

A Gentle Introduction to Machine Learning

Spring 2025

Eric Pacuit

January 30, 2025

Course Information

Instructor: Eric Pacuit (epacuit@umd.edu, pacuit.org)

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Office Hours: TBA

Office: Skinner TBA

Class Times: TuTh 12:30pm - 1:45pm

Course Website: <https://umd.instructure.com/courses/1380870>

Artificial Intelligence at UMD

- ▶ New majors in AI:
 - ▶ Bachelor of Arts in Human-Centered AI

A version of this course will be part of the technical core sequence for this new major.
 - ▶ Bachelor of Science in AI
- ▶ AIM (<https://aim.umd.edu/>): a new interdisciplinary institute focused on research and education in Artificial Intelligence at UMD.
- ▶ VCAI (Values Centered AI: <https://vcai.umd.edu/>)

Online Resources

- ▶ **ELMS Course Website:**

<https://umd.instructure.com/courses/1380870>

- ▶ **Course Website:**

<https://epacuit.github.io/introduction-machine-learning>

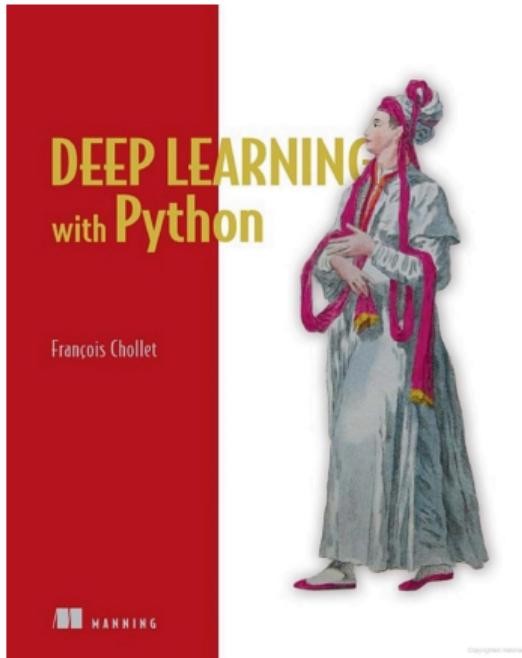
- ▶ **PollEverywhere:**

PollEv.com/epacuit/register?group_key=jKUzrkJWJcUsPeZ77OaLs3mhg

- ▶ **Piazza:**

https://umd.instructure.com/courses/1380870/external_tools/42711

Reading



The relevant chapters will be available on the [ELMS Course Website](#).

Prerequisites

This course is self-contained and does **not** require formal prerequisites in math or programming. However, it is important to note that:

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To ensure all students are prepared, the course will begin with a 2-3 week crash course in Python programming.

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- ▶ **We will discuss and use mathematical notation!**

Students should ideally have some familiarity with the following topics: the concept of a derivative; logarithms and exponents; basic trigonometry, particularly cosines; and graphs of functions.

Computer Science/Machine Learning Majors

This course is intended for students with little to no background in computer science.

Most of the material covered here will be explored in greater depth in computer science courses. Specifically, if you have taken or plan to take **CMCS 422**, I strongly recommend against enrolling in this course.

Before registering, please consult your Academic Advisor to confirm whether this course fulfills your ULC requirements. (My recommendation is that this course should **not** count toward the ULC requirement.)

Grading

Participation	35%
Tutorials	45%
Midterm	10%
Final Exam	10%

Participation

Attending lectures is essential for success in this course. While attendance will not be formally recorded, you are responsible for all material covered during lectures, even if you are absent. It will be very easy to fall behind if you miss classes, so please reach out to me or the TA if you miss more than one or two sessions to ensure you stay on track.

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Your participation grade will be based on two scores:

- ▶ PollEverywhere responses (usually survey questions)
- ▶ The number of contributions to Piazza (questions or comments)

A Brief Introduction to Machine Learning

Machine Learning \neq AI

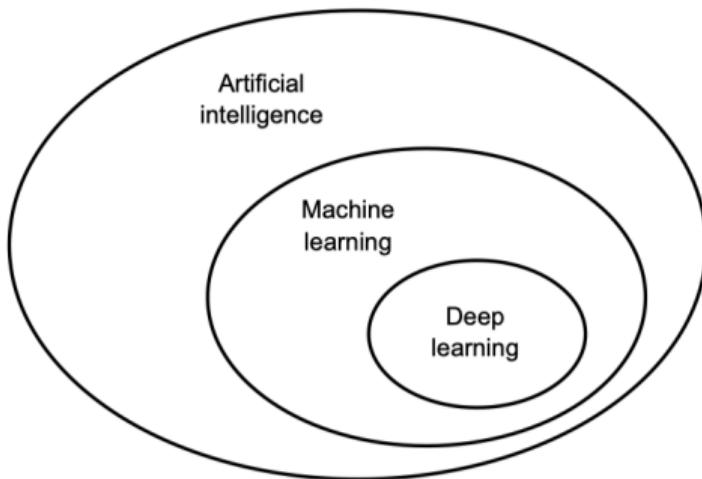
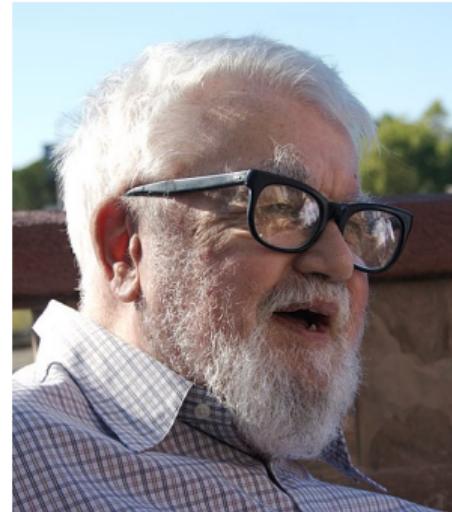


Figure 1.1 Artificial intelligence,
machine learning, and deep learning

Learning

The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it...

An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves.



John McCarthy

Learning

We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.

(1952 Dartmouth Workshop)



John McCarthy

What is Machine Learning?

Learning is any process by which a system improves performance from experience.



Herbert Simon

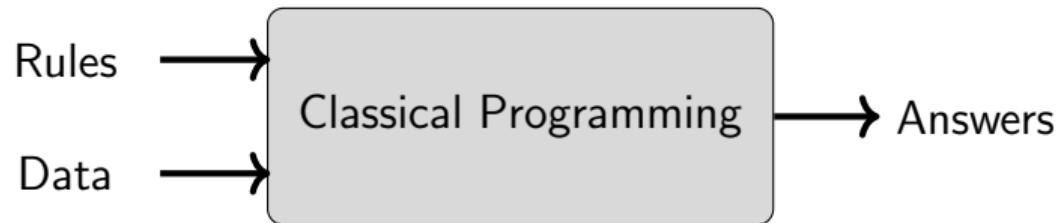
What is Machine Learning?

Machine learning . . . gives computers the ability to learn without being explicitly programmed.

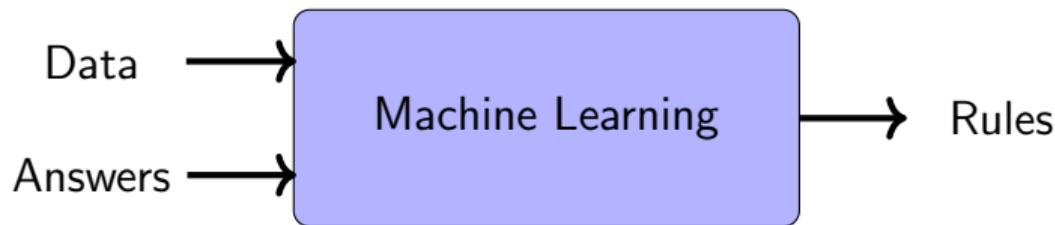
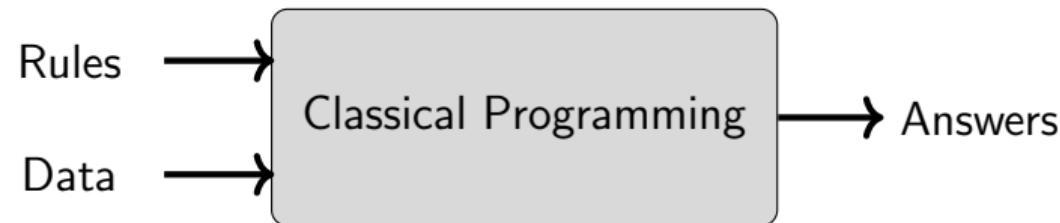


Arthur Lee Samuel

Classical Programming vs. Machine Learning



Classical Programming vs. Machine Learning



Machine Learning

Algorithms that

- ▶ improve their **performance** P
- ▶ at **task** T
- ▶ with **experience** E

A well-defined machine learning task is given by (P, T, E) .

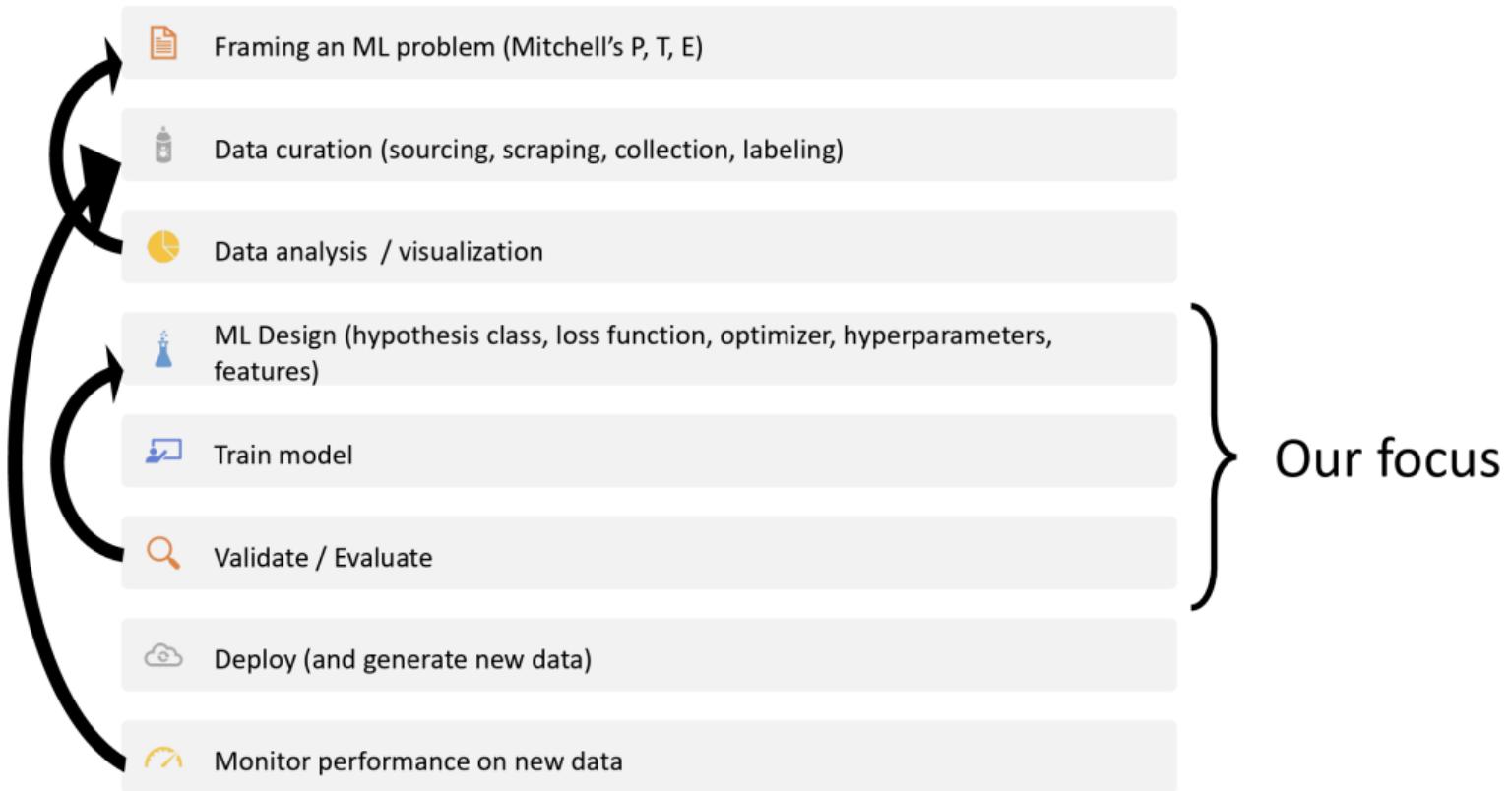


Tom M. Mitchell

Types of Machine Learning Problems

- ▶ **Supervised learning**
 - ▶ Input: Examples of inputs and outputs
 - ▶ Output: Model that predicts unknown output given a new input
- ▶ **Unsupervised learning**
 - ▶ Input: Examples of some data (no “outputs”)
 - ▶ Output: Representation of structure in the data
- ▶ **Reinforcement learning**
 - ▶ Input: Sequence of interactions with an environment
 - ▶ Output: Policy that performs a desired task

Machine Learning Workflow



Bias and Fairness in Machine Learning

The top screenshot shows an article titled "Should We Be Afraid of AI in the Criminal-Justice System?" by Derek Thompson. The bottom screenshot shows an article titled "A Popular Algorithm Is Not Predicting Crimes Than Real People" by Ed Yong.

The Brookings article is titled "It's time for our justice system to embrace artificial intelligence". The Forbes article is titled "Justice, Equity, And Fairness: Exploring The Tense Relationship Between Artificial Intelligence And The Law With Joilson Melo". The New York Times article is titled "Artificial Justice: The Quandary of AI in the Courtroom".

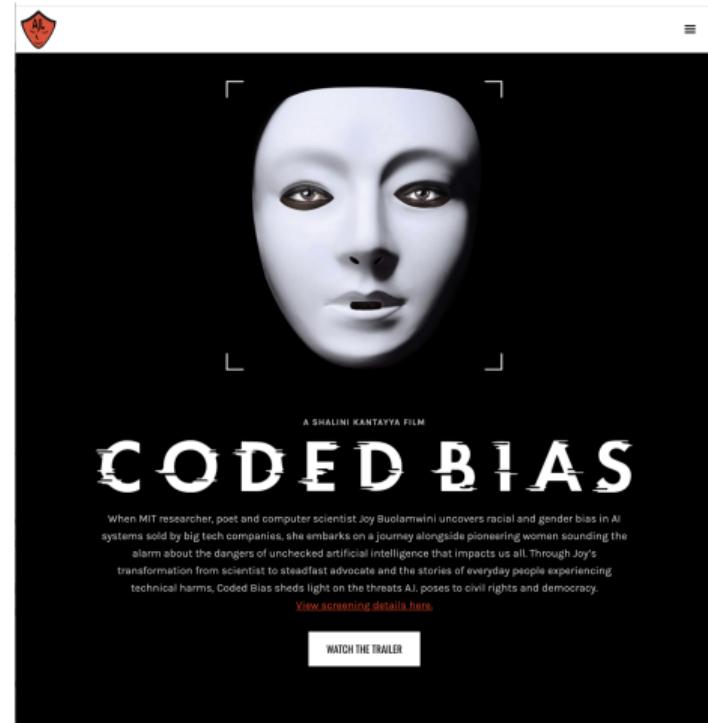
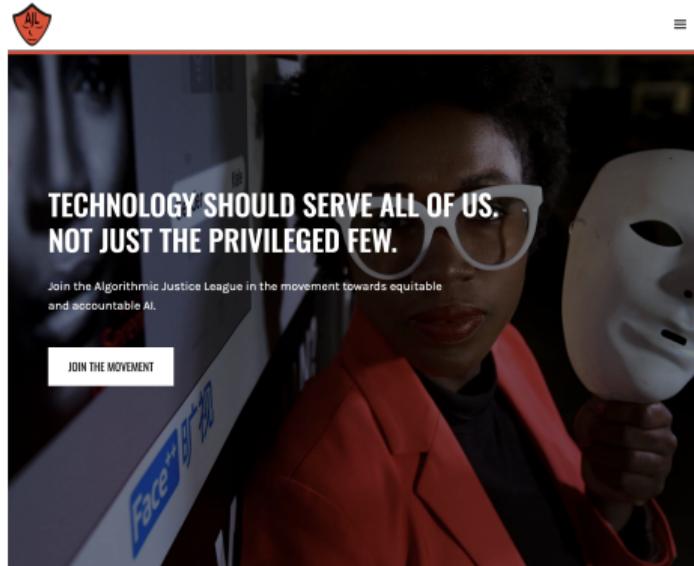
The New York Times article includes a snippet of code:

```
for (int j = 0; j < loc; j++) res[j] = buf[j];
return res;
public void checkResult(int[] res) {
    int chekLoc = 0;
    for (int i = 0; i < res.length; i++) {
        if (res[i] != checkRes[i]) {
            chekLoc = i;
        }
    }
}
Verdict: GUILTY
decodeMessage() {
    int[] res = new int[MAX_RES];
    for (int i = 0; i < MAX_RES; i++) buf[i] = 0;
    for (int i = 0; i < res.length; i++) {
        if (buf[i] == 1) {
            res[i] = 1;
        }
    }
    return res;
}
```

The New York Times article also features a photo of a bust of a man in front of bookshelves.

The opinion piece is titled "When an Algorithm Helps Send You to Prison" by Ellora Thadani Israni.

Algorithmic Justice League: <https://www.ajl.org/>



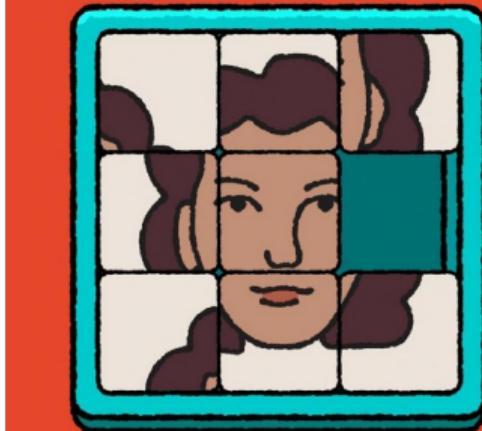
WE COMBINE ART AND RESEARCH TO ILLUMINATE

A PELICAN BOOK

Moral AI

And How We Get There

Jana Schaich Borg
Walter Sinnott-Armstrong
Vincent Conitzer

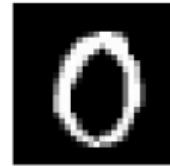


Deep Learning

Deep learning is a specific subfield of machine learning: a new take on learning representations from data that puts an emphasis on learning successive layers of increasingly meaningful representations.

The “deep” in “deep learning” isn’t a reference to any kind of deeper understanding achieved by the approach; rather, it stands for this idea of successive layers of representations.

Classic Example: Recognizing Handwritten Numbers



Keras

```
(train_images, train_labels), (test_images, test_labels) = mnist.load_data()

model = keras.Sequential([
    layers.Dense(512, activation='relu'),
    layers.Dense(10, activation='softmax')
])

model.compile(
    optimizer='rmsprop',
    loss = 'sparse_categorical_crossentropy',
    metrics=["accuracy"])

train_images = train_images.reshape((60000, 28*28))
train_images = train_images.astype('float32') / 255
test_images = test_images.reshape((10000, 28*28))
test_images = test_images.astype('float32') / 255

model.fit(train_images, train_labels, epochs=10, batch_size=128)
```

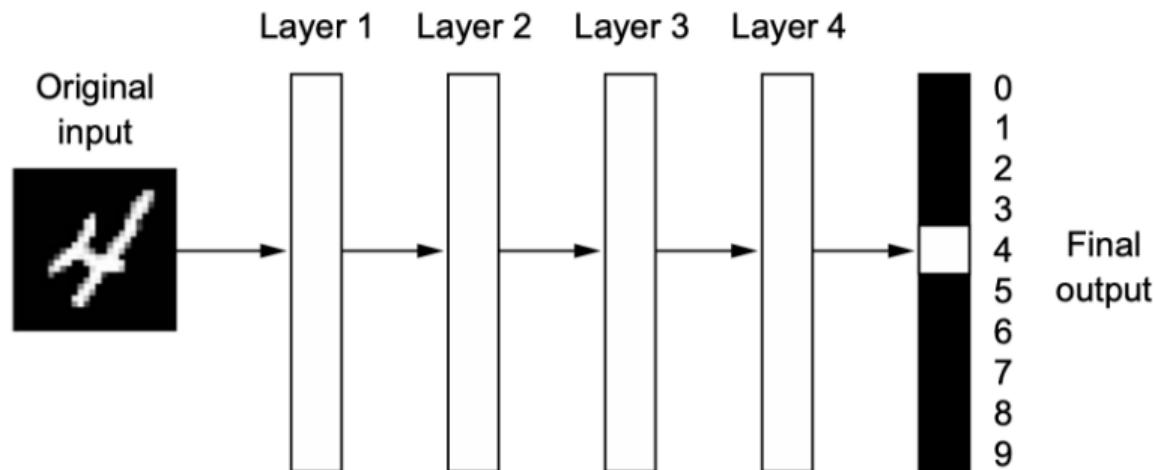
Keras

```
test_loss, test_acc = model.evaluate(test_images, test_labels)
print('Test accuracy:', test_acc)
```

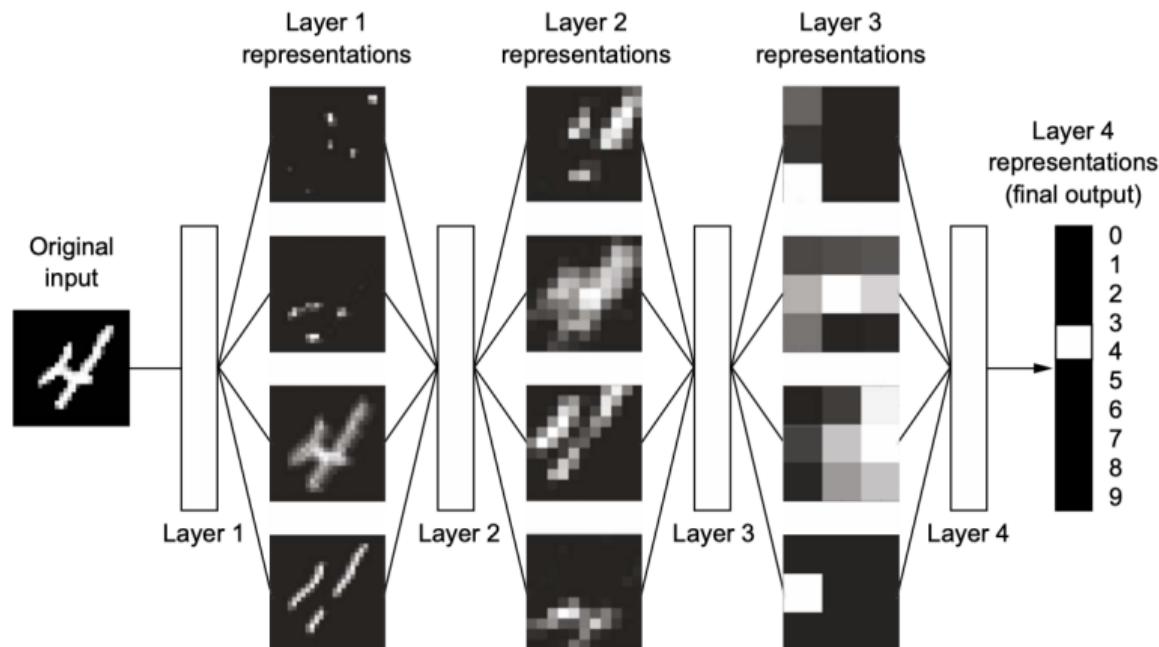
✓ 0.2s

```
313/313 ━━━━━━━━━━ 0s 589us/step - accuracy: 0.9790 - loss: 0.0777
Test accuracy: 0.9822999835014343
```

Neural Net



Neural Net



Crash Course in Python

Python

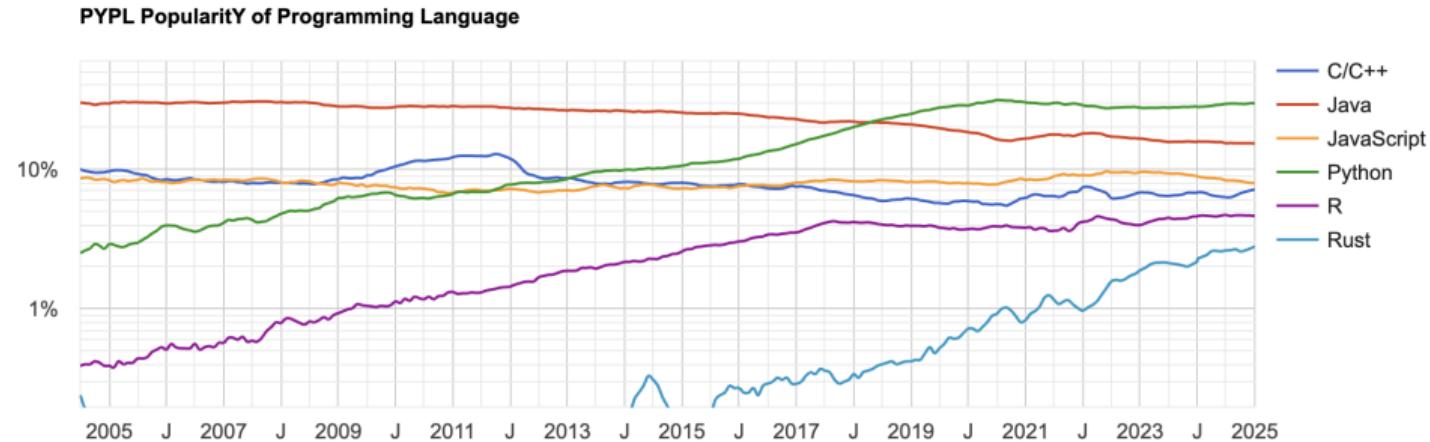
Python is a high-level, general-purpose programming language known for its simplicity, readability, and versatility. Created by **Guido van Rossum** and first released in 1991, Python is widely used for various applications, especially Machine Learning and Data Science.

www.python.org

www.geeksforgeeks.org/reasons-why-you-should-learn-python

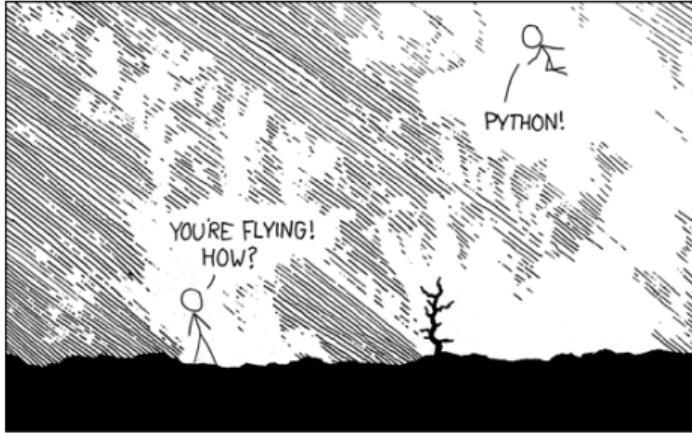
Python

Python is a very popular language!



<https://pypl.github.io/PYPL.html>

Python is fun!



I LEARNED IT LAST
NIGHT! EVERYTHING
IS SO SIMPLE!
/ HELLO WORLD IS JUST
print "Hello, world!"

I DUNNO...
DYNAMIC TYPING?
WHITESPACE?
/ COME JOIN US!
PROGRAMMING
IS FUN AGAIN!
IT'S A WHOLE
NEW WORLD
UP HERE!
/ BUT HOW ARE
YOU FLYING?

I JUST TYPED
import antigravity
THAT'S IT? /
/ ... I ALSO SAMPLED
EVERYTHING IN THE
MEDICINE CABINET
FOR COMPARISON.
/ BUT I THINK THIS
IS THE PYTHON.

Python for Machine Learning and Data Science

Pandas <https://pandas.pydata.org/>

NumPy <https://numpy.org/>

SciPy <https://scipy.org/>

Matplotlib <https://matplotlib.org/>

Seaborn <https://seaborn.pydata.org/>

Keras <https://keras.io/>

Pytorch <https://pytorch.org/>

NLTK <https://www.nltk.org/>

Python Tools

- ▶ Jupyter notebooks: <https://jupyter.org/>
- ▶ Colab: <https://colab.research.google.com/>
- ▶ GitHub: <https://github.com/>
<https://github.com/epacuit/introduction-machine-learning>

LLMs

Should I use ChatGPT to solve tutorials for my class "A Gentle Introduction to Machine Learning"



It depends on how you use ChatGPT. If your goal is to deepen your understanding, then using it as a tool for guidance, explanations, and debugging can be beneficial. However, if you rely on it to simply generate answers without engaging in the problem-solving process, it may hinder your learning.

Here are some ways to use ChatGPT effectively for your "**A Gentle Introduction to Machine Learning**" class:

✓ Good Uses:

1. **Clarification of Concepts** – If you do not understand a topic, ask for an explanation in simpler terms.
2. **Code Debugging** – If your code is not working, use ChatGPT to help troubleshoot.
3. **Alternative Approaches** – Ask about different ways to solve a problem.
4. **Mathematical Intuition** – Use it to get a better grasp of the math behind ML techniques.
5. **Practice Problems** – Generate additional problems to practice concepts.

✖ Bad Uses:

1. **Copy-Pasting Answers** – If you submit ChatGPT-generated answers without understanding, you are not learning.
2. **Bypassing Thinking** – Machine learning requires problem-solving skills, and skipping that process will make later topics much harder.
3. **Ignoring Errors** – ChatGPT can make mistakes. Blindly trusting its answers can lead to misconceptions.

If your tutorials are graded, check your class policies on AI-assisted learning. Some instructors encourage its use as a study aid, while others may have restrictions.

Would you like me to help you structure your learning process using ChatGPT?