

MAE 688: Machine Learning for Mechanical Engineers

Lecture 1-Introduction



Dr. Bing Dong

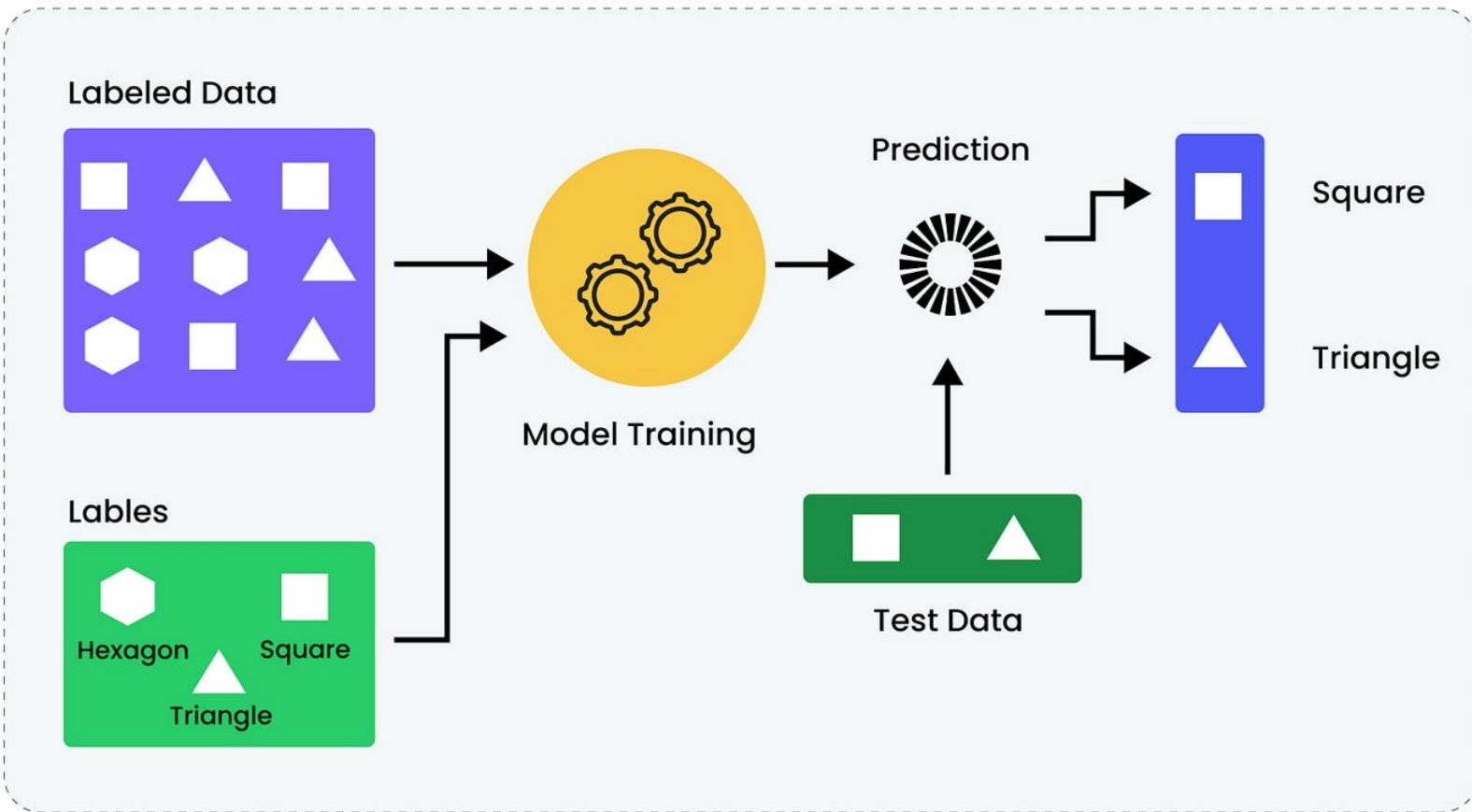
Traugott Professor

Mechanical and Aerospace Engineering

Syracuse University

What is Machine Learning?

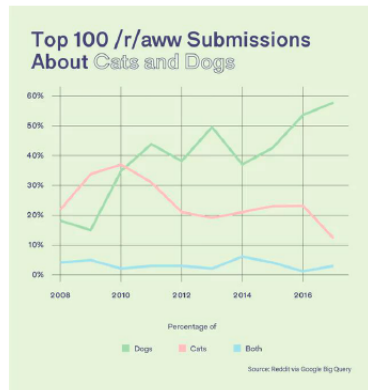
What is Machine Learning?



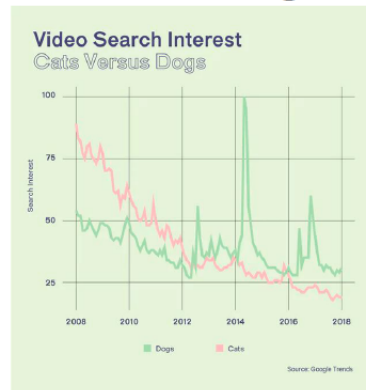
Traditional Algorithms

Social media mentions of Cats vs. Dogs

Reddit



Google

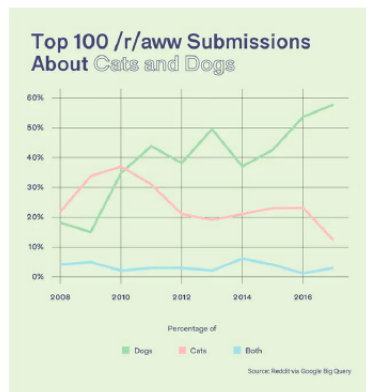


Twitter?

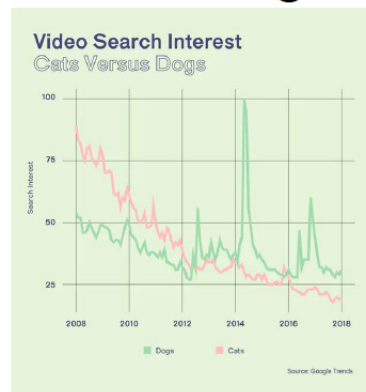
Traditional Algorithms

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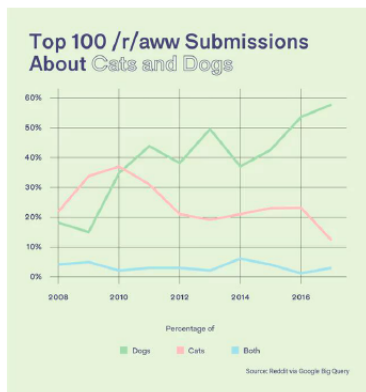
Twitter?

Write a program that sorts tweets into those containing “**cat**”, “**dog**”, or **other**

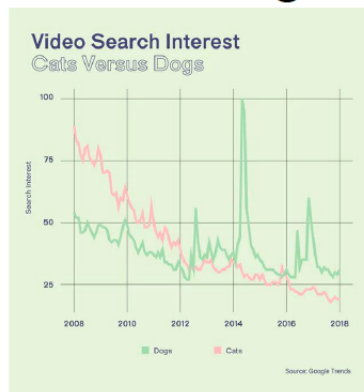
Traditional Algorithms

Social media mentions of Cats vs. Dogs

Reddit



Google



Twitter?

```
cats = []
dogs = []
other = []
for tweet in tweets:
    if "cat" in tweet:
        cats.append(tweet)
    elif "dog" in tweet:
        dogs.append(tweet)
    else:
        other.append(tweet)
return cats, dogs, other
```

Write a program that sorts tweets into those containing "cat", "dog", or other

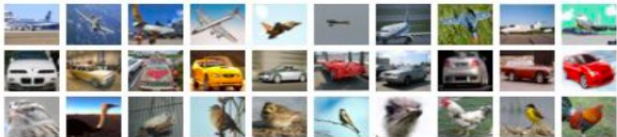
Machine Learning Algorithm

Write a program that sorts images
into those containing “**birds**”,
“**airplanes**”, or ***other***.



Machine Learning Algorithm

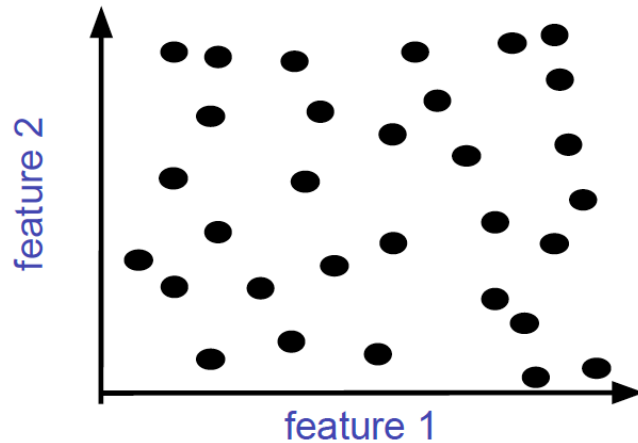
Write a program that sorts images into those containing “**birds**”, “**airplanes**”, or **other**.



```
birds = []
planes = []
other = []
for image in images:
    if bird in image:
        birds.append(image)
    elseif plane in image:
        planes.append(image)
    else:
        other.append(tweet)
return birds, planes, other
```

Machine Learning Algorithm

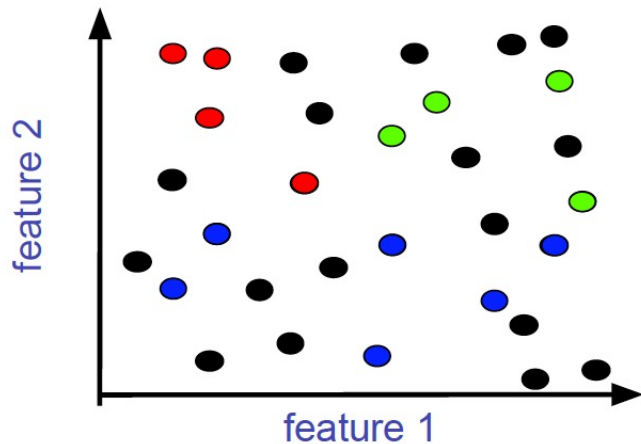
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    elif plane in image:
        planes.append(image)
    else:
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return birds, planes, other
```

Machine Learning Algorithm

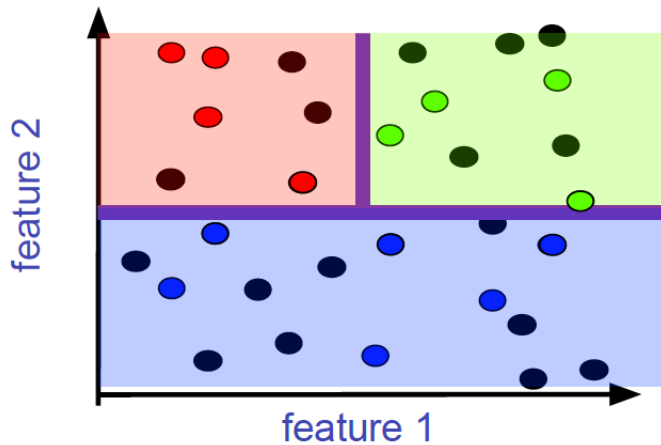
Write a program that sorts images into those containing “birds”, “airplanes”, or *other*.



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return birds, planes, other
```

Machine Learning Algorithm

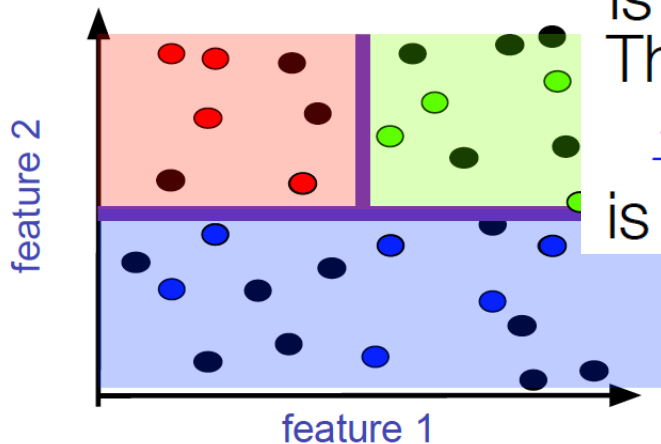
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other = []
for image in images:
    if bird in image:
        birds.append(image)
    elif plane in image:
        planes.append(image)
    else:
        other.append(tweet)
return birds, planes, other
```

Machine Learning Algorithm

Write a program that sorts images into those containing “**birds**”, “**airplanes**”, or **other**.



The decision rule of
if "cat" in tweet:
is **hard coded by expert**.
The decision rule of
if bird in image:
is **LEARNED using DATA**

```
birds = []  
planes = []  
other = []  
for image in images:  
    image:  
    ne in image:  
    append(image)  
    append(tweet)  
    planes, other
```

Essentials of Machine Learning

- **Data:** past observations
- **Hypotheses/Models:** devised to capture the patterns in data
- **Prediction:** apply model to forecast future observations

Classification

Spam Filtering

Welcome to New Media Installation: Art that Learns

Carlos Guestrin to 10615-announce, Osman, Miche show details 3:15 PM (8 hours ago) Reply

Hi everyone,

Welcome to New Media Installation:Art that Learns

The class will start tomorrow.
Make sure you attend the first class, even if you are on the Wait List
The classes are held in Doherty Hall C316, and will be Tue, Thu 01:30-4:20 PM.

By now, you should be subscribed to our course mailing list: 10615-announce@cs.cmu.edu.
You can contact the instructors by emailing: 10615-instructors@cs.cmu.edu

Natural_LoseWeight SuperFood Endorsed by Oprah Winfrey, Free Trial 1 bottle, pay only \$5.95 for shipping mfw rlk Spam | X

Jaquelyn Halley to nherlein, bcc: thehorny, bcc: anç show details 9:52 PM (1 hour ago) Reply

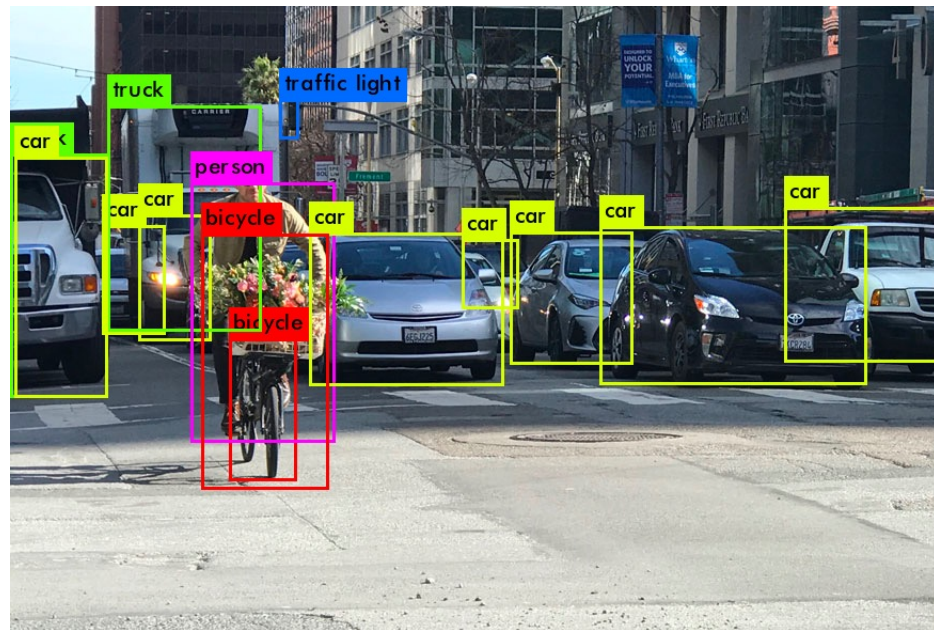
=== Natural WeightLOSS Solution ===

Vital Acai is a natural WeightLOSS product that Enables people to lose wieght and cleansing their bodies faster than most other products on the market.

Here are some of the benefits of Vital Acai that You might not be aware of. These benefits have helped people who have been using Vital Acai daily to Achieve goals and reach new heights in there dieting that they never thought they could.

- * Rapid WeightLOSS
- * Increased metabolism - BurnFat & calories easily!
- * Better Mood and Attitude
- * More Self Confidence
- * Cleanse and Detoxify Your Body
- * Much More Energy
- * BetterSexLife
- * A Natural Colon Cleanse

Object Detection

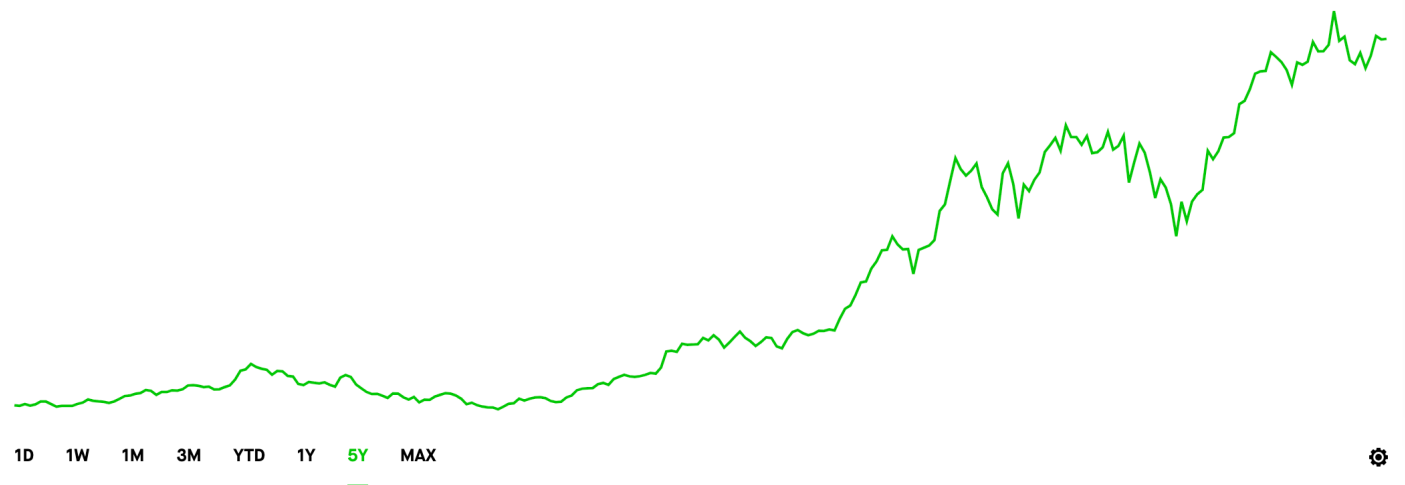


Regression

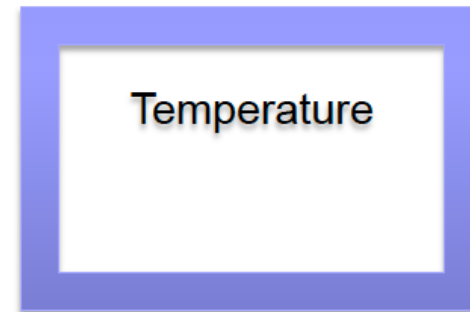
Predicting Stock Market

NVIDIA
\$189.13

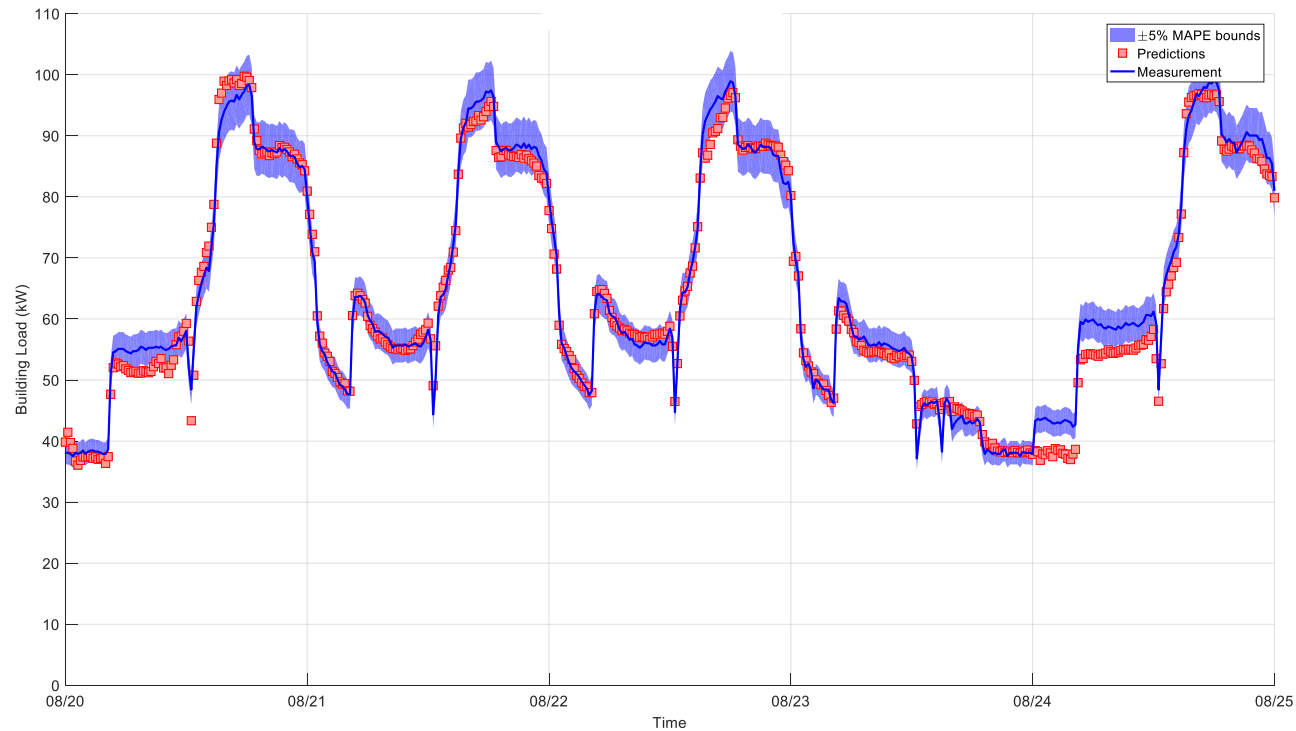
+\$176.03 (+1,343.27%) Past 5 years



Weather Prediction

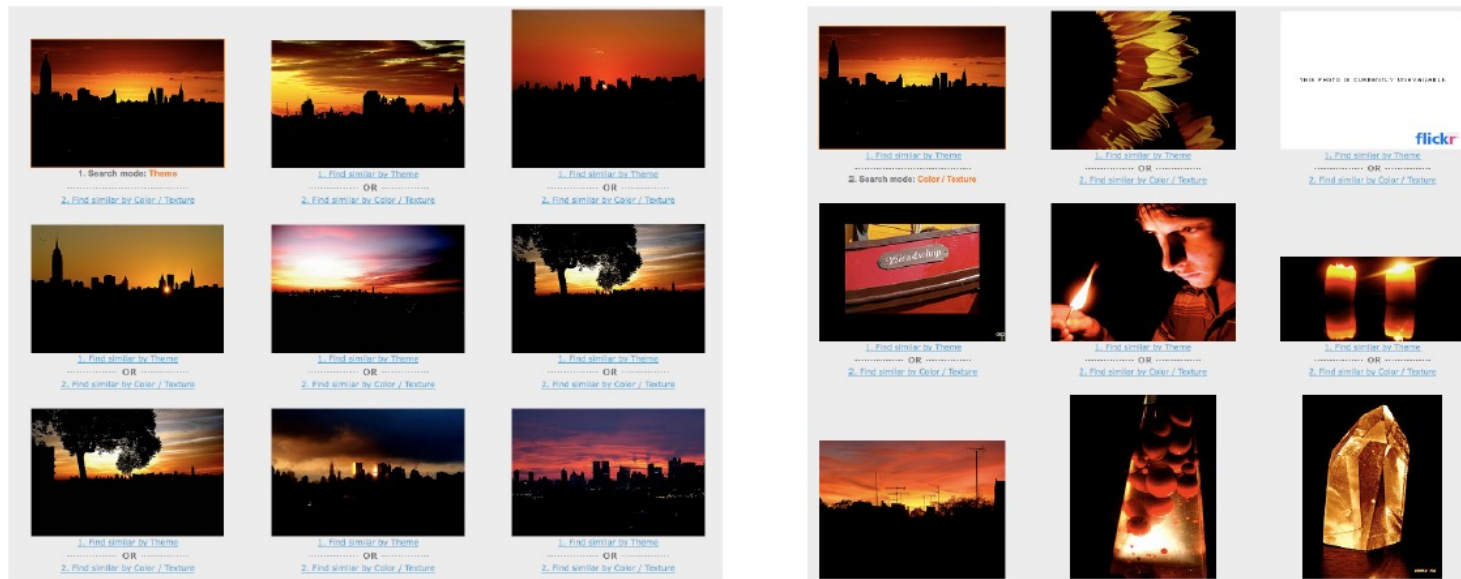


Building Energy Usage Prediction



Similarity

Given data, Find similar images



Similarity

Similar Products—Amazon, Netflix, Spotify, etc.



Processing: A Programming Handbook for Visual Designers and Artists (Hardcover)

by [Casey Reas](#) (Author), [Ben Fry](#) (Author), [John Hertz](#) (Foreword)

★★★★★ (13 customer reviews)

Available from [these sellers](#).

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- 
Learning Processing: A Beginner's Guide to... by Daniel Shiffman
★★★★★ (7) \$44.05

MAE 688: Machine Learning for Mechanical Engineers

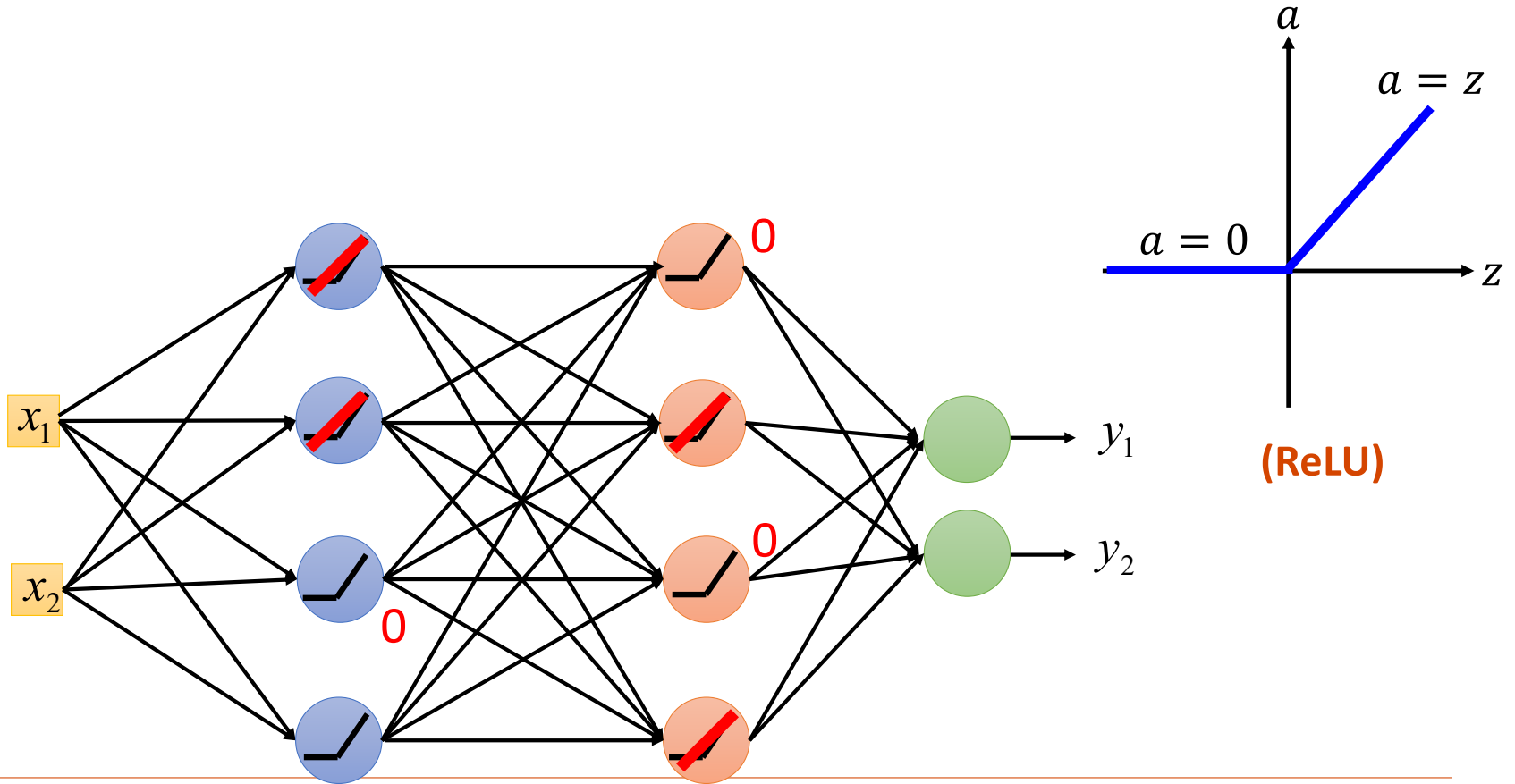
What is this class about:

This course will cover fundamentals of machine learning techniques, and their applications to mechanical engineers. The course will cover both theory and the practical implementation of the learned techniques. Student performance will be assessed through exams, assignments and final project. This class requires intermediate programming in Python.

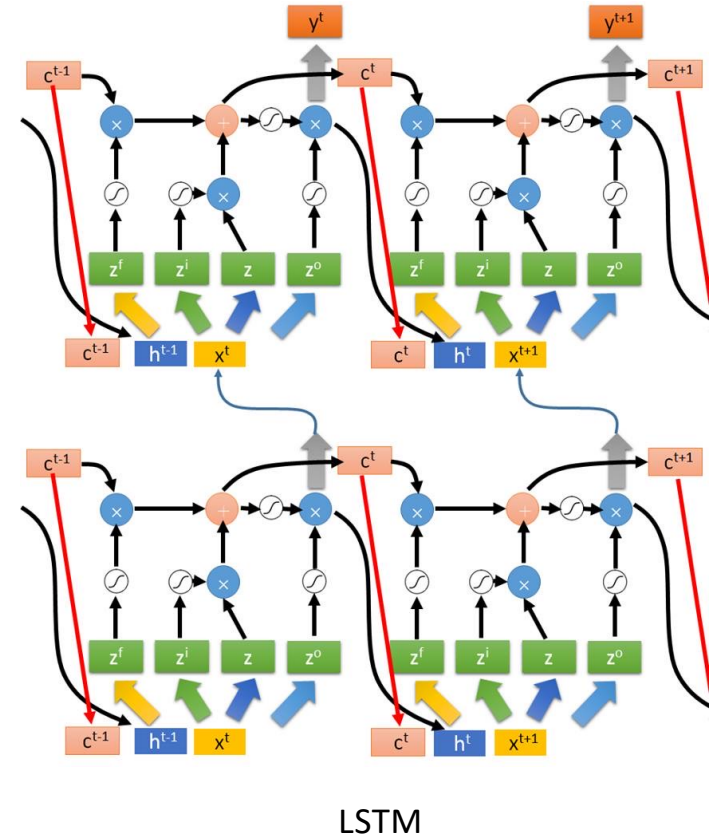
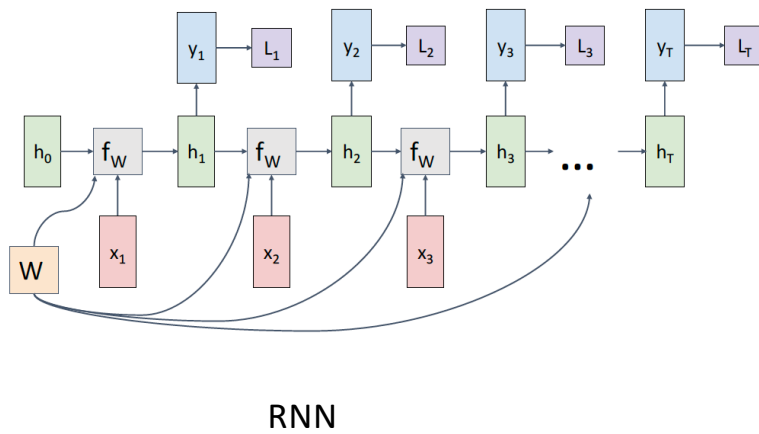
Prerequisites:

Knowledge of Probability
Familiar with Python programming language

Deep Learning: Deep Neural Network



Deep Learning: LSTM and RNN



Transformer

2017

Attention Is All You Need

Ashish Vaswani*
Google Brain
avaswani@google.com

Noam Shazeer*
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noam@google.com

Niki Parmar*
Google Research
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Jakob Uszkoreit*
Google Research
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Llion Jones*
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Aidan N. Gomez* †
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Lukasz Kaiser*
Google Brain
lukaszkaizer@google.com



Transformer

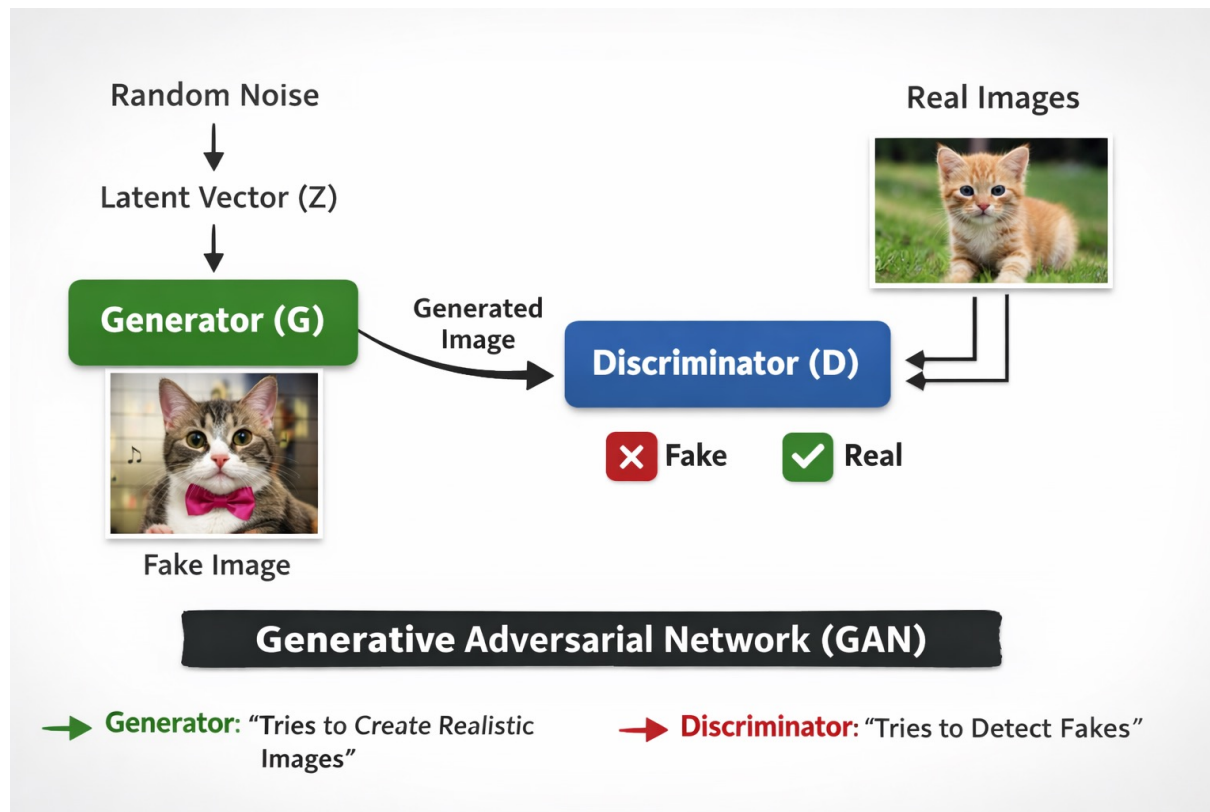
BERT 340M

GPT-2 (1.5B)

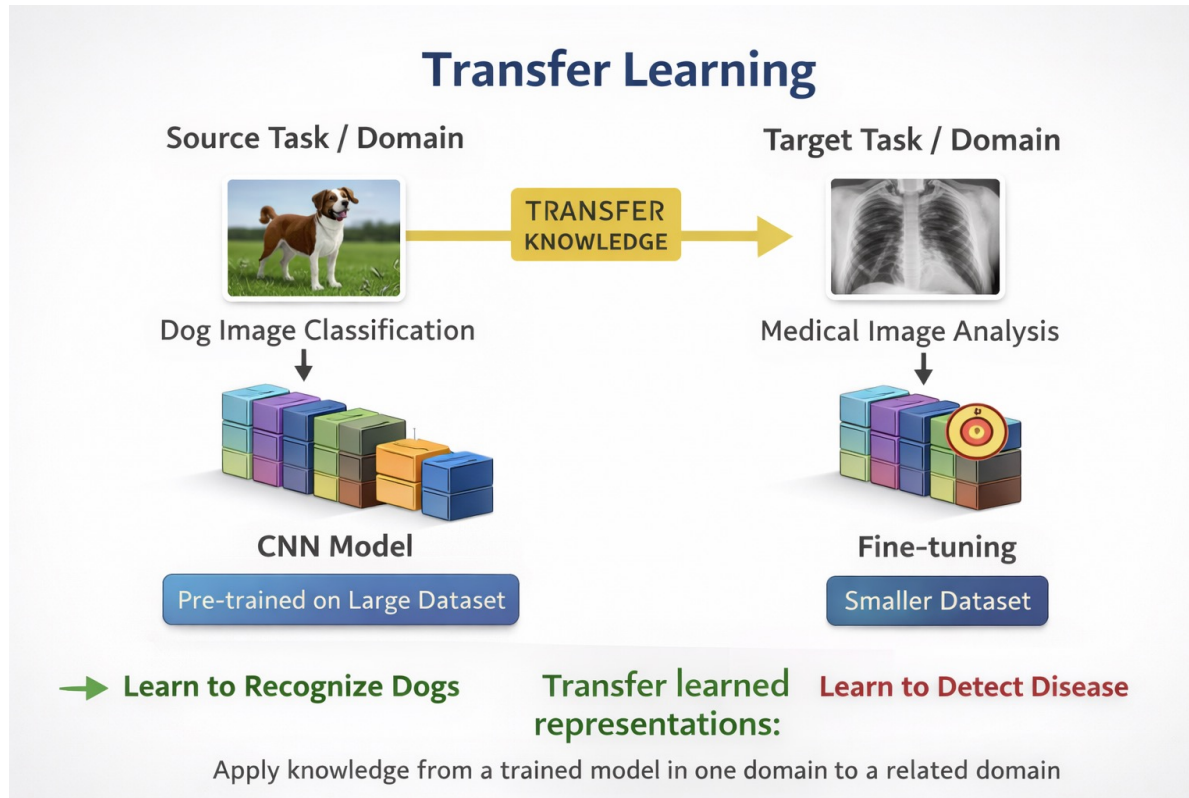
GPT-3 (175B)

GPT-4 (2T)

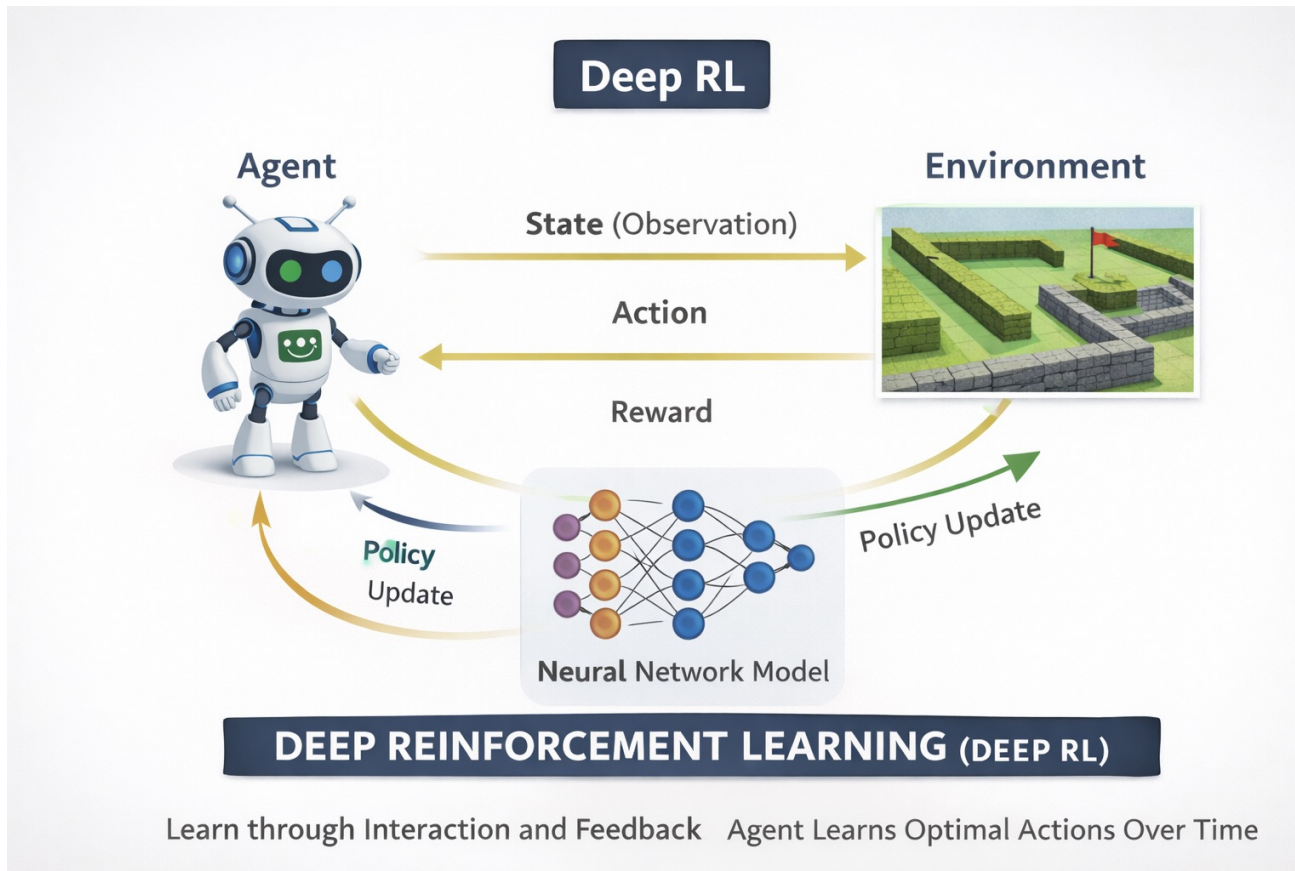
Generative Adversarial Network



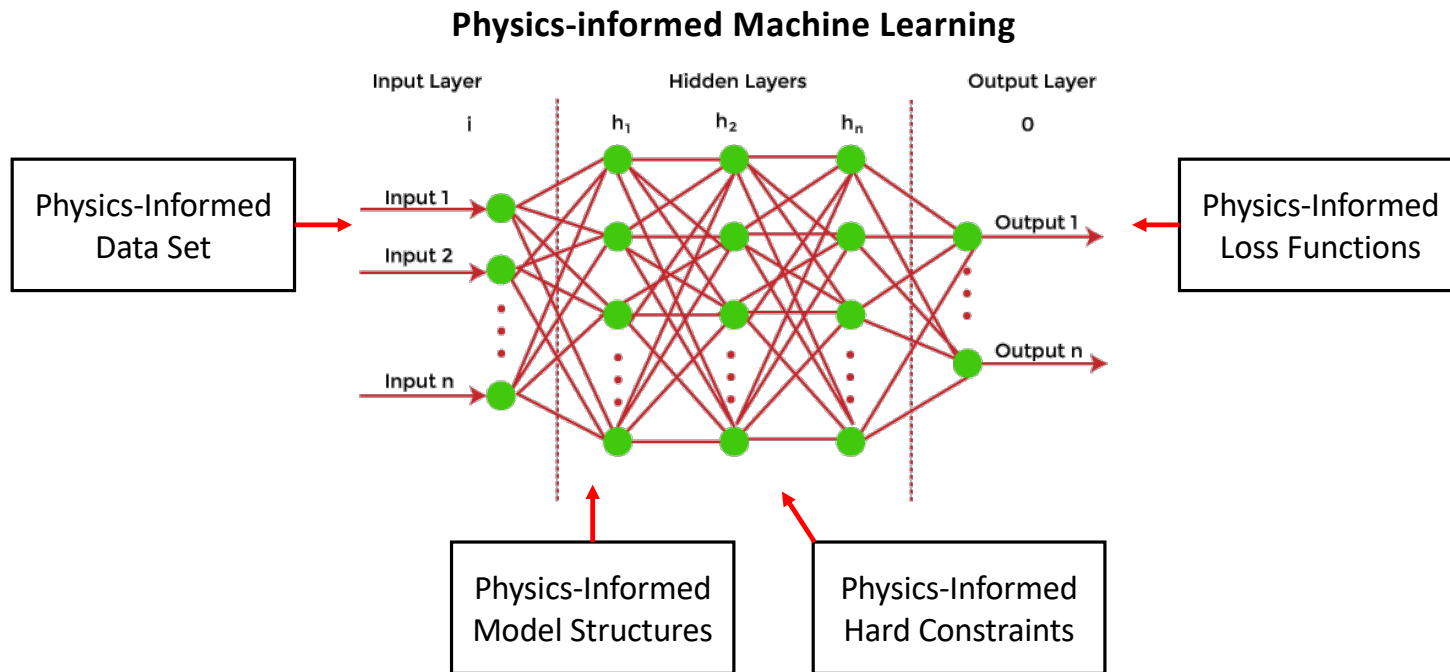
Transfer Learning



Deep Reinforcement Learning



Physics-informed Machine Learning (PIML)



Learn from data but constrained by physics
Combine the strengths of both physical models and data-driven models

LLM/Generative AI



Gemini



ChatGPT

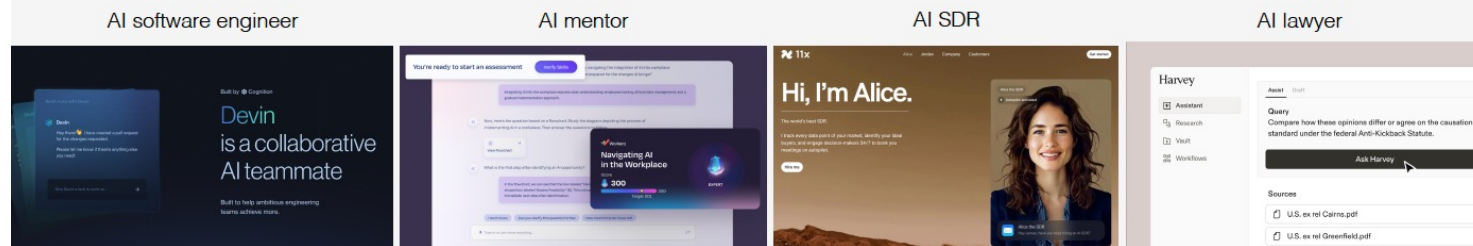


Claude

AI Agent

- Augmenting LLMs
- Prompt and Context Engineering
- Retrieval-Augmented Generation (RAG)
- Agentic AI workflow
- Evals
- Multi-agent Workflow

There are more and more specialized agentic workflows.



Class Schedule

Week	Date	Sections	Comments
1	Jan 12	Introduction	
	Jan 14	Deep Learning (1): Model Structure	
2	Jan 21	Deep Neural Network (2): Training part 1	HW1 Out
3	Jan 26	Lab: DNN Part 1	
	Jan 28	Deep Neural Network (2): Training part 2	
4	Feb 2	Deep Neural Network (3): LSTM/Recurrent Neural Network	HW1 Due/HW2 Out
	Feb 4	Lab: DNN Part 2-RNN/LSTM	
5	Feb 9	Transformer	
	Feb 11	Generative adversarial network (GAN) (1)	
6	Feb 16	Generative adversarial network (GAN) (2)	Midterm project out
	Feb 18	Lab: Transformer/GAN	
7	Feb 23	Transfer Learning	HW2 Due/HW3 Out
	Feb 25	Lab: Transfer Learning	
8	Mar 2	Self-supervised learning: Adaptation	Midterm project Due
	Mar 4	Review Midterm Project	

Class Schedule

9	Mar 16	Deep Reinforcement Learning (1)	
	Mar 18		
10	Mar 23	Deep Reinforcement Learning (2)	
	Mar 25		
11	Mar 30	Lab: Reinforcement Learning: RL	Due/HW4 Out
	Apr 1	Physics-informed Machine Learning (PIML)	
12	Apr 6	Introduction to Generative AI	
	Apr 8	From LLM to AI Agent: Context Engineering	
13	Apr 13	Lab: Prompt/Context Engineering/Agent	
	Apr 15	How LLM Works	HW4 Due
14	Apr 20	Lab: Tokenization, embedding	

Class Schedule

	Apr 22	LLM Evaluation	
15	Apr 27	Student Presentation (1)	
	Apr 29	Student Presentation (2)	
Final Week	May 4	Final Project Report Due	

Grading

Homework	20%
Mid-term Project	25%
Final Project Proposal	10%
Final Project Paper (IBPSA Format)	35%
<u>Final Project Presentation (Oral)</u>	<u>10%</u>
Total	100%

GRADING SCALE:

90%-100% = A

80%-90% = B

70%-80% = C

60%-70% = D

0%-60% = F

Late Submission

LATE SUBMISSION POLICY:

You have the option to submit your assignment after the announced deadline (started late, had to travel, computer malfunction etc.). The following policy will apply:

- Submission after the deadline, but within the first 2 hours of the deadline: Your nominal assignment grade is multiplied by 0.95.
- Submission after the deadline, but within the first 24 hours of the deadline: Your nominal assignment grade is multiplied by 0.80.
- For further delays, 10% will be deducted for additional 24-hour blocks. For example, if you submit your assignment 30 hours passed the deadline, the multiplier is 0.70. 50 hours passed the deadline; the multiplier is 0.60 etc.

No Required Text Book

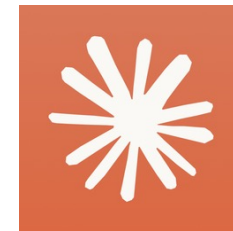
ASK



Gemini



ChatGPT



Claude

Privacy

For correspondences regarding grades, health, or any other personal matters, email the instructors directly

Academic Integrity

How I handle plagiarism?

Here is the university rule for academic integrity. <https://class.syr.edu/wp-content/uploads/2018/08/Academic-Integrity-Policy-Violation-and-Sanction-Classification-Rubric-Updated-081018.pdf>

Academic Integrity

Academic Integrity Violation and Sanction Classification Rubric

Violations below are exemplars and do not represent the full range of behaviors that violate Syracuse University's Academic Integrity Policy. The specific circumstances of each case will be evaluated by trained members of the School or College Academic Integrity Panel.

Examples of Level 1 Violations (Historically, the most common violation types)

- a. Plagiarism in a small section of a larger assignment in which other sources are appropriately documented, e.g., one unattributed source within a multi-source, multi-page essay
- b. Inappropriate collaboration on a small homework assignment

Sanctions for Level 1 Violations*

Course: Zero on the assignment/exam,
grade reduction, or course failure

AND

School/College: Letter of reprimand

!!!!!!Do not copy and paste others code!!!!

First time: 0 grade and a warning

Academic Integrity

Examples of Level 3 Violations: (Repeat violations & exceptional 1st violations)

- a. Plagiarism so extensive that a major course assignment worth half or more of the course grade contains little or no original work, e.g. plagiarism that accounts for three quarters of the text in a culminating course paper
- b. Plagiarism in a comprehensive examination or dissertation
- c. Purchase or sale of a paper from an essay mill
- d. Violation of professional ethics, e.g. submission of substantially plagiarized work to a professional organization or company
- e. Cheating on a comprehensive or other qualifying examination
- f. Forgery of academic or other documents created to support false academic claims or extend academic deadlines, e.g. forged medical excuses, family death certificates or alteration of a transcript

Probation resulted from a violation:

Sanctions for Level 3 Violations*

Course: Zero on the assignment/exam,
grade reduction, or course failure

AND

School/College:

A. Suspension with transcript notation lasting for the length of suspension and indicating suspension resulted from an academic integrity violation

OR

B. Expulsion with permanent transcript notation indicating that expulsion resulted from an academic integrity violation

!!!!!!Do not copy and paste others code!!!!!

Second time: 0 grade and suspension or expulsion

Vibe Coding is Encouraged

What is Vibe Coding

From ChatGPT:

“**Vibe coding** is an informal term for a programming style where the developer focuses on **intuition, flow, and rapid experimentation** rather than strict planning, formal specifications, or perfect code structure.”

Vibe Coding is Encouraged

From ChatGPT:

Vibe Coding

Intuition-driven
Fast iteration
Flexible structure
Creative

Traditional Coding

Plan-driven
Careful design
Rigid architecture
Predictable

Homework using Vibe Coding

Please mark your code if you use AI tools

“The following code is generated by AI tool: X”

“Beginning of AI generated code”

Your code here.

“End of AI generated code”

Lab Requirements

- All programming work in this course will be done using Python
- We will use the following software:

	Software	Version	Download Link
Language	Python	3.8 or higher	Download Python
Integrated development environment (IDE)	PyCharm	Community edition	Install PyCharm
Machine learning framework	PyTorch	1.9	PyTorch

- Free Python tutorial: [Python Tutorial - YouTube](#)
- Free Python book: [Automate the Boring Stuff with Python](#)

Questions? Email Yiting Yang <yyang301@syr.edu>

Any Questions?

bidong@syr.edu