ML/AI scientist and related jobs or Ph.D. in AI. If you intend to be only a software engineer with some ML knowledge or a practical data engineer, this is not the right course for you. You can take CS 555, CS 677, CS 688, or CS 699.

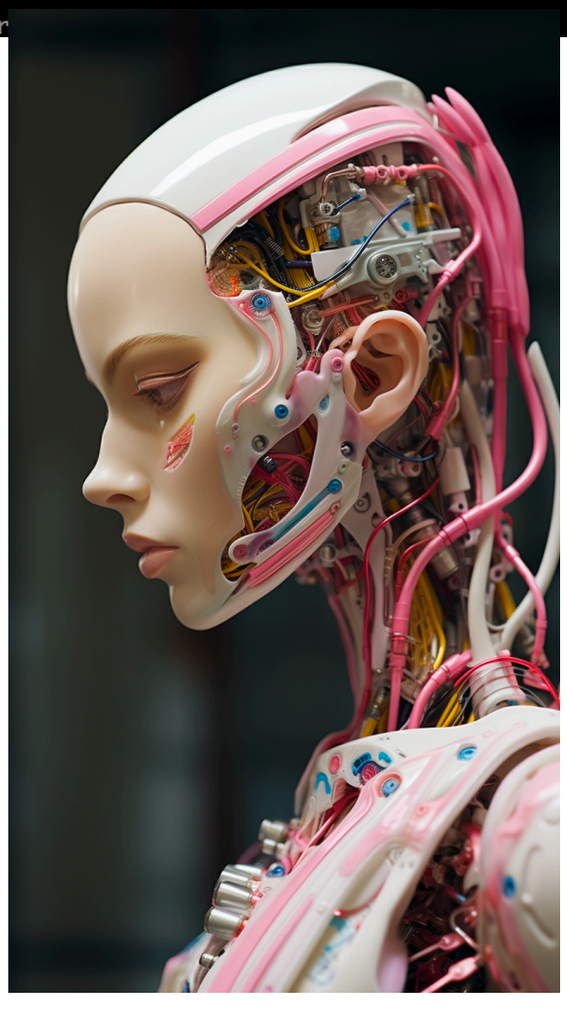
4. Are you ok investing a lot of time in learning state-of-the-art ML and AI algorithms?

5. Are you okay with learning models that resolve state-of-the-art problems, but no other university or online courses teach them in this detail in one semester?

6. Although the result is existing, the approach toward getting the result might be very boring and include some mathematical understanding.

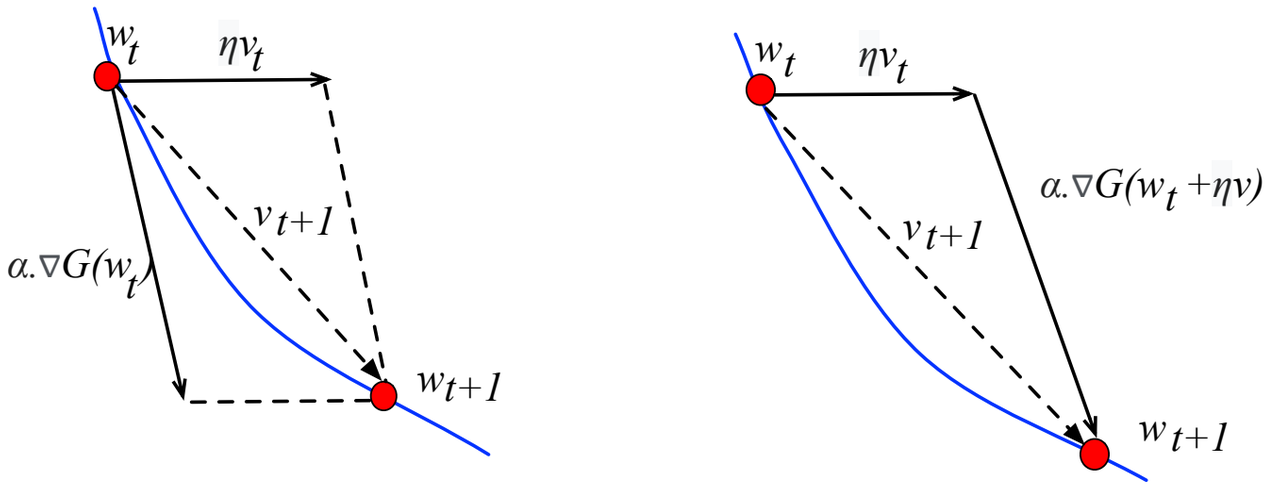
What you think about Generative AI

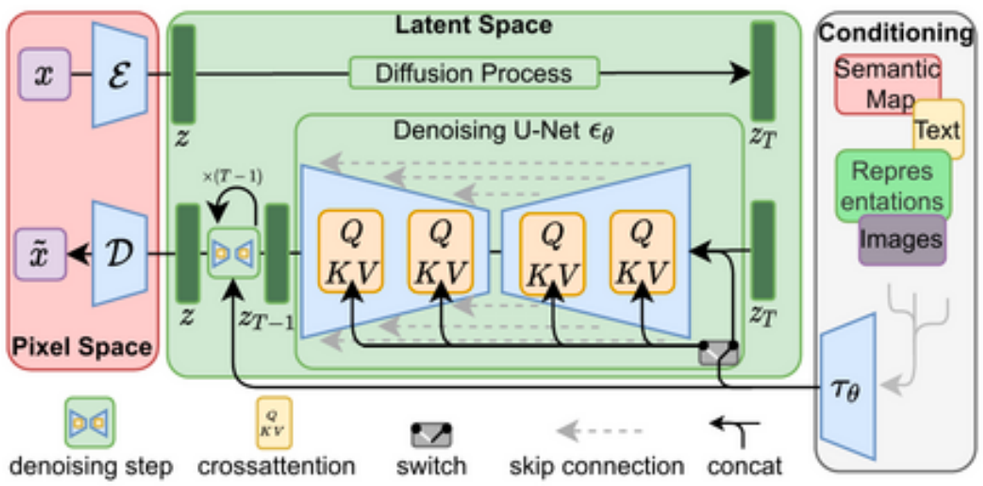


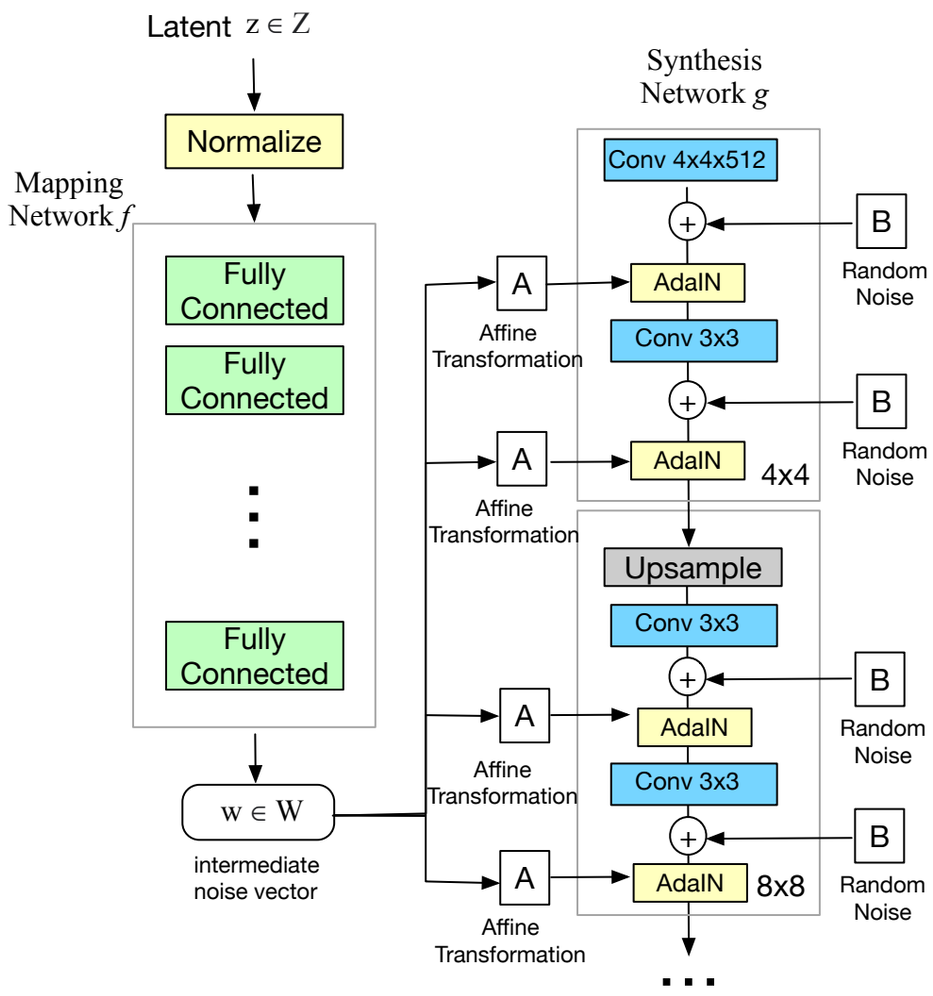


What you learn in this class

$$J = \begin{bmatrix} \nabla f(x,y) \\ \nabla g(x,y) \end{bmatrix} = \begin{bmatrix} \frac{\partial f(x,y)}{\partial x} & \frac{\partial f(x,y)}{\partial y} \\ \frac{\partial g(x,y)}{\partial x} & \frac{\partial g(x,y)}{\partial y} \end{bmatrix}$$







$$W(C,G) = \max_{w \in W} \mathbb{E}_{x \sim C}[f_w(x)] - \mathbb{E}_{z \sim G}[f_w(g_\theta(z))]$$

$$f(x) \approx f(a) + \frac{f'(a)}{1!}(x-a) + \frac{f''(a)}{2!} + \ldots + \frac{f^{(n)}(a)}{n!} \approx \sum_{n=0}^{\infty} \frac{f^{(n)}(a)}{n!}(x-a)^n$$

Course Policy

- This course is very different from our traditional MET courses. Here, we deal with Neural Networks, and it is not possible to run the code in the class.

- This course has lots of theory and little coding. Nevertheless, in your assignments, you will do the coding, but we do not discuss coding skills in the class.

- It takes time to build a neural network model, and then later we could use the model. Therefore, for the neural network parts of the course, we do have lots of theories and very few codings.

- We are using existing models, and in your assignments, you will experiment with coding neural networks because you might need to leave your model to train the system for several hours.

- This course requires some learn-it-yourself for your assignments. If you feel you are not confident in learning something on your own and researching, I doubt if this course is useful or if you enjoy our journey in this semester. Perhaps you can take it another semester when you get more senior in programming and solution finding.

- The material we learn here is very large, which is extremely useful for those of you who give job interviews as senior data scientists or apply for a Ph.D.

Evaluation 1/4

- You have five assignments total 50%, final project 25%, 25% final exam.

- For the final exam: you can use your slides to prepare for it. Or I might give you some transcripts (https://github.com/Rezar/MLBook). It is a closed book and essay writing.

- I would not put you under stress, but you really dedicate time to this important and challenging course and deeply understand your assignments.

- Near the end of the semester, we do not have time to increase your grade by updating your grade for your missing assignments.

Evaluation 2/4

- Your homework grades will be marked based on the following criteria

    1. Do you correctly understand the problem? And do you choose the correct algorithm?

    2. Does it run properly, or does it perform all tasks which have been asked in the assignment?

    3. Can you judge the results and prepare a proper report about them?

    4. Are you able to explain your code and answer my or my tutor’s questions about this?

    5. **You need to submit 3-12 minutes presentation of your homework and describe your code, and what you have done. Every time, we will review it in class and discuss it.**

    6. If you use ChatGPT, that is fine with me, but you need to be able to describe the code and any modification you have applied to the code. Just copy/paste from ChatGPT or another AI code-writing tool is considered plagiarism.

Evaluation 3/4 (final project)

- Your final project grants you 25% points on your final grade.

- The final exam is not easy, but it prepares you for a job interview in a data science field.

- Exams might not be practical, but in this course, there are concepts that we can not evaluate your assignments. To be sure you have learned the theoretical concepts we have explained.

Evaluation 4/4 (Class attendance)

- Class attendance is not mandatory, but experience shows that students who attend the class get significantly higher grades + if you ask me for a recommendation letter, I should know you in person.

- Besides, this class is the least crowded class I have in my career, and I believe we should all be in the class to gain a very good learning experience.

Summary

- 50% Assignments
- 25% Final project
- 25% Final Exam

Course Modules (1)

- **Session 1,2: Statistics Required for Generative Models.**
    - Data distributions
    - Methods to measure distribution
- **Session 3,4: Regression Models**
    - Linear Regression, Multi-Linear Regression, Polynomial Regression, Parameter estimation, Pieceweise Regression, Regression Challenges and Resolutions. Regression Model Evaluation.
    - Logistic Regression, Parameter estimation, Softmax Regression (Classifier), Parameter estimation.
    - Evaluating Regression Models.
    - Overfitting and Underfitting, Bias-variance trade-off.
    - Regularizations
- **Session 4: Machine Learning Optimization**
    - Mathematical concepts
    - Gradient Descent
    - Newton-Raphson

Course Modules (2)

- **Session 4, 5: Basic concepts of Neural Networks**
  - **Artificial Neural Network Structure:**
    - Perceptron Algorithm,
    - Multi-Layer Perceptron,
    - Activation Functions,
    - Neural Cost Functions
  - **Neural Network Optimizers:**
    - SGD with Momentum,
    - Nesterov with Momentum,
    - Adagrad,
    - RMSProp
  - **Backpropagation**
  - **Regularization in Neural Network:**
    - Vanishing and Exploding Gradient,
    - Batch Normalization,
    - Dropout,
    - Early Stopping
- **Session 5,6 :**
  - **Convolutional Neural Network:**
    - Convolution and Cross Correlation,
    - CNN steps,
    - Different types of Convolutions.
  - **Recurrent Neural Network:**
    - Concepts,
    - LSTM,
    - GRU,
    - Bidirectional RNN,
    - Deep RNN,

Course Modules (3)

- **Session 7, 8: Self-Supervised Neural Network**
  - Concepts of Representation Learning
  - Self Organized Map (SOM)
  - Boltzmann Machine
  - Restricted Boltzmann Machine
  - Deep Belief Network and Deep Boltzmann Machine
  - **Auto Encoders:** Concepts, Types (Sparse, Denoising, Contractive, Stacked), Variational AutoEncoders, UNet
  - **Generative Adversarial Networks:** Concepts, Training GAN, Challenges, GAN Evaluation.
  - **GAN Architectures:** CGAN, DCGAN, WGAN, WGAN-GP, Pix2Pix, CycleGAN, StyleGAN models
- **Session 9, 10: Transformer**
  - Transformer concepts and architecture.

Course Modules (4)

- **Session 11, 12: NLP advances**
  - Transformer concepts and architecture.
  - NLP models based on Transformer Architecture.
  - Post Chat-GPT models
  - Prompt engineering
  - NLP and LLM model evaluation
- **Session 13,14: Generative Computer Vision**
  - text-to-image models.
  - NeRF, 3D Gaussian Splatting

Course Modules (4)

- **Session 11, 12: NLP advances**
  - Transformer concepts and architecture.
  - NLP model
  - Post Chat-
  - Prompt eng
  - NLP and LL
- **Session 13,1**
  - text-to-image models.
  - NeRF, 3D Gaussian Splatting
- **Session 14: Project Presentation ?**

This is an approximate plan and it might change during the semester.

Communication with me

- If you have more than one question, please wrap them inside one email and avoid distributing your questions in different emails.

- *Sending me an email to get an extra grade at the end of the semester does not work. I will treat all students fairly and can not add a few extra grades to a particular student who asked for a grade.*

About Me

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Reference Book

https://github.com/rezar/mlbook