

A Gentle Introduction to Machine Learning

Spring 2025

Eric Pacuit

January 28, 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-Facing 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>

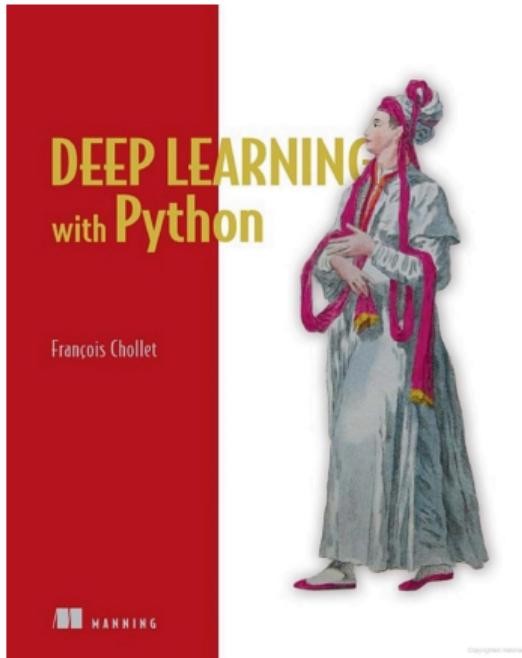
- ▶ **PollEverywhere:**

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

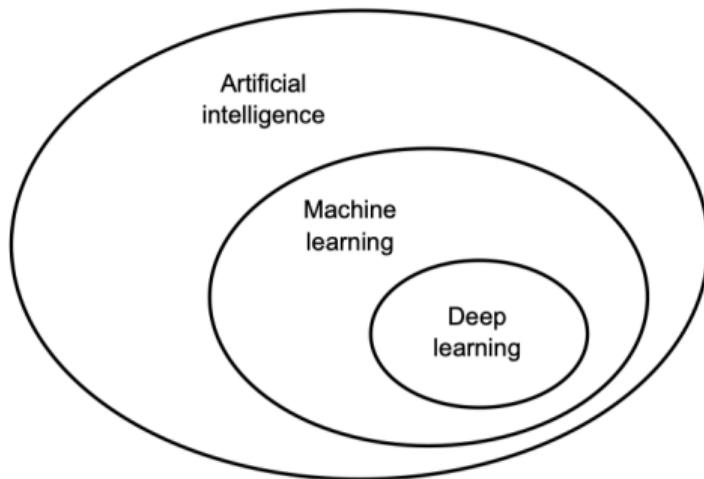


Figure 1.1 Artificial intelligence,
machine learning, and deep learning

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

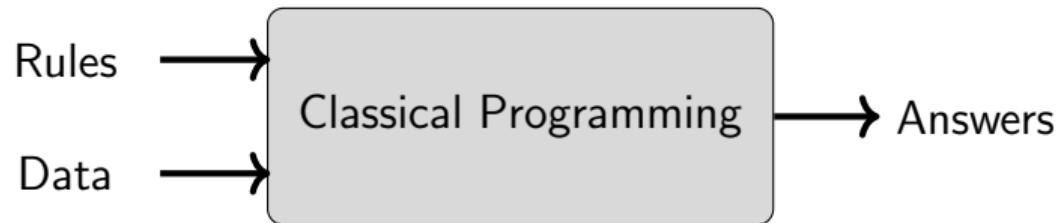
What is Machine Learning?

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

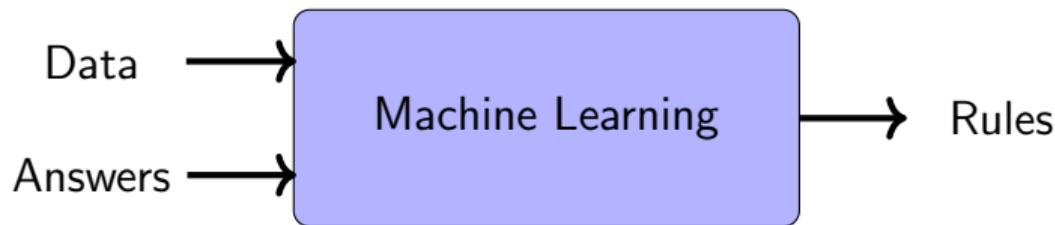
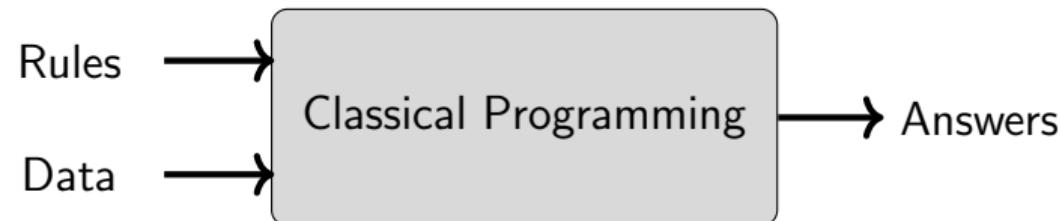


Arthur Lee Samuel

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) .

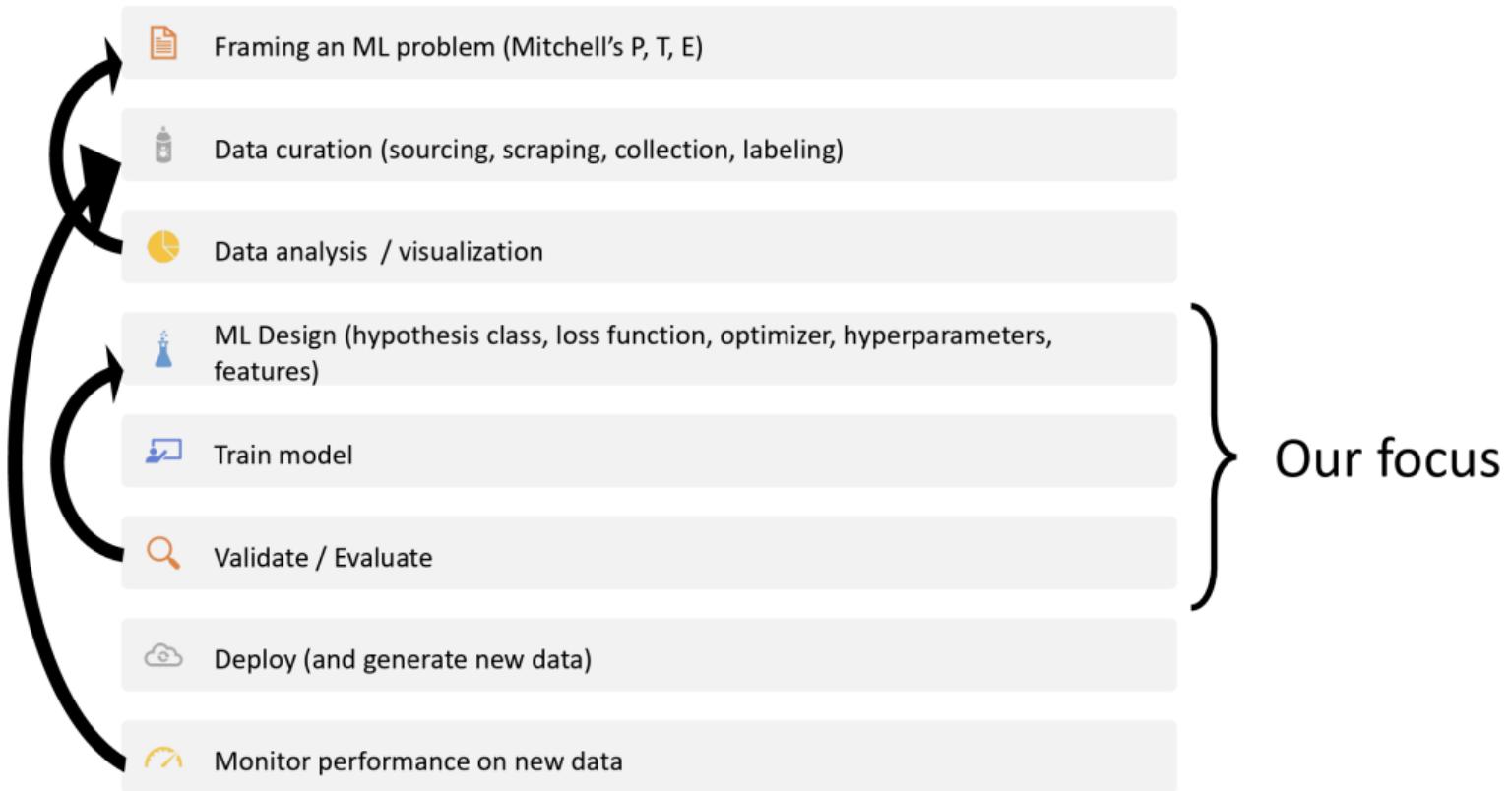


Tom M. Mitchell

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".

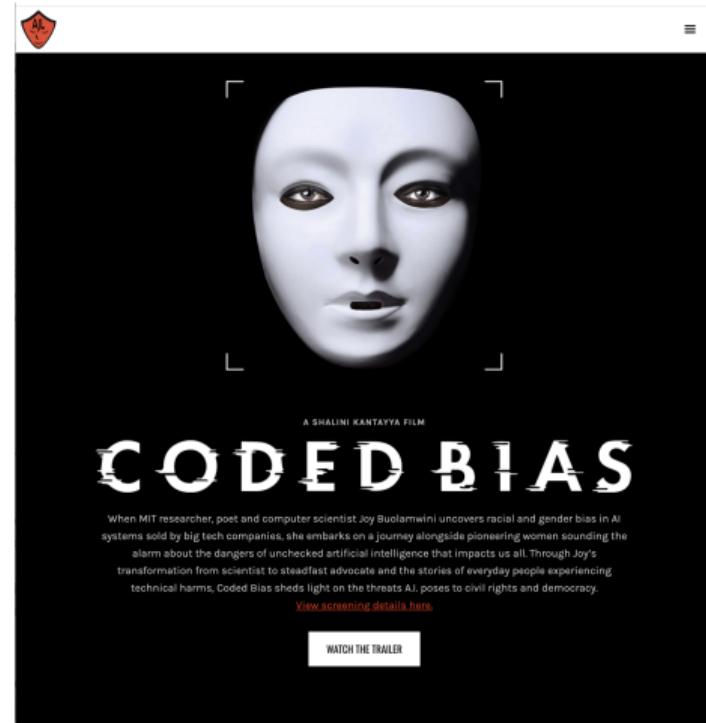
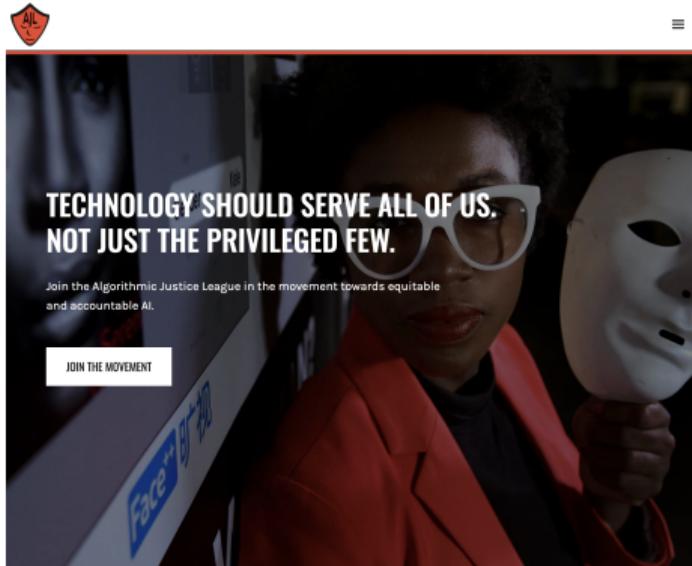
The New York Times article includes a snippet of code:

```
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];
    int loc = 0;
    for (int i = 0; i < MAX_RES; i++) {
        buf[i] = 0;
    }
    for (int i = 0; i < res.length; i++) {
        res[i] = buf[i];
    }
    loc = checkResult(res);
}
```

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

The article is titled "When an Algorithm Helps Send You to Prison" by Ellora Thadani Israni. It includes a quote: "'black box' AI system has been influencing criminal justice decisions for over two decades – it's time to open it up".

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



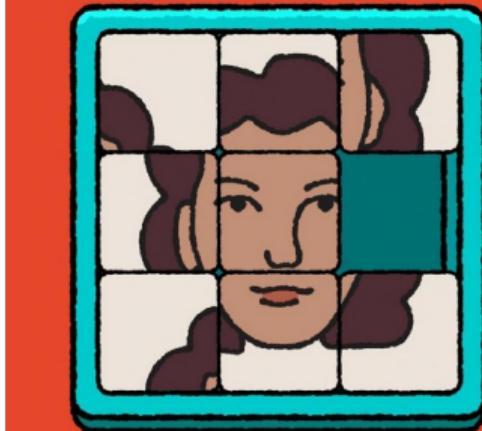
WE COMBINE ART AND RESEARCH TO ILLUMINATE

A PELICAN BOOK

Moral AI

And How We Get There

Jana Schaich Borg
Walter Sinnott-Armstrong
Vincent Conitzer

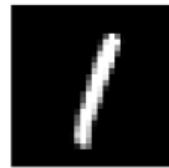


Deep Learning

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)
```

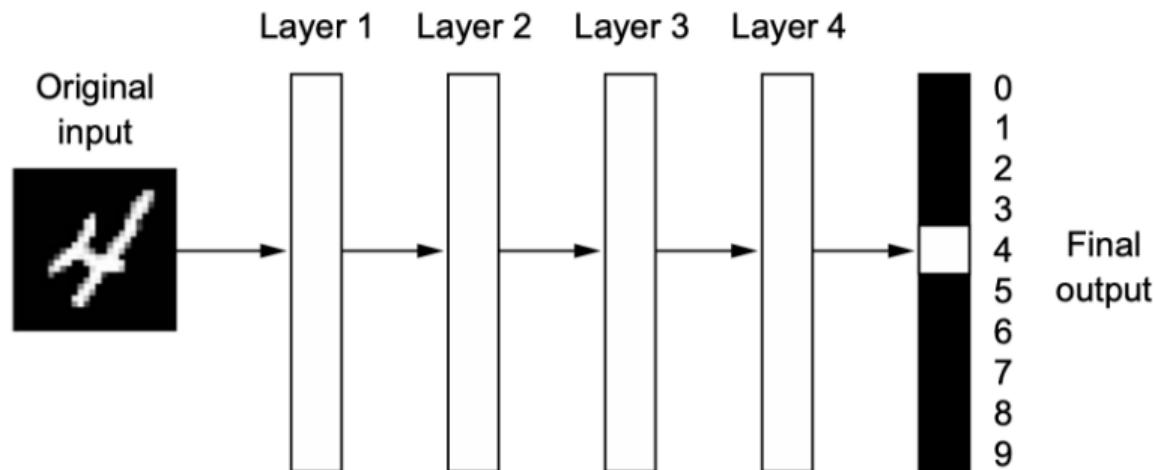
Keras

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

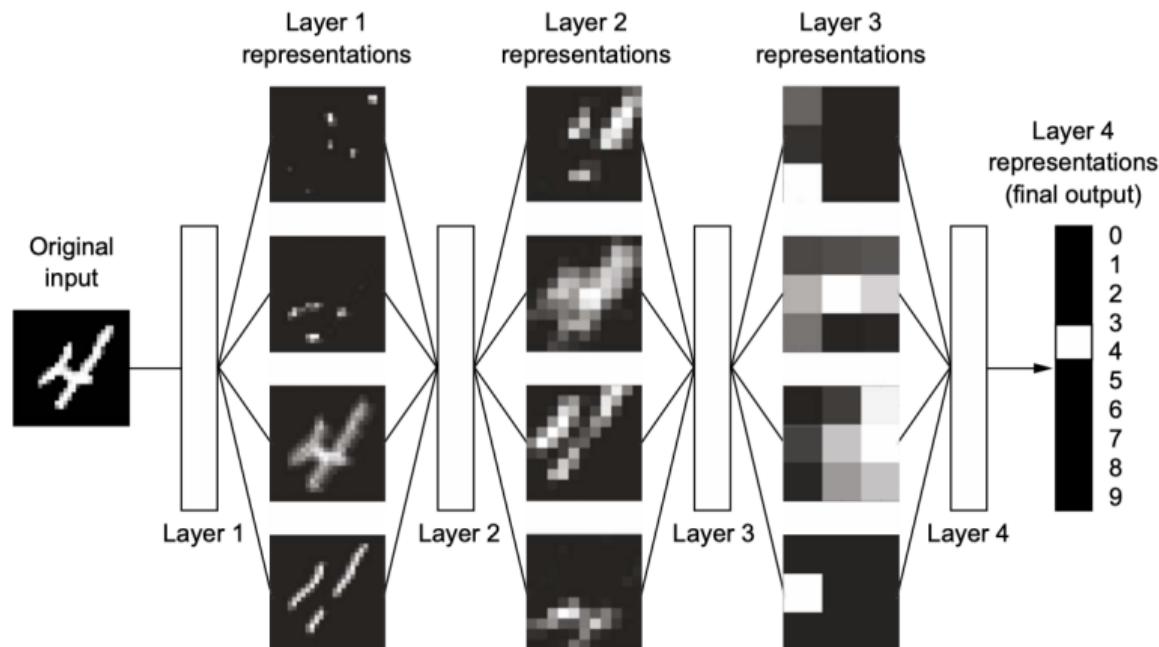
✓ 0.2s

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

Neural Net



Neural Net



Crash Course in Python

Python

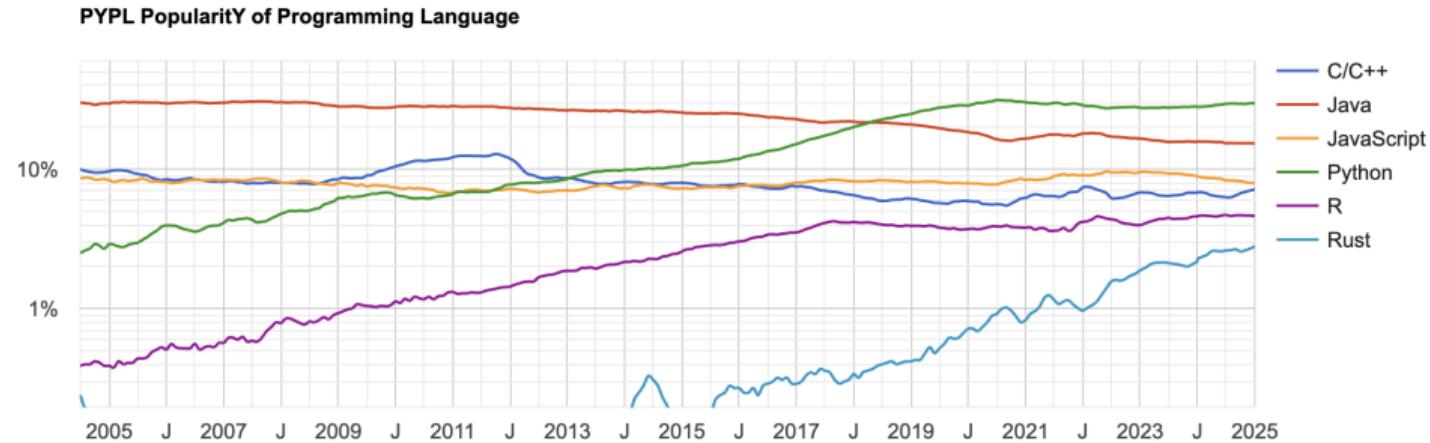
Python is a high-level, general-purpose programming language known for its simplicity, readability, and versatility. Created by **Guido van Rossum** and first released in 1991, Python is widely used for various applications, especially Machine Learning and Data Science.

www.python.org

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

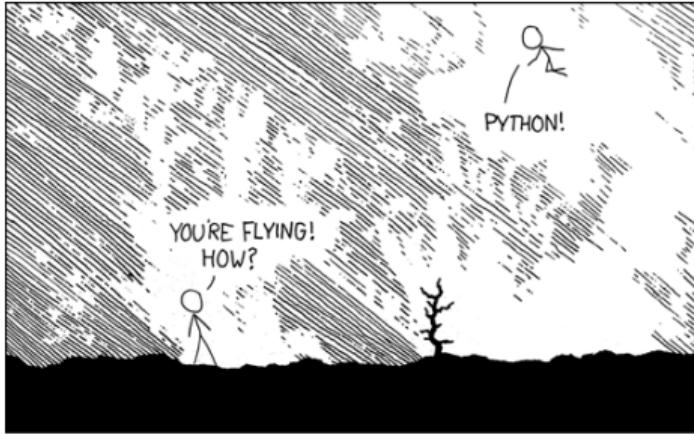
Python

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>