Short-course & Hands-on Workshop: Artificial Intelligence Algorithms for Everyone

June 23 to June 26, 2025

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university of groningen

Let's get to know each other

1. Name
2. Where are you right now
3. How much do you know about statistics and AI in a scale from 1 (very little) to 10 (a lot)?
4. How much do you know about coding and coding in Python in a scale from 0 (nothing) to 10 (a lot)
5. Hobby

June 23 (Monday)	**Introduction to artificial intelligence and Python programming (homogenization)** • The history of the spring and winters in artificial intelligence: from automatons to deep artificial neural networks and up to the singularity of human-level artificial intelligence • Introduction to Python programming of artificial intelligence algorithms, elastic nets and vibe coding
June 24 (Tuesday)	**Machine learning algorithms** • Machine learning algorithms for classification and regression: elastic nets, XGBoost, artificial neural networks, support vector machines, random forests • Time Series Forecasting : modeling and predicting time series data in practice with META's Prophet and long short-term memory models • Model evaluation, feature engineering, feature selection, and fine-tuning: metrics based on error minimization and the confusion matrix, Bayesian hypertuning
June 25 (Wednesday)	**Deep learning algorithms and recent trends in Artificial Intelligence** • Deep learning algorithms and Large Language Models (LLMs): the Transformers' architecture • Semantic and sentiment analysis of textual data with RoBERTa • Ethical considerations on the application of AI algorithms and mitigation strategies • Recent advances in AI: liquid neural networks, how to use DeepSeek without worrying about privacy issues, spatial machine learning, systematic reviews and literature reviews in 5-minutes with GPTs, quantum computing, liquid neural networks
June 26 (Thursday)	Presentations: • Using Mobile Phone Surveys (MPS) to measure child mortality during crisis periods (Kassoum Dianou) • Ways in which AI can support autonomous navigation in Space Missions (Duna Meya i Mendoza)

Practical applications

- AI as psychological assistants & therapists
- Determinants of salary (income)
- Credit scoring
- Demographic (population) forecasts (time series forecasting)
- Literature reviews with ChatGPT and DeepSeek
- Locally running LLMs

Other examples:

- Spatial machine learning
- Semantic and sentiment analysis of textual data with RoBERTa

Schedule (CET)

- First section: 2:30 PM to 3:15 PM

  First break: 3:15 PM to 3:30 PM

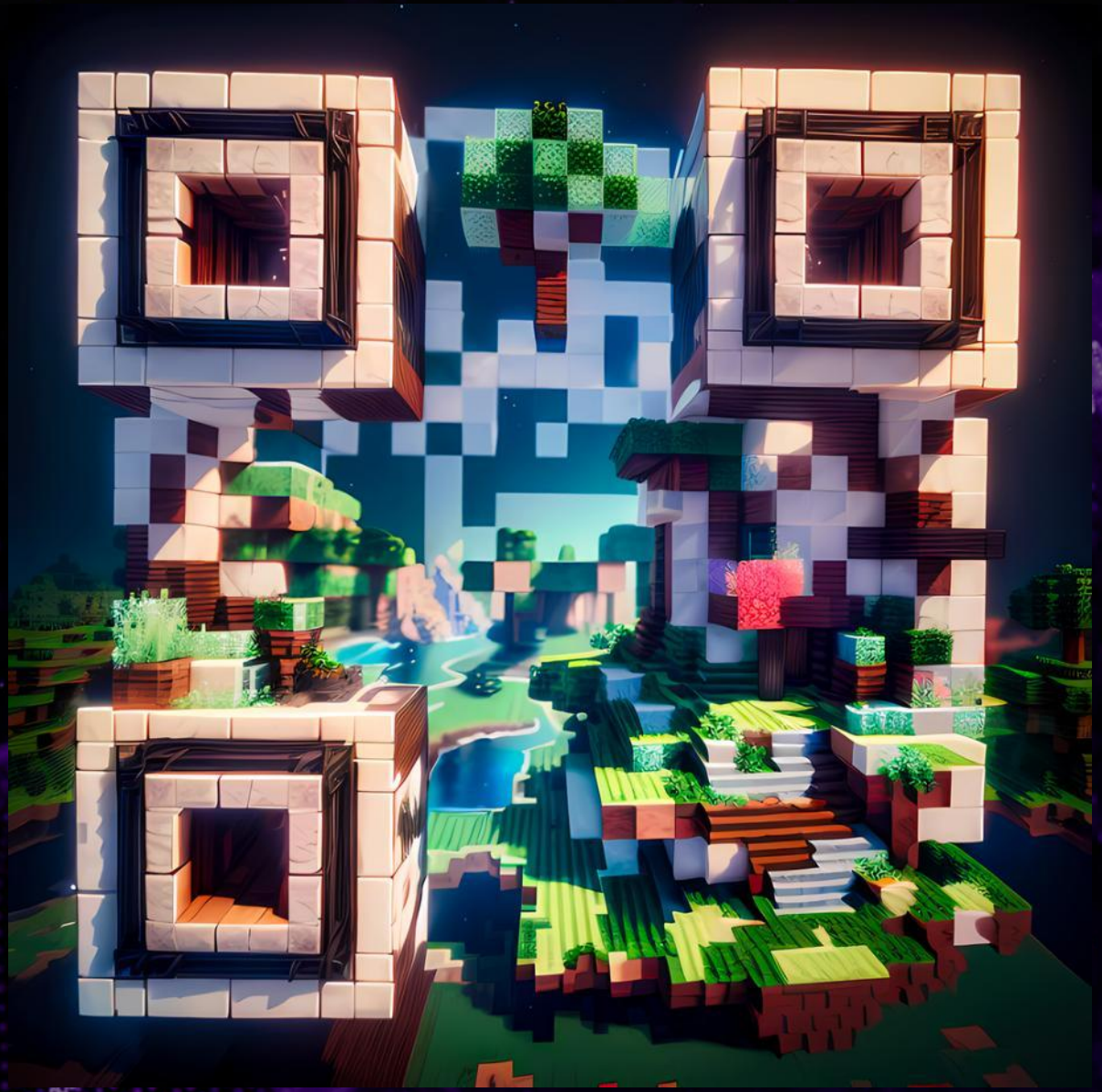
- Second section: 3:30 PM to 4:15 PM

  Second break: 4:15 PM to 4:30 PM

- Third session: 4:30 PM to 5:00 PM

Optional extra space for questions and comments: 5:00 PM to 5:30 PM

GitHub repository



https://github.com/rogon666/AI_workshop

- Presentations
- Databases
- Python scripts
- Additional lectures (papers, books)

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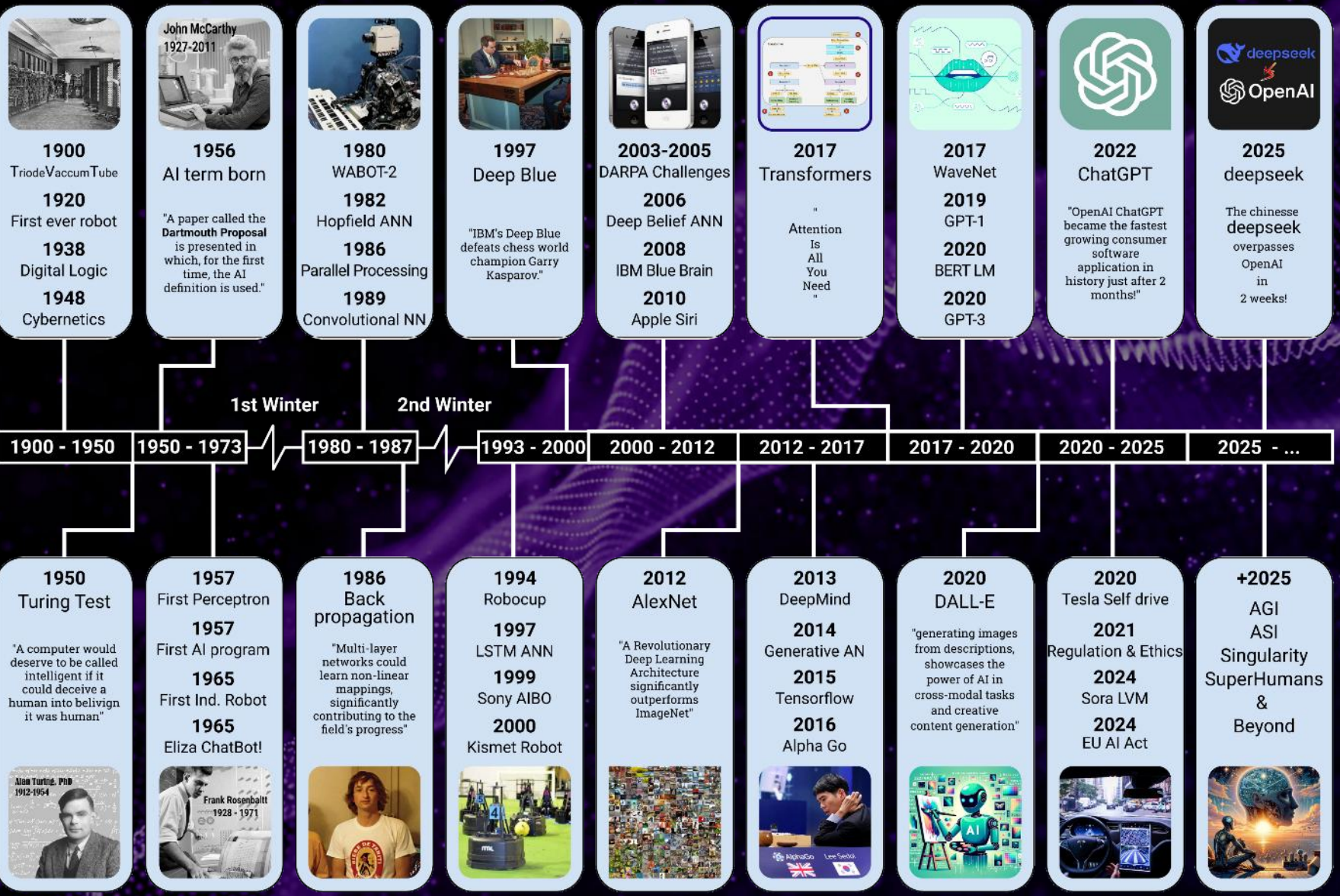
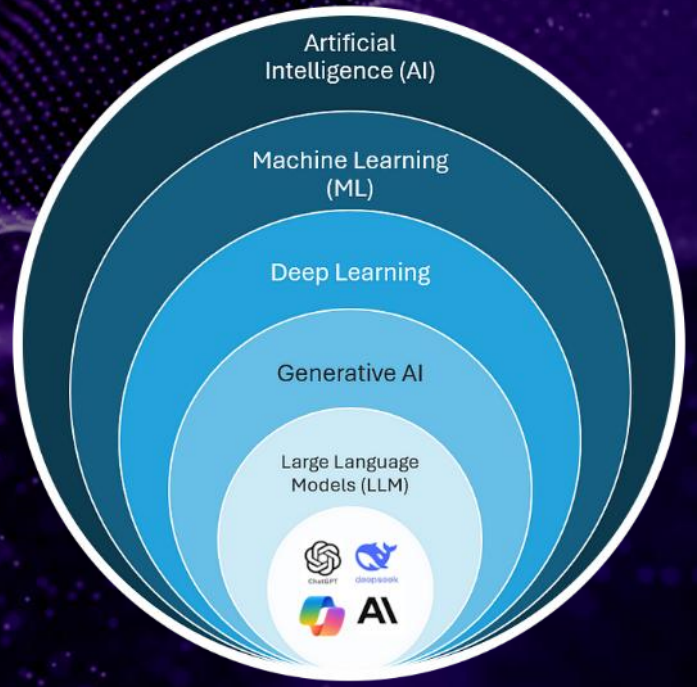
June 26 (Thursday)	Using Mobile Phone Surveys (MPS) to measure child mortality during crisis periods: challenges and implications for health systems in Low- and Middle-Income Countries Kassoum Dianou Joseph Ki-Zerbo University and Catholic University of Louvain

AI: history and definition



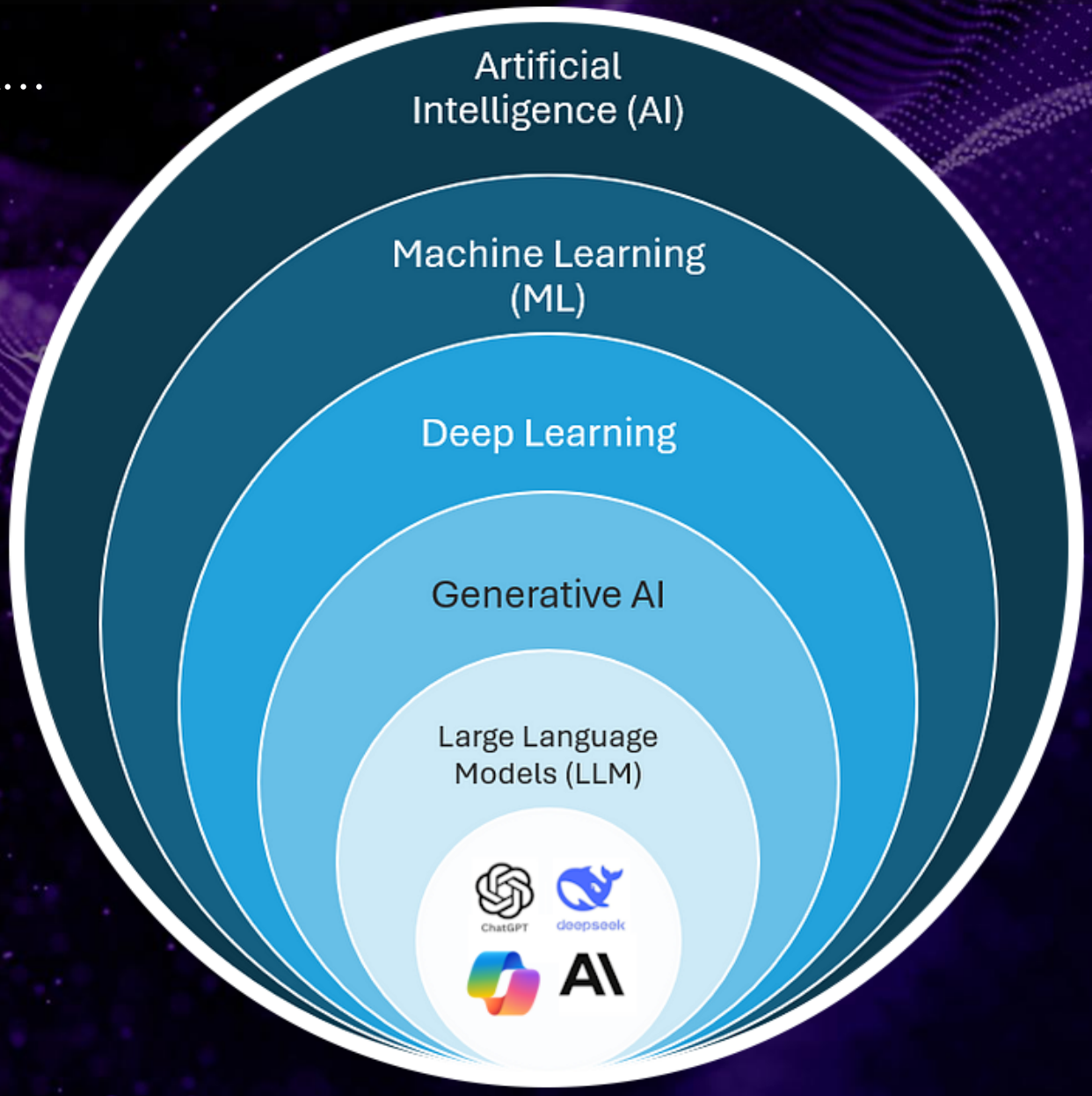


AI: history and definition

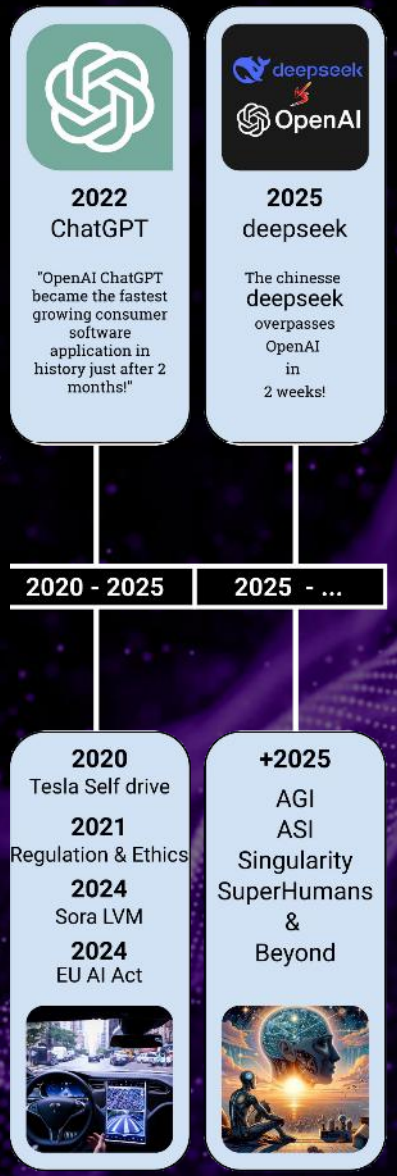
"The exciting new effort to make computers think… machines with minds, in the full and literal sense."
— **Minsky, M. (1968). *Semantic Information Processing*.** MIT Press.

"Probabilistic AI seeks to understand how to design systems that reason and act under uncertainty… using tools from probability theory and statistics."
— **Russell, S., & Norvig, P. (2020). *Artificial Intelligence: A Modern Approach* (4th ed.).** Pearson.

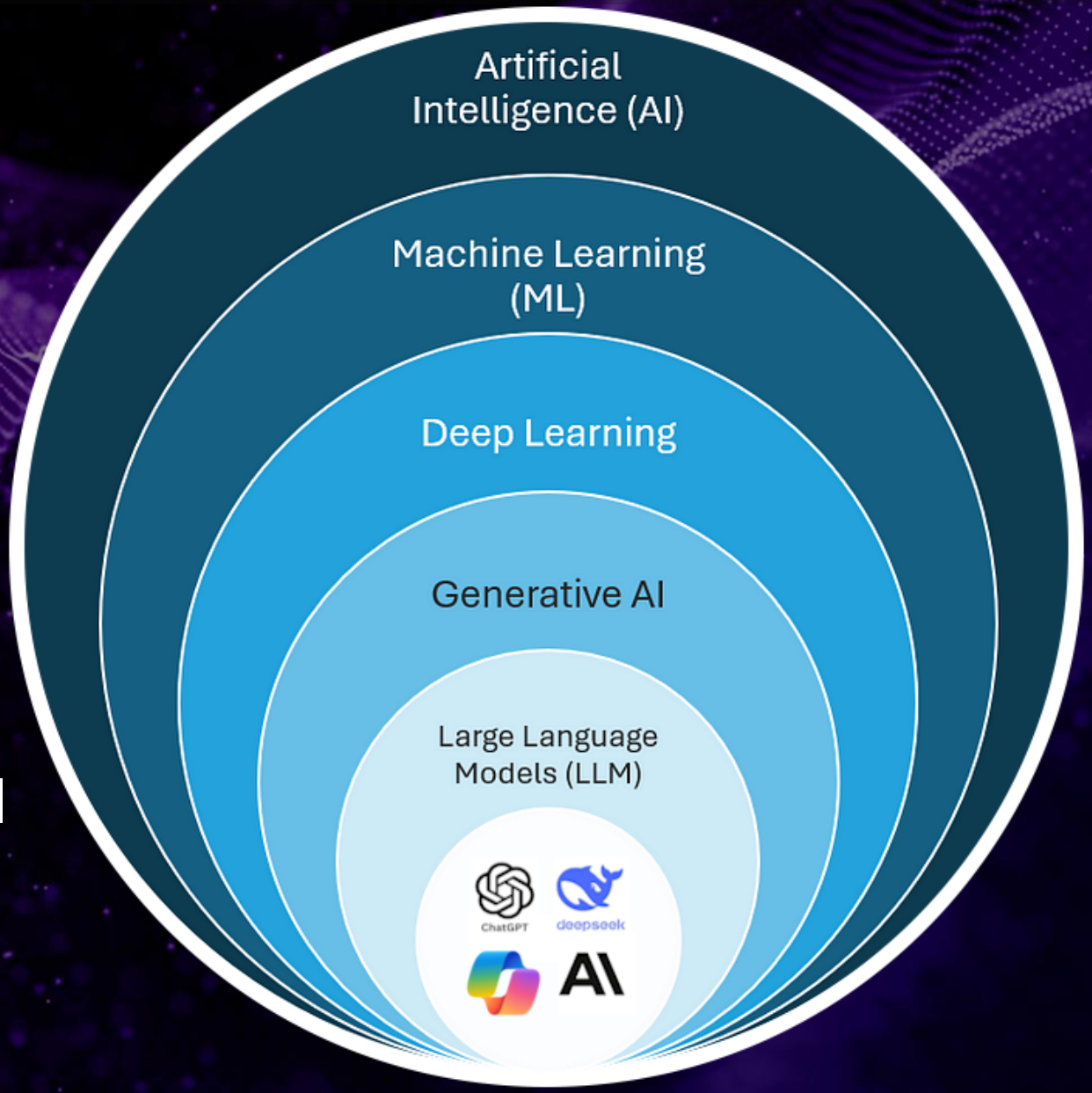
"The essence of intelligence is inference from incomplete information, which the Bayesian paradigm addresses with normative optimality."
— **Ghahramani, Z. (2015). *Probabilistic machine learning and artificial intelligence*. Nature, 521(7553), 452–459.**



AI: history and definition



Narrow AI
vs.
AGI, ASI



AI algorithms and AI models

AIgorithm:

A series of logical steps or instructions used to perform a specific task

```
Output: salary
Input: age, experience, education
if age > 6
   for (age) t = 1:n
      education(t) = f(studies)
      while (education & age) > acceptable
         for (years) e = 1:m
            experience = e
         end
         salary(t) = f(education, age, experience, 0)
      end
   end
end
```

AI algorithms and AI models

Model:

Simplified representation of a process, system, or phenomenon from the real world. It is a mathematical or statistical construct.

$$\text{salary} = f(\text{education}, \text{age}, \text{experience})$$

$$\text{salary} = f(\text{education}, \text{age}, \text{experience}; \Theta)$$

$$\Theta = [\theta_{\text{educ}}, \theta_{\text{age}}, \theta_{\text{expe}}]$$

$$\text{salary} = f(\text{education}, \text{age}, \text{experience}; \theta_{\text{educ}}, \theta_{\text{age}}, \theta_{\text{expe}})$$

Assuming that $f(\cdot)$ is linear:

$$\text{salary} = \theta_0 + \theta_{\text{educ}} \cdot \text{education} + \theta_{\text{age}} \cdot \text{age} + \theta_{\text{expe}} \cdot \text{experience}$$

Adding an i.i.d. term: $\varepsilon \sim \mathcal{N}(\mu, \sigma^2)$

$$\text{salary} = \theta_0 + \theta_{\text{educ}} \cdot \text{education} + \theta_{\text{age}} \cdot \text{age} + \theta_{\text{expe}} \cdot \text{experience} + \varepsilon$$

AI algorithms and AI models

$$\text{salary}_i = \theta_0 + \theta_{\text{educ}} \cdot \text{education}_i + \theta_{\text{age}} \cdot \text{age}_i + \theta_{\text{expe}} \cdot \text{experience}_i + \varepsilon_i$$

Estimation Algorithm:

Input: salary, education, age, experience data

Output: estimators of $\theta_{\text{educ}}, \theta_{\text{age}}, \theta_{\text{expe}}$

1. **Matrix Representation:**

   $\Theta = [\theta_{\text{educ}}, \theta_{\text{age}}, \theta_{\text{expe}}]$

   $X = [\text{education}_i, \text{age}_i, \text{experience}_i]$

   $y = [\text{salary}_1, \text{salary}_2, \ldots, \text{salary}_n]$

   $y = X\Theta + \varepsilon$

   $y - X\Theta = \varepsilon$

2. **Matrix Operations:** Calculation of transposed and inverse matrices: $X', (X'X)^{-1}$

3. **OLS Estimators:** $\Theta = (X'X)^{-1}X'y \qquad i = 1, 2, \ldots, n$

   $\hat{\Theta} = [\hat{\theta}_{\text{educ}}, \hat{\theta}_{\text{age}}, \hat{\theta}_{\text{expe}}]$

Sample partitions in AI

- **Train-Test Split:** The most basic and common method. The data is divided into two parts: a training set to train the model (estimate the model parameters) and a test set to evaluate the model's performance on unseen data.
- **Hold-Out with Validation:** Similar to the train-test split, but includes a third validation set:
    - **Training (Train):** To adjust the model parameters.
    - **Validation:** To adjust hyperparameters and prevent overfitting.
    - **Test:** For the final evaluation of the model.

Sample partitions in AI

Data Partitioning in 4 Groups:

Training (train): $i = 1, \ldots, m$

person	salary	education	age	experience
i=1	2640	24	40	10
...	...	...	...	...
i=8	6400	30	57	12
...	...	...	...	...
i=m	3555	29	32	9

y train

X (train)

Evaluation (test): $i = m, m + 1, \ldots, n$

person	salary	education	age	experience
i=m	5656	27	38	5
i=m+1	3322	24	37	10
...	...	...	...	...
i=n	4300	32	40	13

y test

X test

The training set is used to train the model (estimate the model parameters).

The test set is used to evaluate the model's performance on unseen data.

Sample partitions in AI

Data Partitioning:

Training (train): i=1,…,m

$$salary_i = \theta_0 + \theta_{educ} education_i + \theta_{age} age_i + \theta_{expe} experience_i + \varepsilon_i$$

$$\boldsymbol{\Theta} = [\theta_{educ}, \theta_{age}, \theta_{expe}],$$

$$X_{\text{train}} = [\text{education}_i, \text{age}_i, \text{experience}_i],$$

$$y_{\text{train}} = [\text{salary}_1, \text{salary}_2, \ldots, \text{salary}_m]$$

$$y_{\text{train}} = X\Theta + \varepsilon$$

$$\underset{\Theta \in \mathbb{R}}{\operatorname{argmin}}\ \varepsilon: \hat{\Theta} = (X\_train' X\_train)^{-1} X\_train' y\_train$$

$i=1,2,\ldots,m$

Evaluation (test): $i = m, m+1, \ldots, n$

$$y_{\text{predicted}} = X_{\text{test}} \hat{\Theta}$$

Mean Squared Error (MSE):

$$MSE = \frac{1}{m} \sum_{i=m}^{n} (y_{\text{test},i} - y_{\text{predicted},i})^2$$

The training set is used to train the model (estimate the model parameters).

The test set is used to evaluate the model's performance on unseen data.

Jargon

Econometrics and Statistics	Machine learning
Estimation	Learning, training
Parameters	Weights
Explanatory variables (X).	Features/inputs
Dependent variable (y)	Target/output
Estimation in the full sample* (limited samples).	Data partitioning.(train/test) (big data)
Purpose: inference, prediction.	Purpose: prediction
Maximization of in-sample fit.	Minimization of prediction error

(*) In general, but not always, e.g., rolling estimation.

Machine learning in AI

Given an input space X (feature space) and an output space Y, machine learning is an optimization problem where the goal is to find a function $f: X \rightarrow Y$ that predicts the output $y \in Y$ given an input $x \in X$, with f^* being optimal in terms of **generalization** and **regularization**:

$$\mathcal{D} = \{(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)\} \qquad x_i \in \mathcal{X} \qquad y_i \in \mathcal{Y}$$

$$f^* = \arg\min_{f \in \mathcal{F}} \mathbb{E}_{(x,y)\sim P}\left[L(f(x), y)\right]$$

$$f^* = \arg\min_{f \in \mathcal{F}} \frac{1}{n} \sum_{i=1}^{n} L(f(x_i), y_i)$$

$$f^* = \arg\min_{f \in \mathcal{F}} \left[\frac{1}{n} \sum_{i=1}^{n} L(f(x_i), y_i) + \lambda R(f)\right]$$

Machine learning in AI

Given a set of functions (models), M_1, M_2,..., Mk, it is necessary to consider performance measures for continuous and discrete variables when deciding on the best function (model):

$$M_1, M_2, \ldots, M_k$$

$$\hat{\beta}_{\text{train},i} = \arg\max_\beta \log \mathcal{L}(\beta; X_{\text{train},i}, y_{\text{train}})$$

$$\hat{y}_{\text{test},i} = g^{-1}(X_{\text{test},i}\hat{\beta}_{\text{train},i})$$

$$\text{MSE}_i = \frac{1}{n_{\text{test}}} \sum_{j=1}^{n_{\text{test}}} (y_{\text{test},j} - \hat{y}_{\text{test},ij})^2$$

$$R_i^2 = 1 - \frac{\sum_{j=1}^{n_{\text{test}}} (y_{\text{test},j} - \hat{y}_{\text{test},ij})^2}{\sum_{j=1}^{n_{\text{test}}} (y_{\text{test},j} - \bar{y}_{\text{test}})^2}$$

$$\text{AUC-ROC}_i = \text{AUC}(\text{Curva ROC}_i)$$

$$M_{\text{best}} = \arg\min_i \text{MSE}_i$$

$$M_{\text{best}} = \arg\max_i R_i^2$$

$$M_{\text{best}} = \arg\max_i \text{AUC-ROC}_i$$

Elastic Nets

Elastic Nets are based on a regularization that aims to find a solution that minimizes the loss function with a combined penalty of **L1** (Lasso) and **L2** (Ridge).

$$\min_{\beta} \left\{ \frac{1}{2N} \sum_{i=1}^{N} \left(y_i - \sum_{j=1}^{p} X_{ij} \beta_j \right)^2 + \lambda_1 \sum_{j=1}^{p} |\beta_j| + \lambda_2 \sum_{j=1}^{p} \beta_j^2 \right\}$$

Elastic Nets are useful in situations where the predictor variables are highly correlated or when the number of variables is greater than the number of observations.

Elastic Nets

Lasso (Least Absolute Shrinkage and Selection Operator, L1), Ridge (L2), and Elastic Nets are regularization techniques that help reduce overfitting and deal with multicollinearity and redundant variables.

$$\hat{\beta}_{\text{ridge}} = \arg\min_{\beta} \left(\sum_{i=1}^{m} (y_i - \hat{y}_i)^2 + \lambda \sum_{j=1}^{n} \beta_j^2 \right)$$

$$\hat{\beta}_{\text{lasso}} = \arg\min_{\beta} \left(\sum_{i=1}^{m} (y_i - \hat{y}_i)^2 + \lambda \sum_{j=1}^{n} |\beta_j| \right)$$

$$\hat{\beta}_{\text{elastic}} = \arg\min_{\beta} \left(\sum_{i=1}^{m} (y_i - \hat{y}_i)^2 + \lambda_1 \sum_{j=1}^{n} |\beta_j| + \lambda_2 \sum_{j=1}^{n} \beta_j^2 \right)$$

Elastic Nets

Lasso (Least Absolute Shrinkage and Selection Operator, L1), Ridge (L2), and Elastic Nets are regularization techniques that help reduce overfitting and deal with multicollinearity and redundant variables.

In `sklearn.linear_model.ElasticNet`, you're solving the following regularized least-squares problem on your data $(X, y) \in \mathbb{R}^{n \times p} \times \mathbb{R}^n$:

$$\min_{w \in \mathbb{R}^p,\, b \in \mathbb{R}} \frac{1}{2n} \|y - Xw - b\mathbf{1}\|_2^2 + \alpha \Big(\underbrace{\ell_1\text{-term}}_{l_1\_ratio \, \|w\|_1} + \underbrace{\ell_2\text{-term}}_{(1 - l_1\_ratio) \, \frac{1}{2}\|w\|_2^2} \Big)$$

$\alpha > 0$ scales the overall penalty strength.

$l\_1\_ratio \in [0, 1]$ interpolates between **pure Lasso** and **pure Ridge**.

$\|w\|_1 = \sum_{j=1}^{p} |w_j|.$

$\|w\|_2^2 = \sum_{j=1}^{p} w_j^2.$

Python

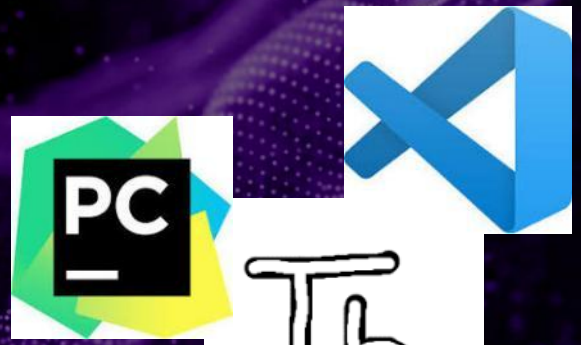
- Programming language.
- Python was conceived in the late 1980s by Guido van Rossum at Centrum Wiskunde & Informatica (CWI) in the Netherlands.
- 2000: Python 2.0
- 2018: Guido van Rossum, the 'benevolent dictator for life' of Python, responsible for the project's decision-making, leaves the project.
- 2025: Python 3.x

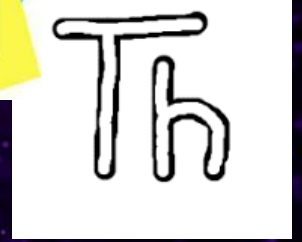
Used by Wikipedia, Google, Yahoo!, CERN, NASA, Facebook, Amazon, Instagram, Spotify.

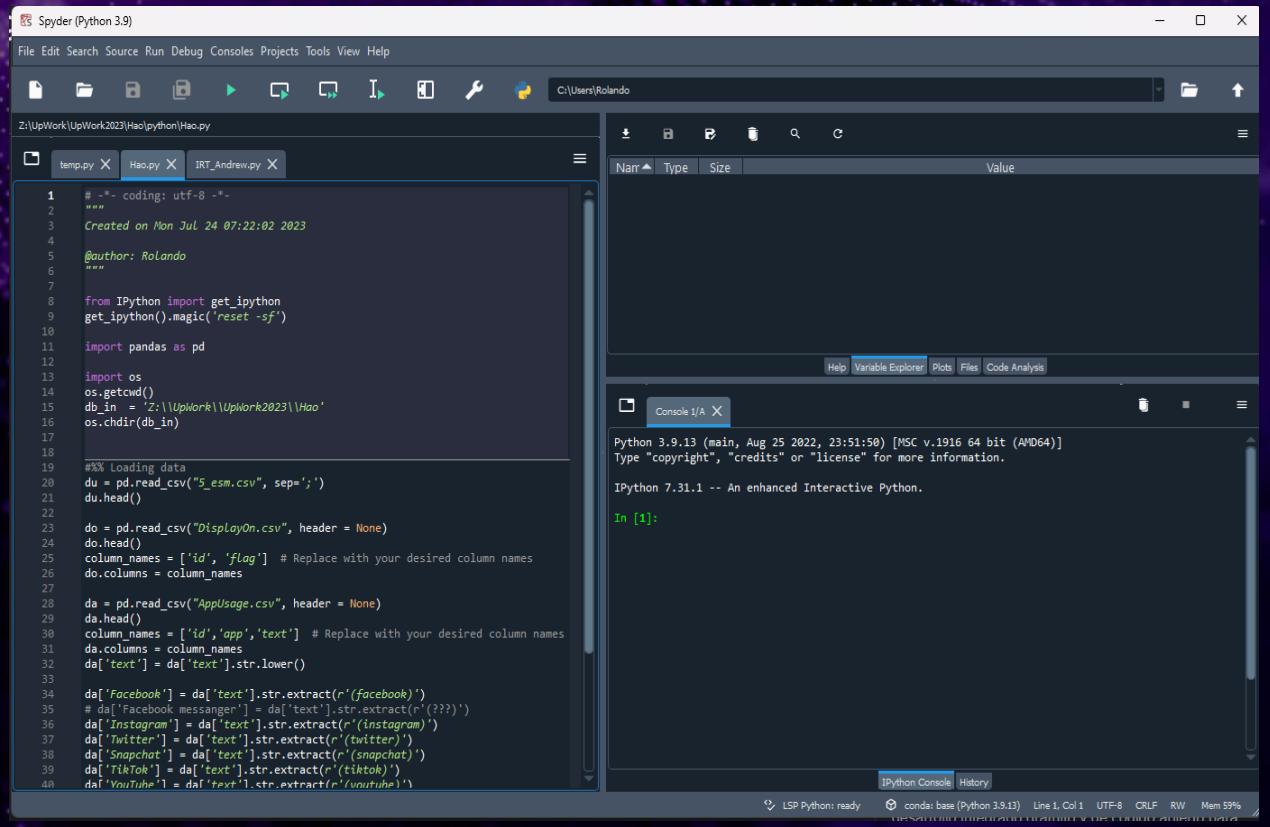
Python

IDE (Integrated Development Environments):

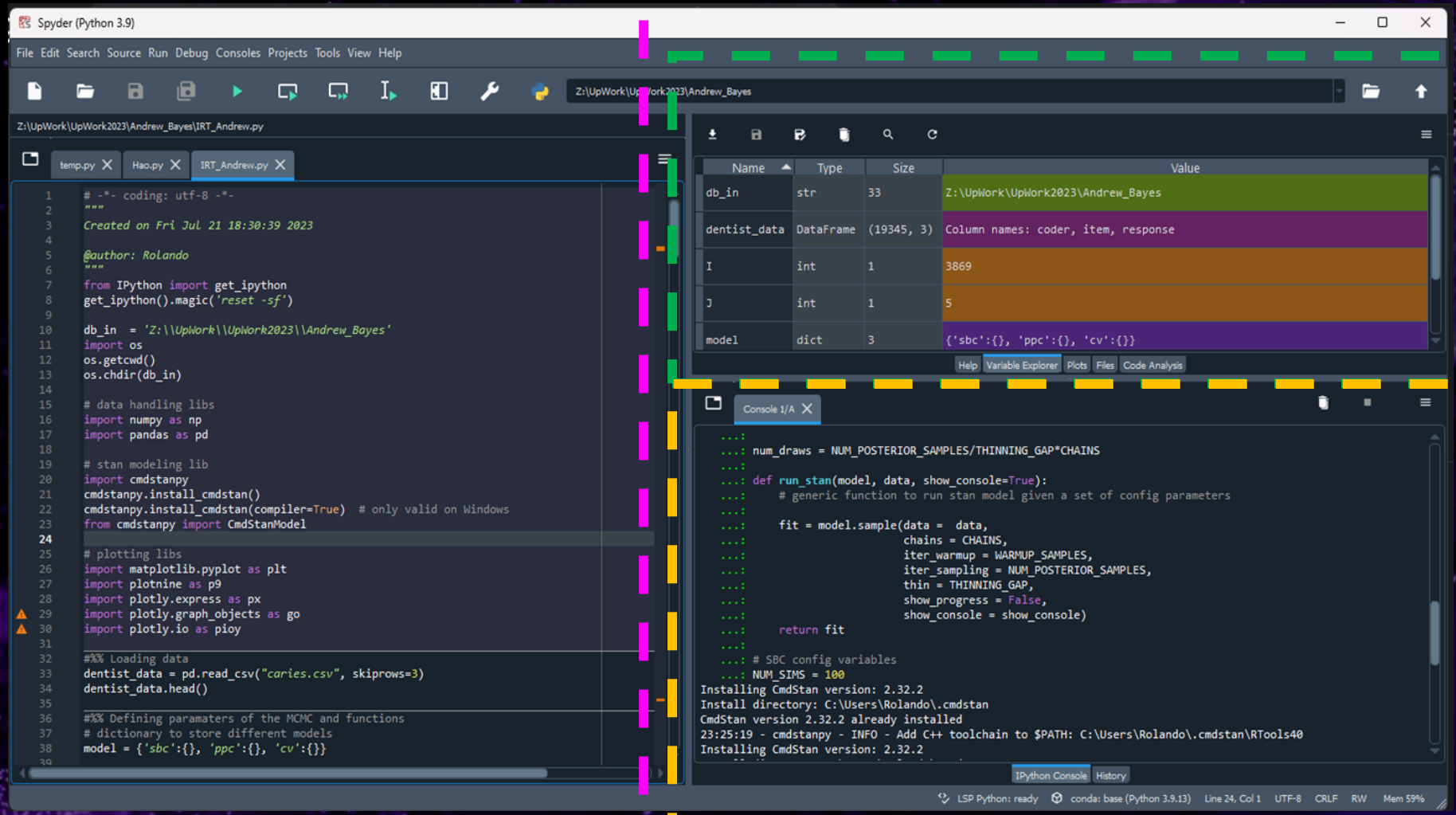
- PyCharm
- Jupyter
- Spyder
- Python IDLE
- Thonny
- …





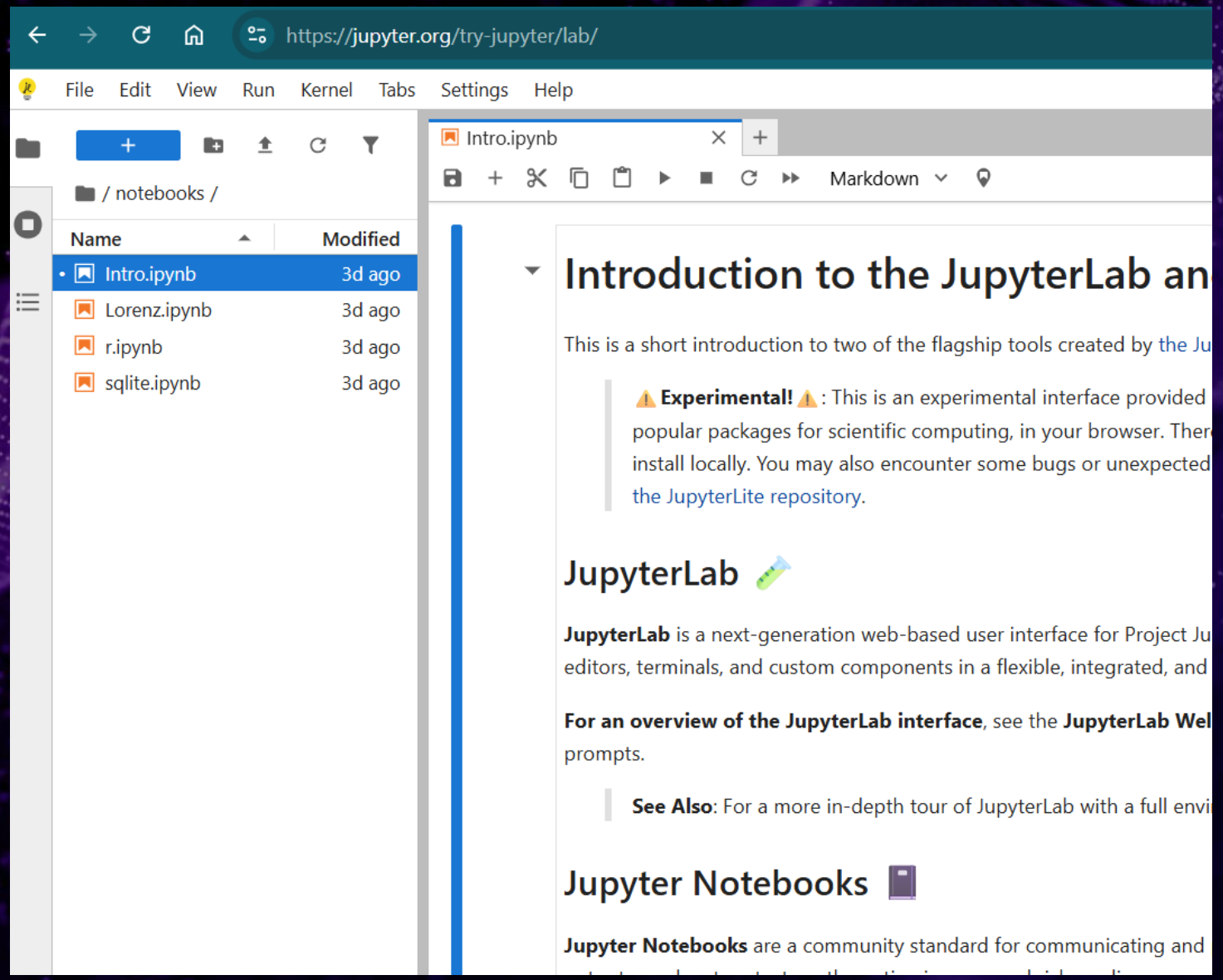


Python and Spyder



Python and Jupyter

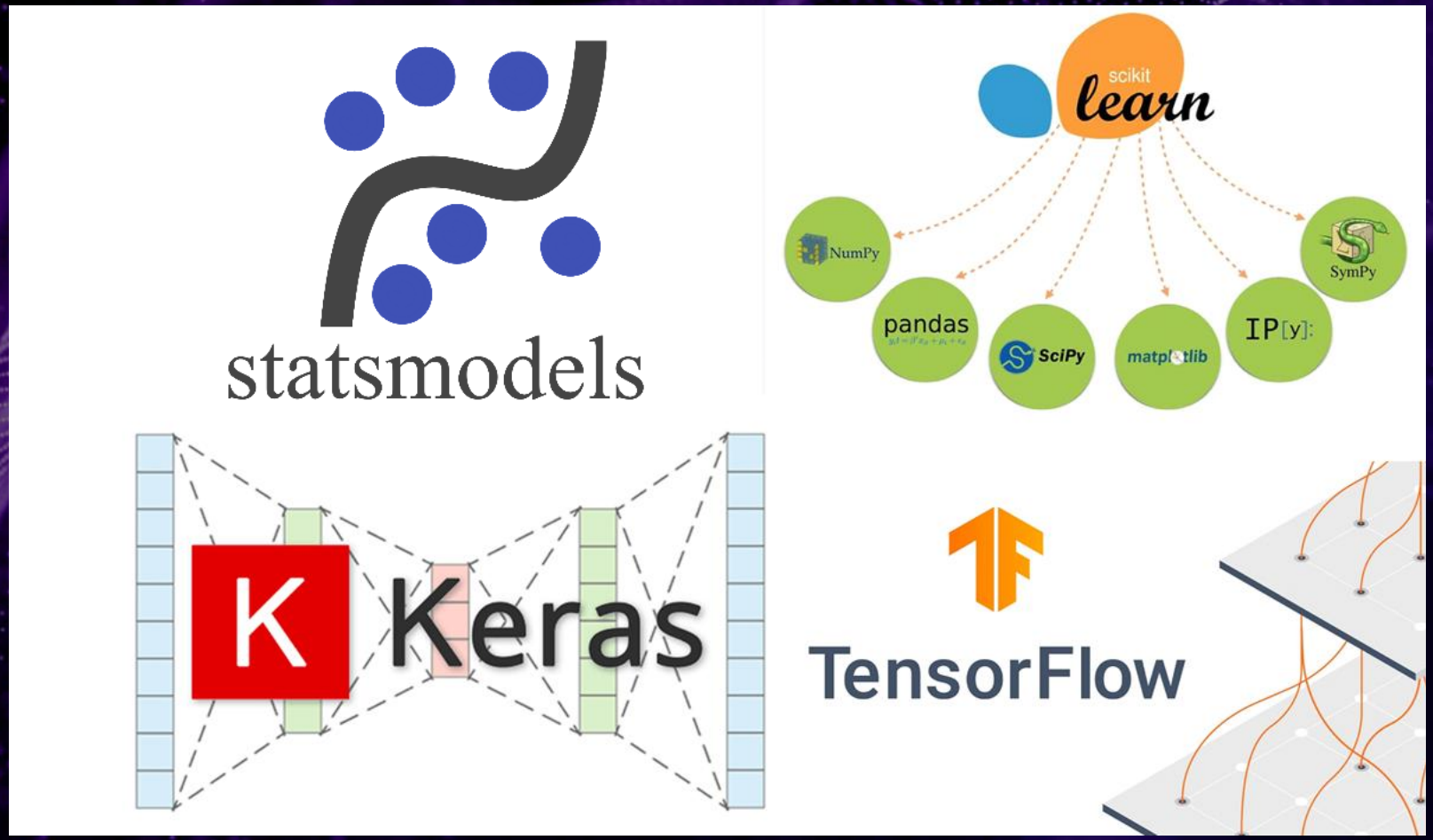
Jupyter Notebooks are interactive computational documents that seamlessly combine code, text, equations, visualizations, and outputs, all in a browser-based environment.



Python

Specialized libraries/packages:

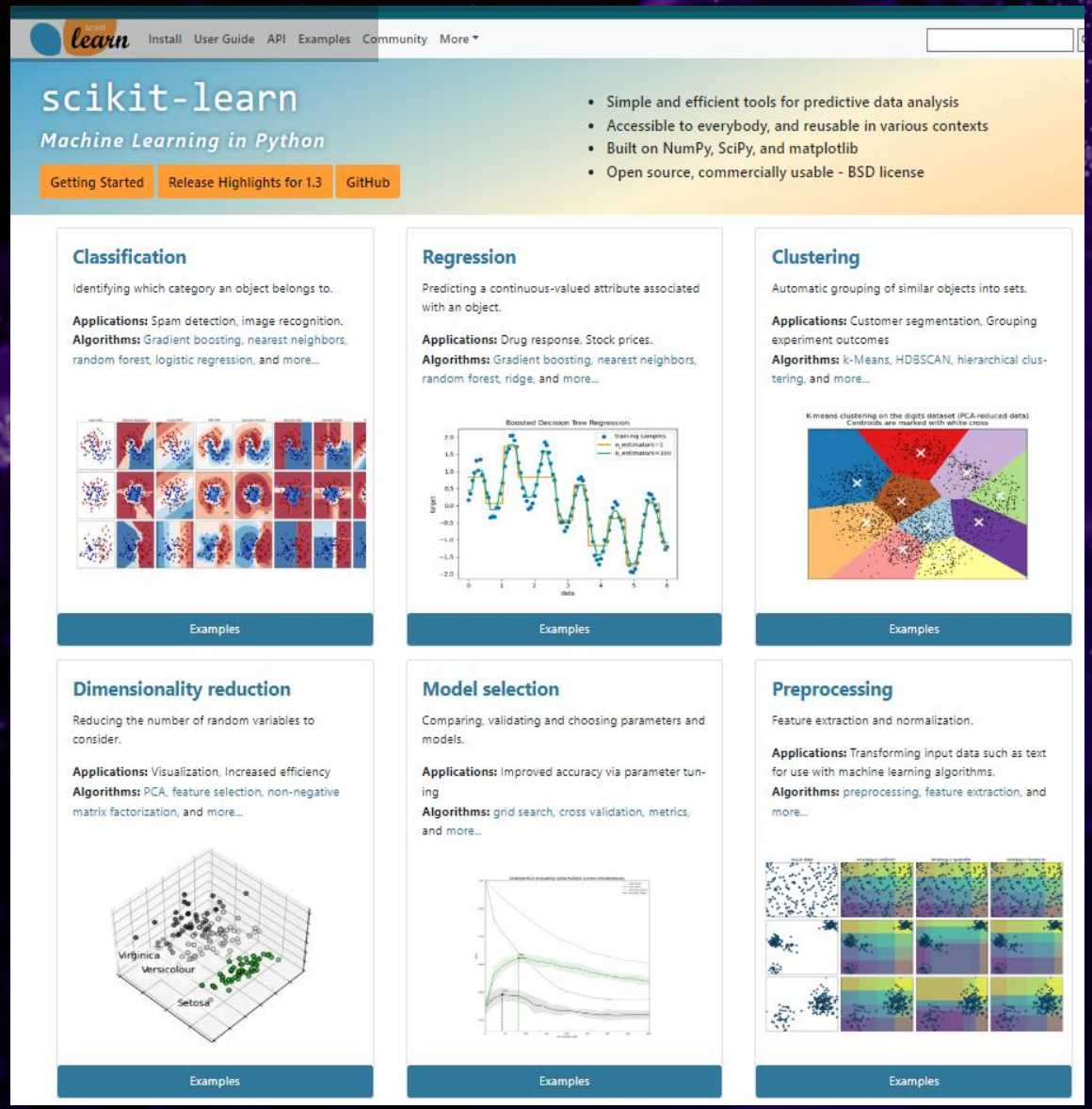
- Statsmodels
- Numpy
- Pandas
- Matplotlib
- Scikit-learn
- Tensorflow
- Keras



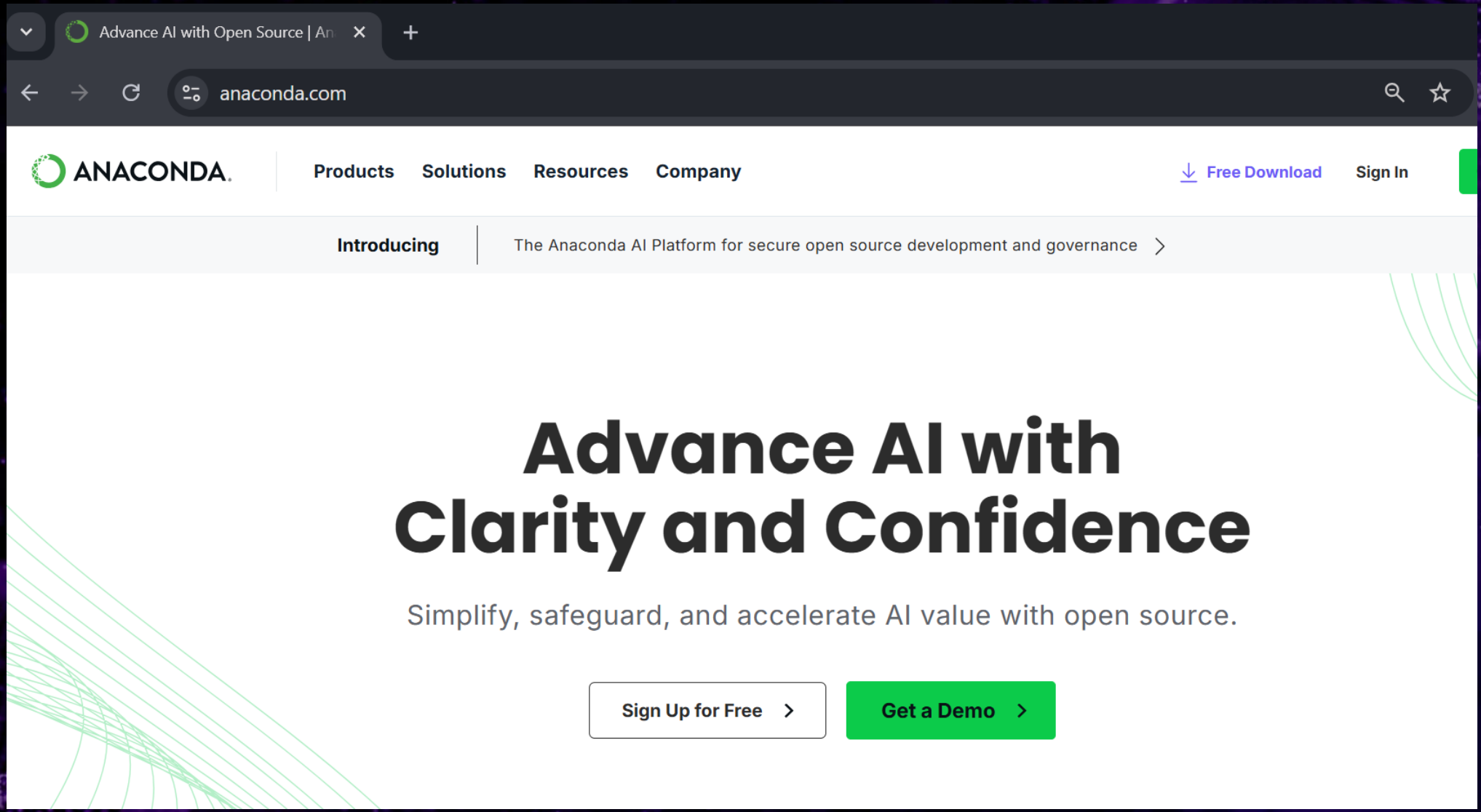
Python

Scikit-learn
https://scikit-learn.org/stable/

- Classification
- Regression
- Clustering
- Dimensionality Reduction
- Model selection
- Data preprocessing (data preparation)



Python and Anaconda



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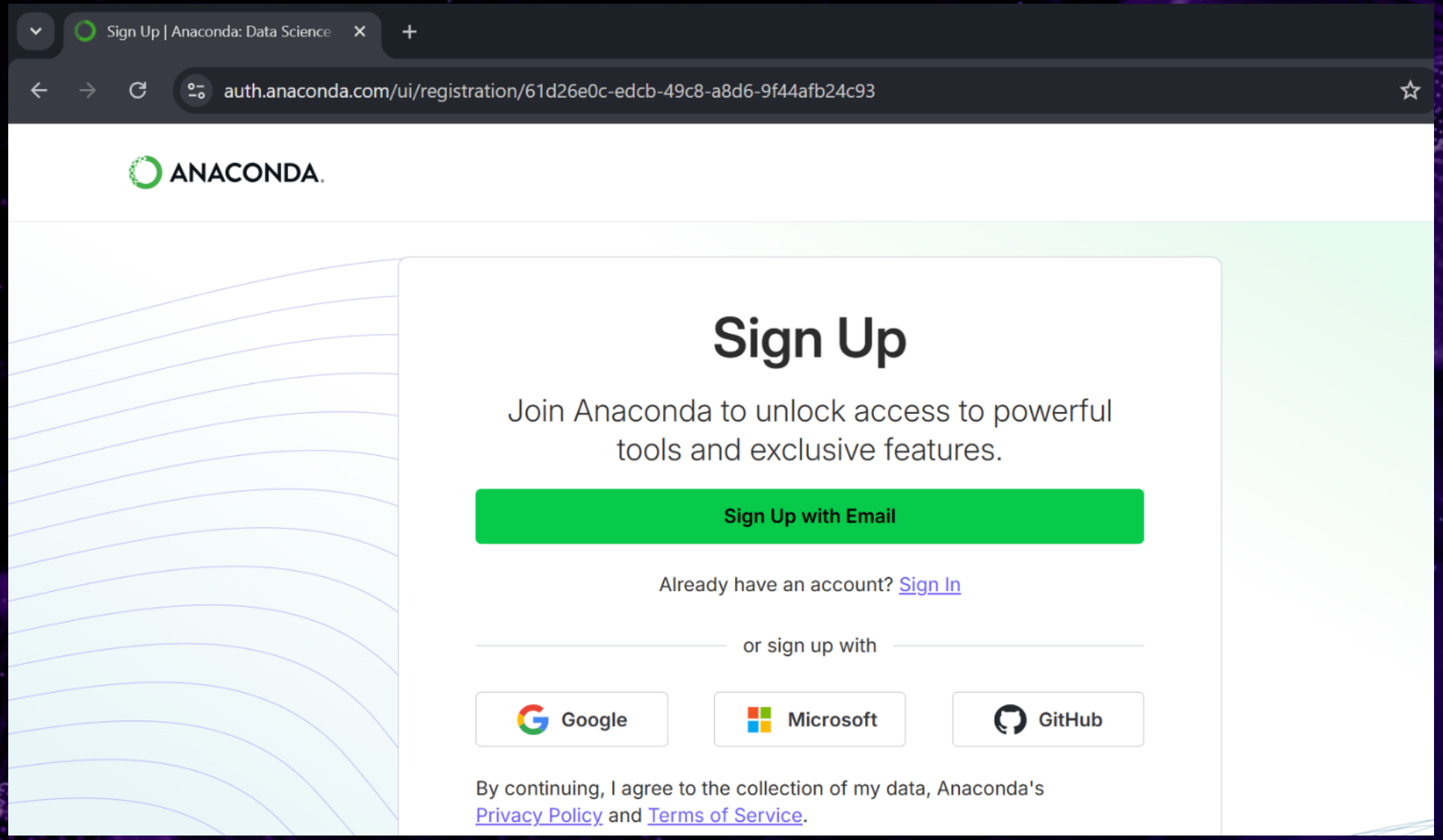
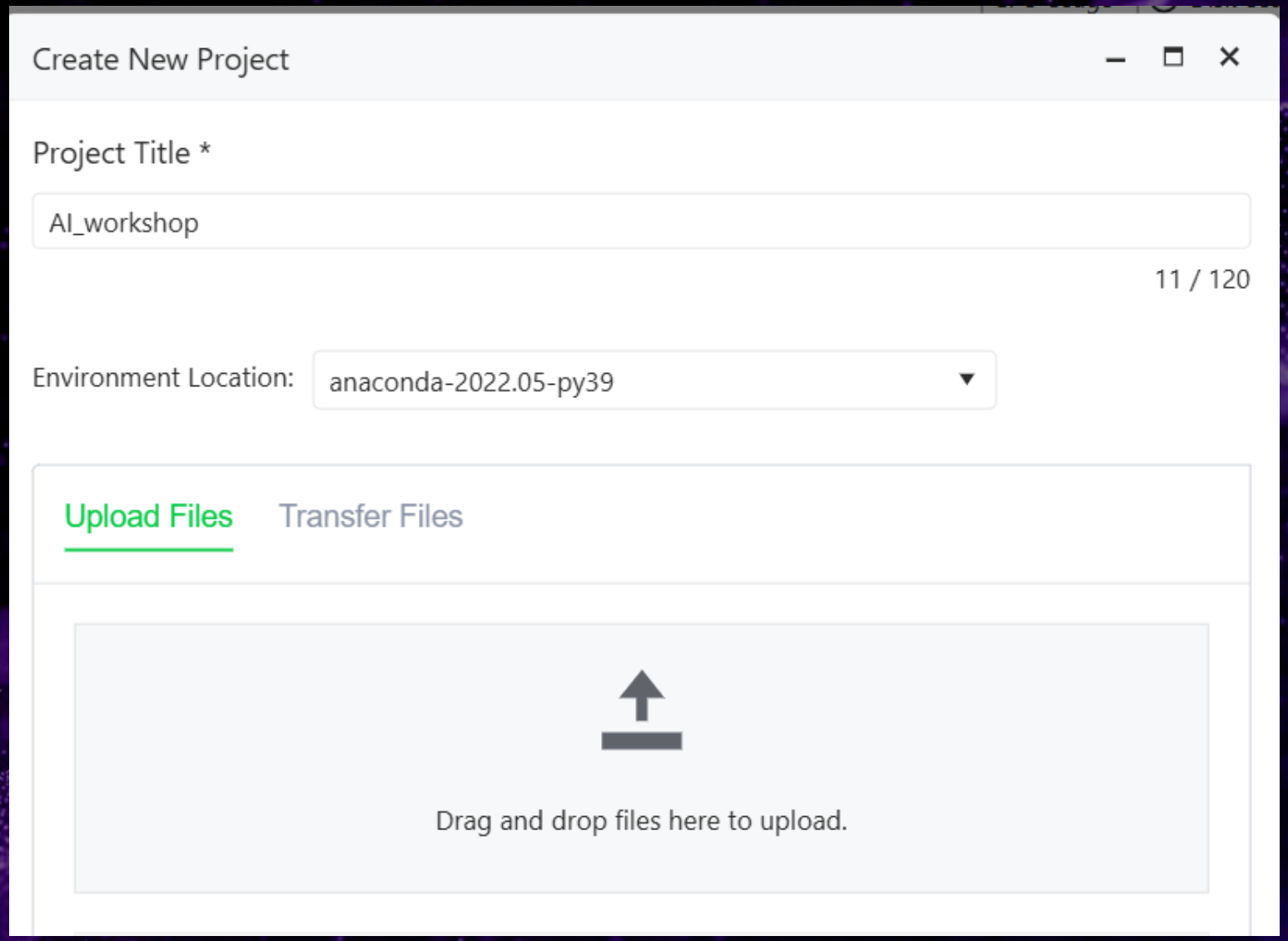


Python and Anaconda



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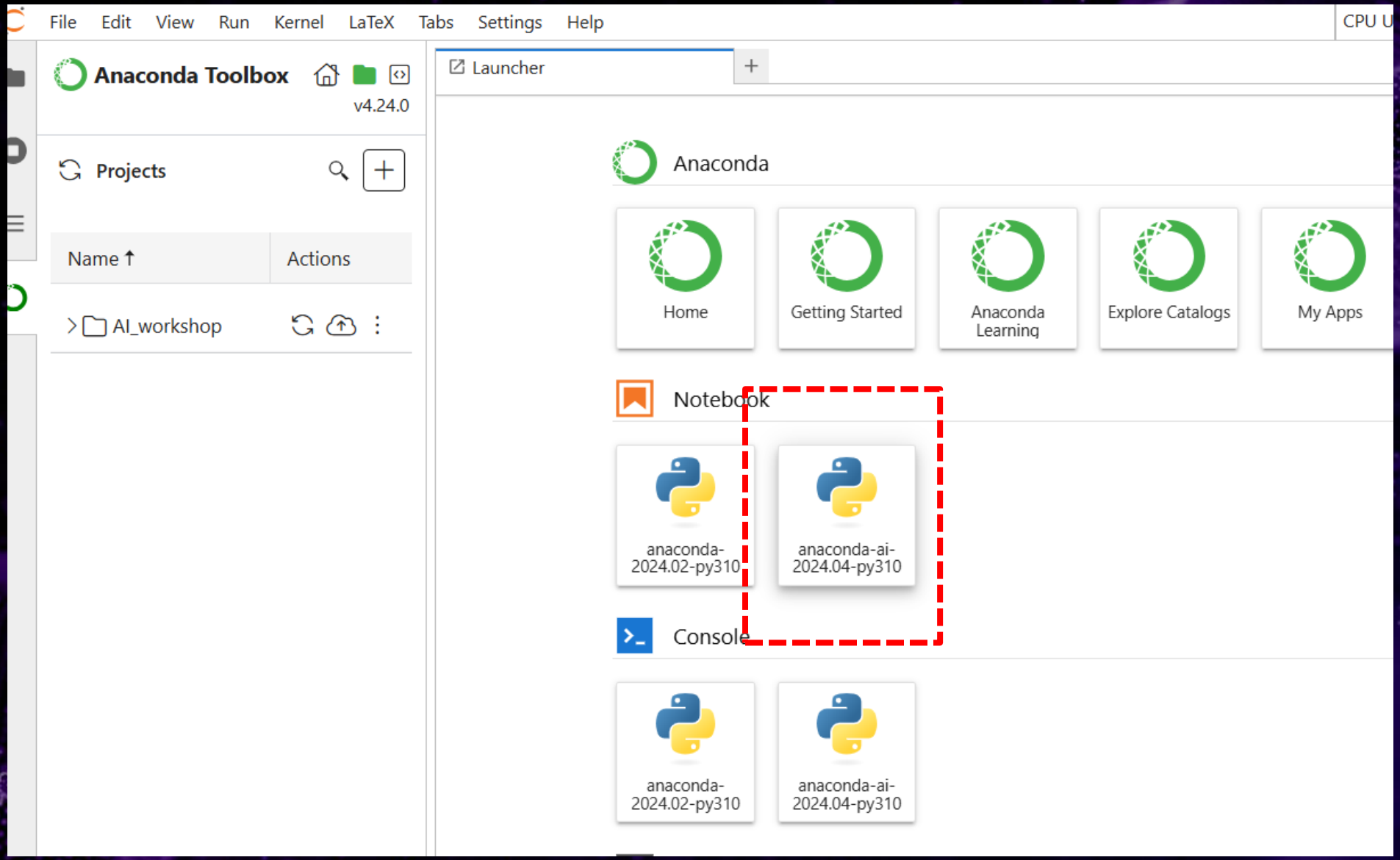
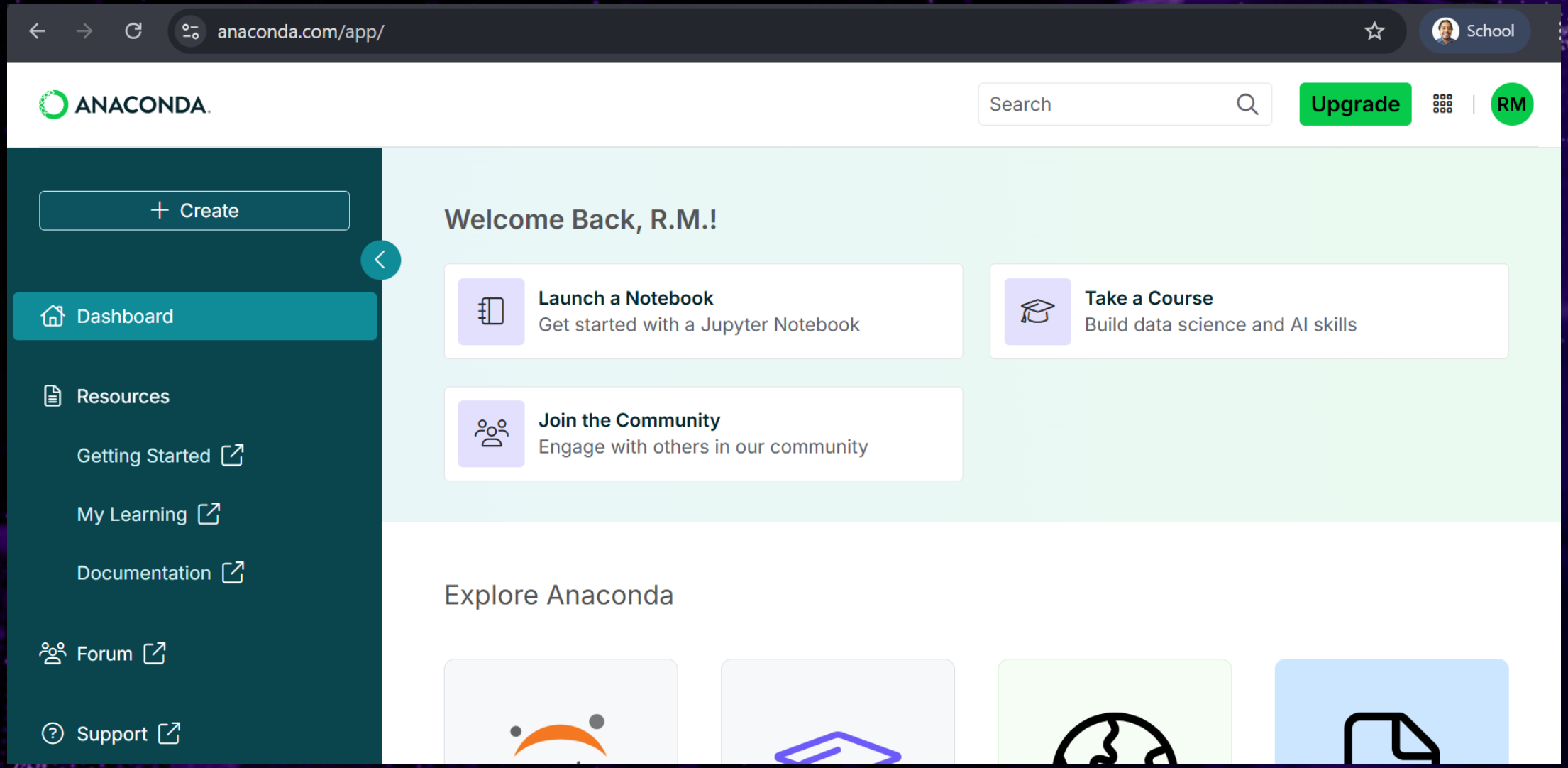
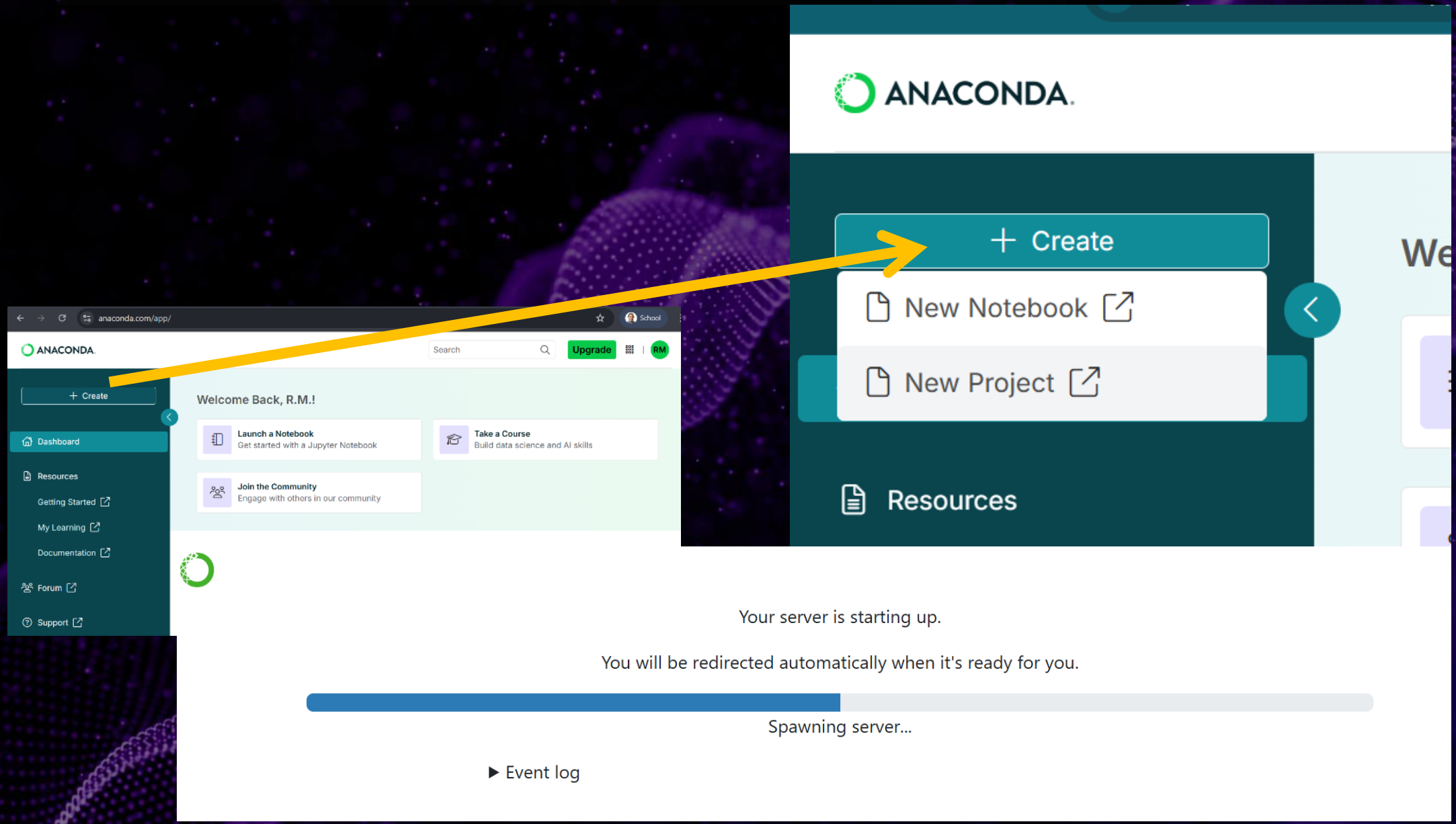


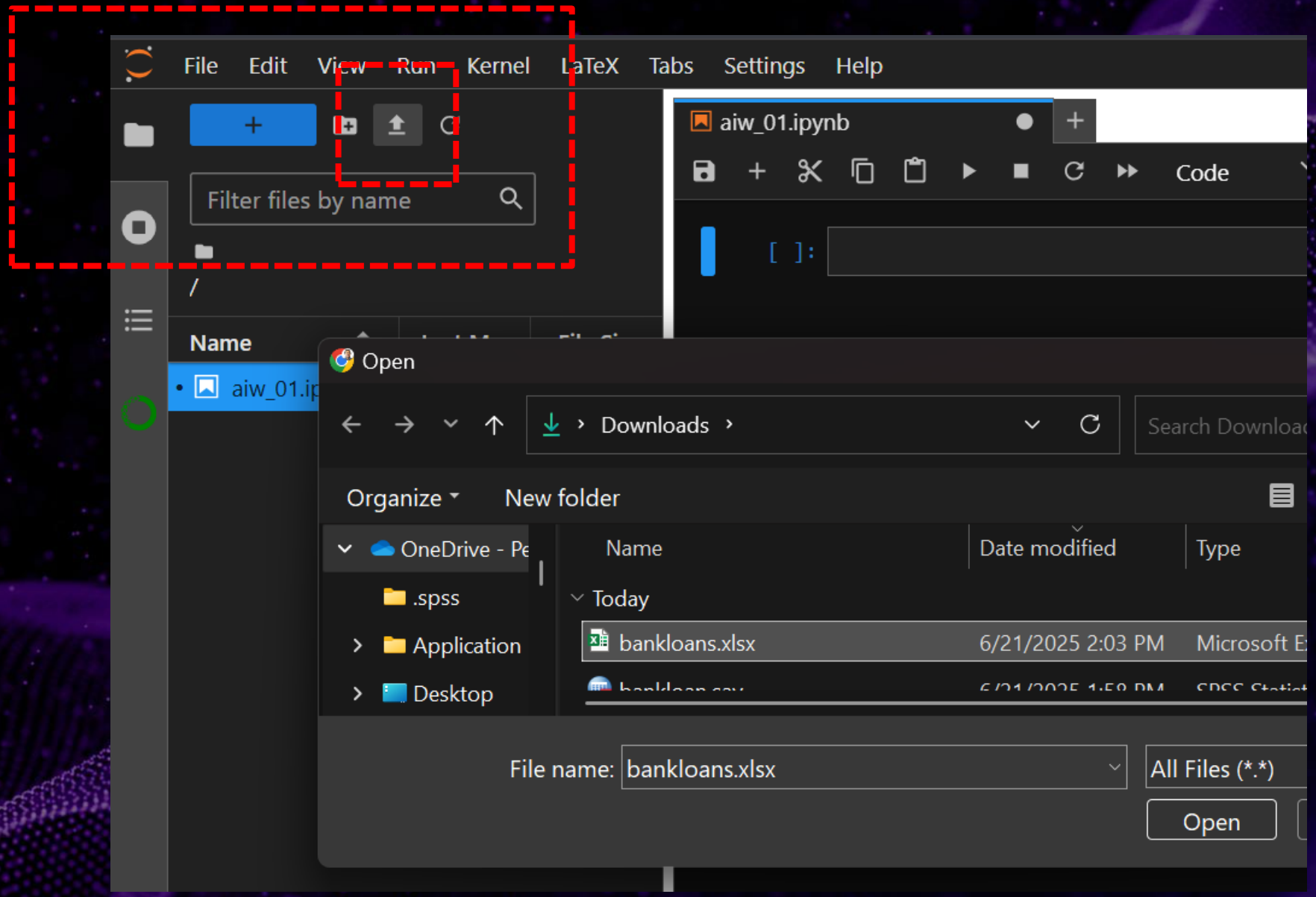
Python and Anaconda



Python and Anaconda



Python and Anaconda



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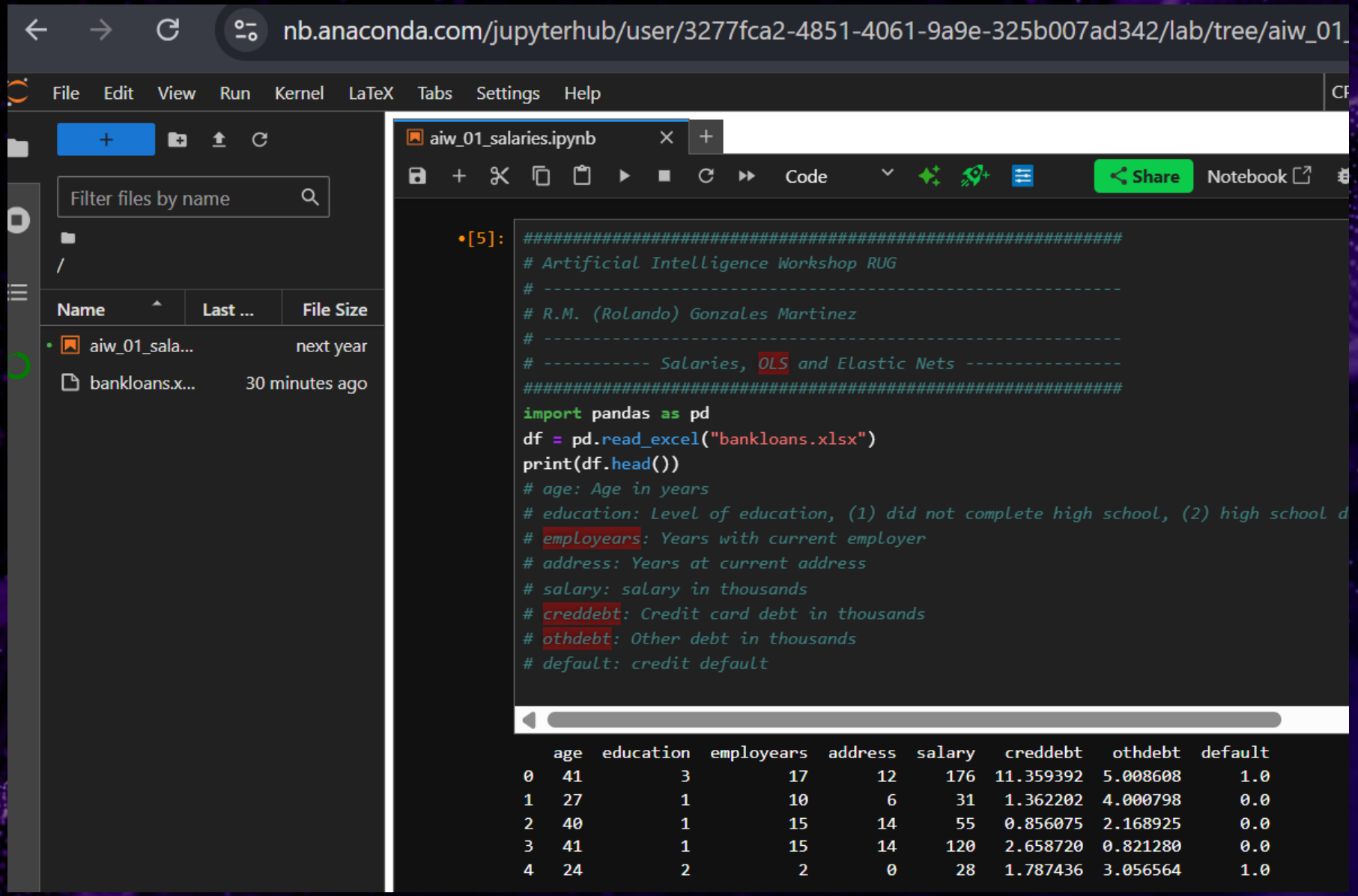
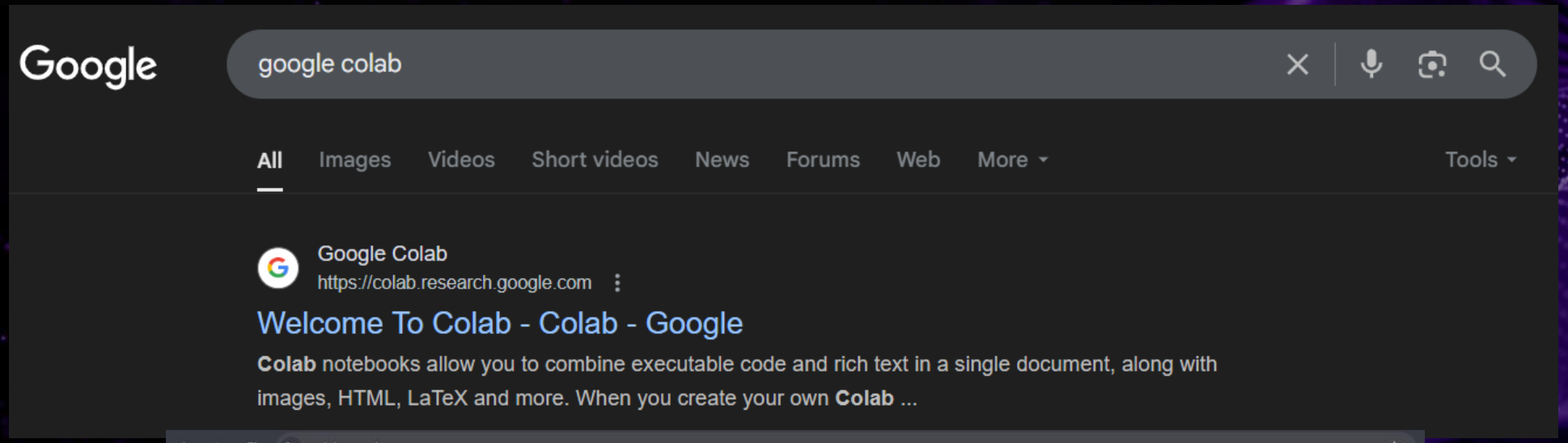
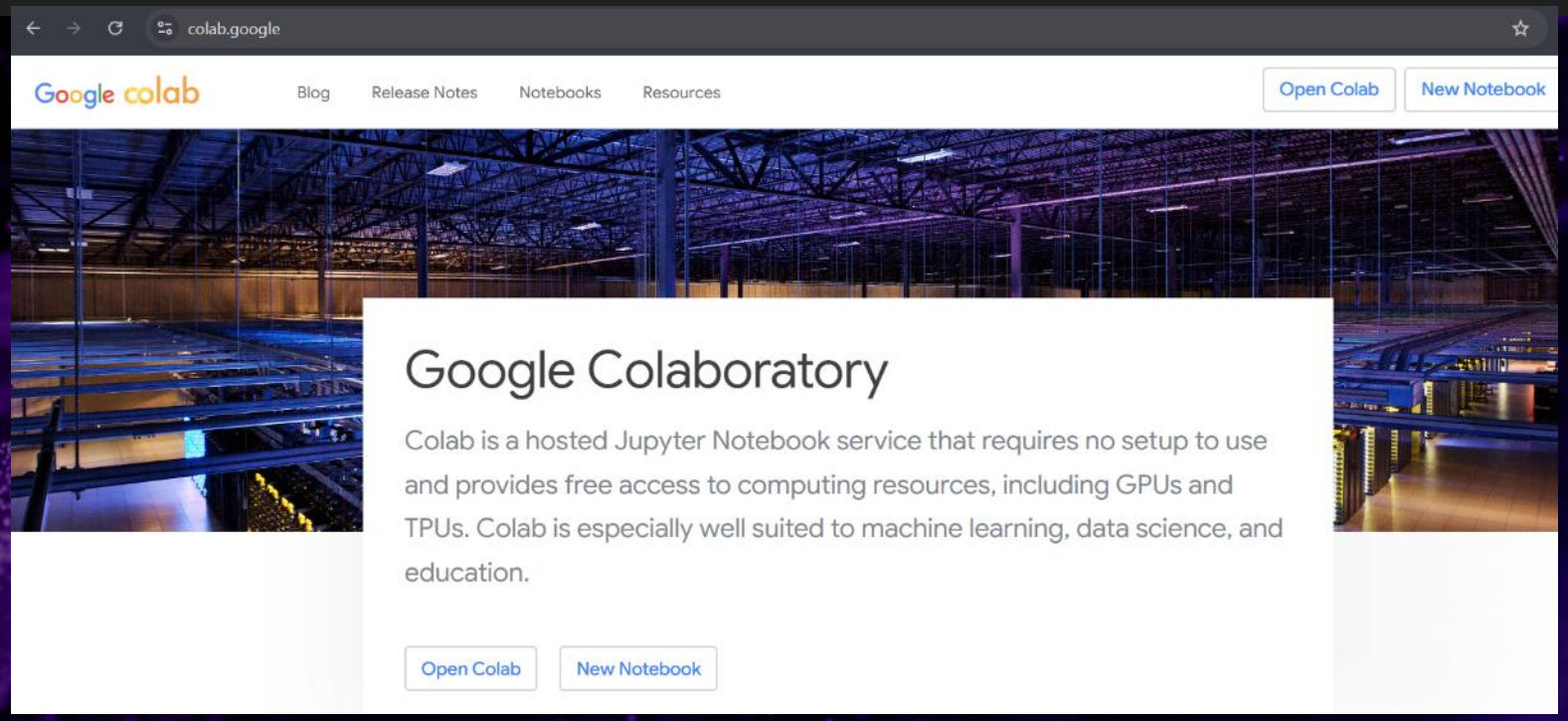
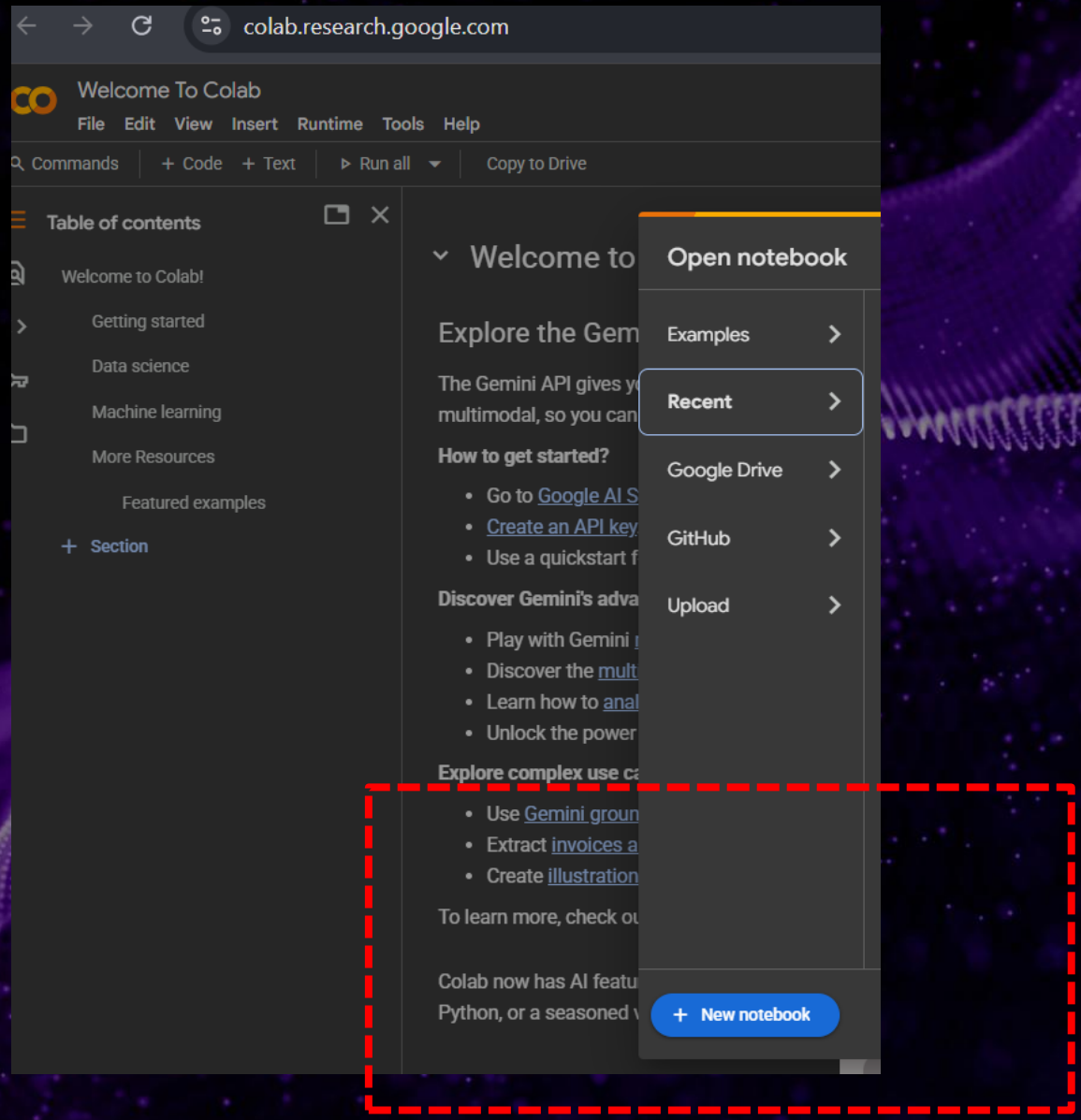


Python and Google Colab

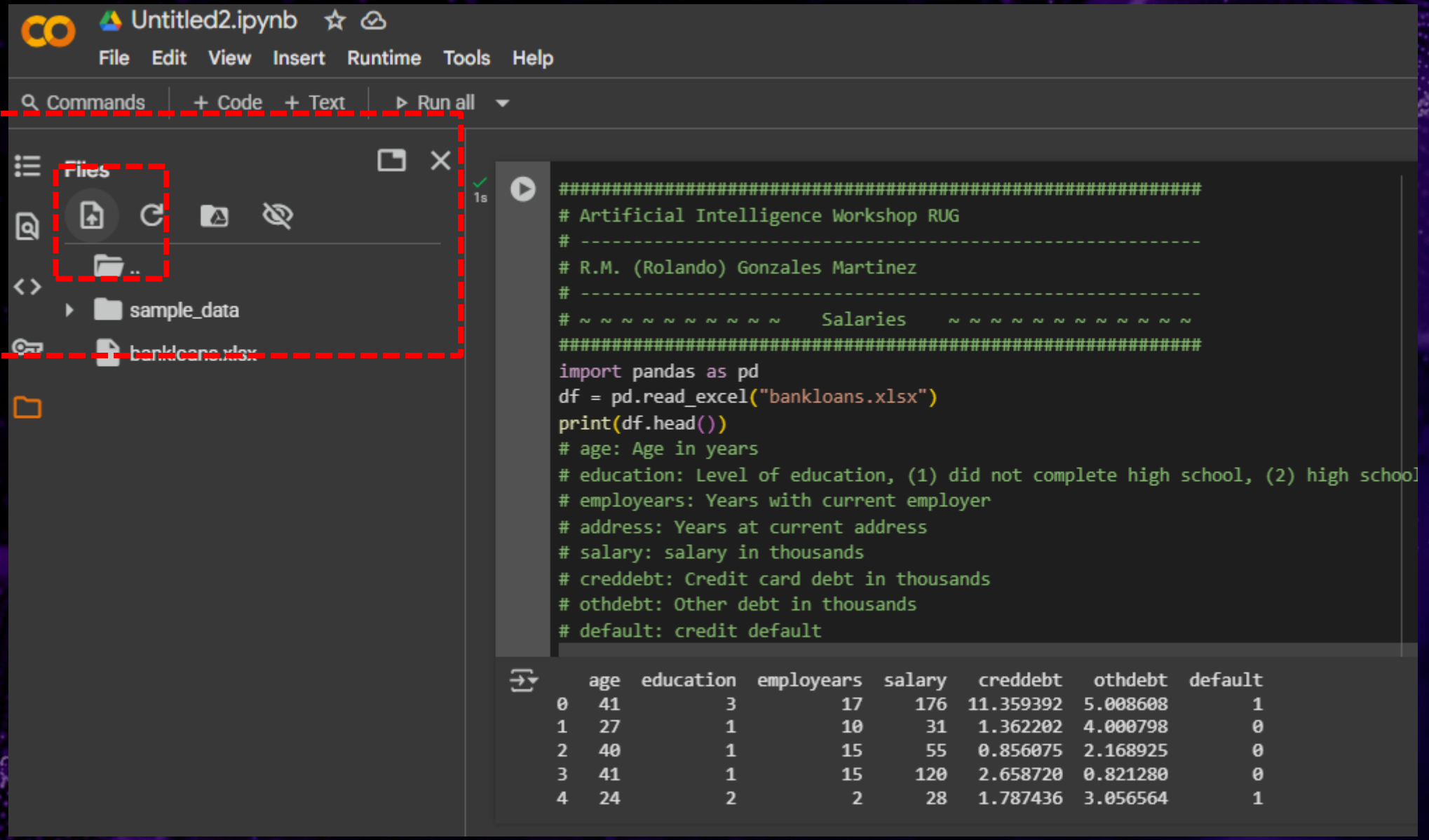




Python and Google Colab



Python and Google Colab



Big data

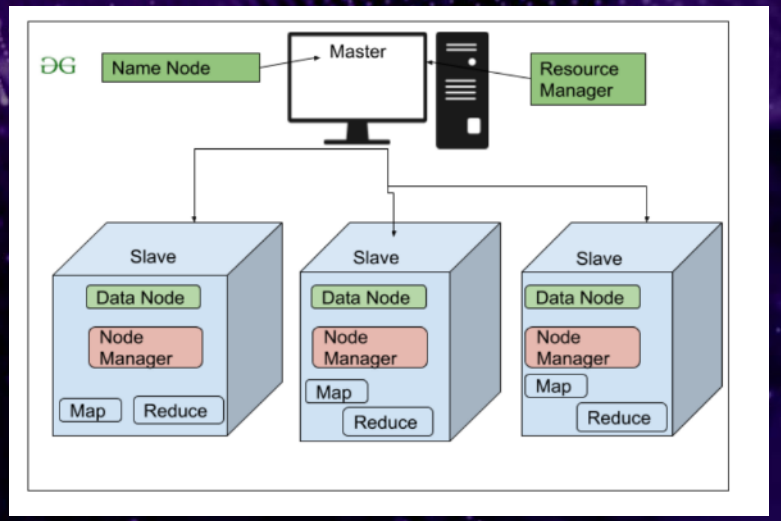
3 V's:

- **Volume:** Terabytes, petabytes, or even exabytes that cannot be managed or processed by conventional systems (sensors, social media, transaction logs).
- **Velocity:** generated at an incredibly fast pace, in real time or at very short intervals.
- **Variety:** Big data can present a wide range of formats and types, such as text, images, audio, video, geospatial data, structured, and unstructured data.

Distributed storage and processing of large datasets

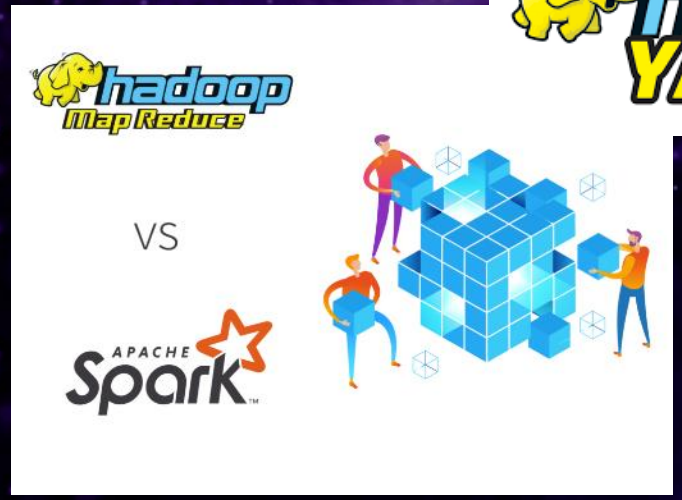
- **Apache Hadoop:** a system designed to store large amounts of data in clusters of servers. It divides files into blocks and distributes them across the nodes of the cluster.

- **Master-slave structure:** The NameNode acts as the master and is responsible for maintaining the metadata of the file system, including file names, block locations, and permissions. The DataNodes are the slave nodes that store the actual data blocks.



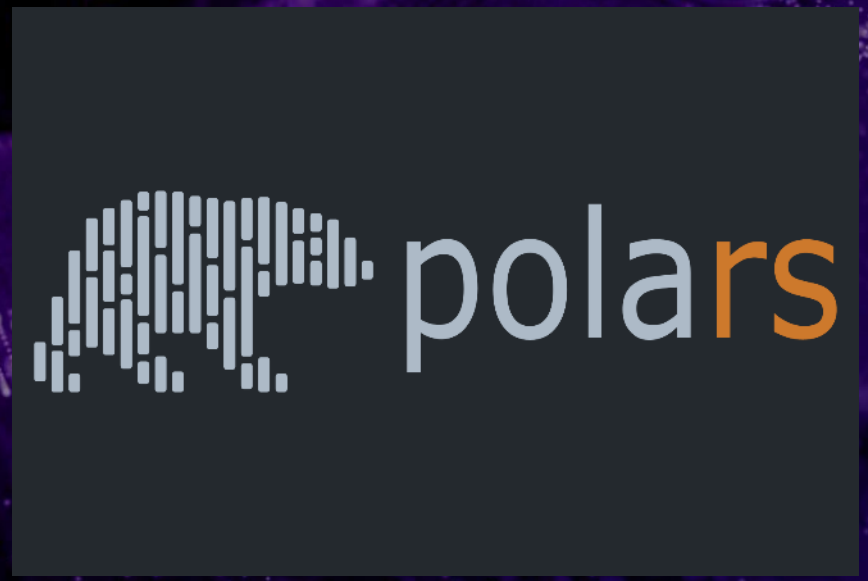
Hadoop Ecosystem

- **Hive:** a data storage and query system that allows SQL-like queries on data stored in a distributed manner (HDFS).
- **Pig:** a language for performing data transformations and analysis in Hadoop.
- **Spark:** an in-memory data processing system that is faster than MapReduce for certain types of tasks.
- **YARN:** a resource manager that enables multiple applications to run efficiently on the same cluster.



More accessible options

- Parallel computing (CPU)
- GPU, TPU
- Cloud computing (CPU, GPU)
- Use of libraries like Polars



Laboratory: Python scripts

Python scripts:

- aiw_00_elizaAI.ipynb: AI-based psychological counseling system
- aiw_01_salaries.ipynb: Python script for OLS regression and Elastic Nets
- aiw_02_credit.ipynb: Python script for credit scoring
- aiw_03_creditlm.ipynb: Python script for credit scoring with machine learning logic

AI as psychological assistants & therapists

- Issue: increasing demand for psychotherapy and limited access to specialists
  Goal: emulating professional therapists' conversational styles to provide cognitive, social, and emotional support

Fig. 1. An example of Ryan the CompanionBot interacting with a user in the experimental setup.

Socially Assistive Robotics (SAR)
Dino, F., Zandie, R., Abdollahi, H., Schoeder, S., & Mahoor, M. H.. Delivering cognitive behavioral therapy using a conversational social robot. In *2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 2089-2095). IEEE.

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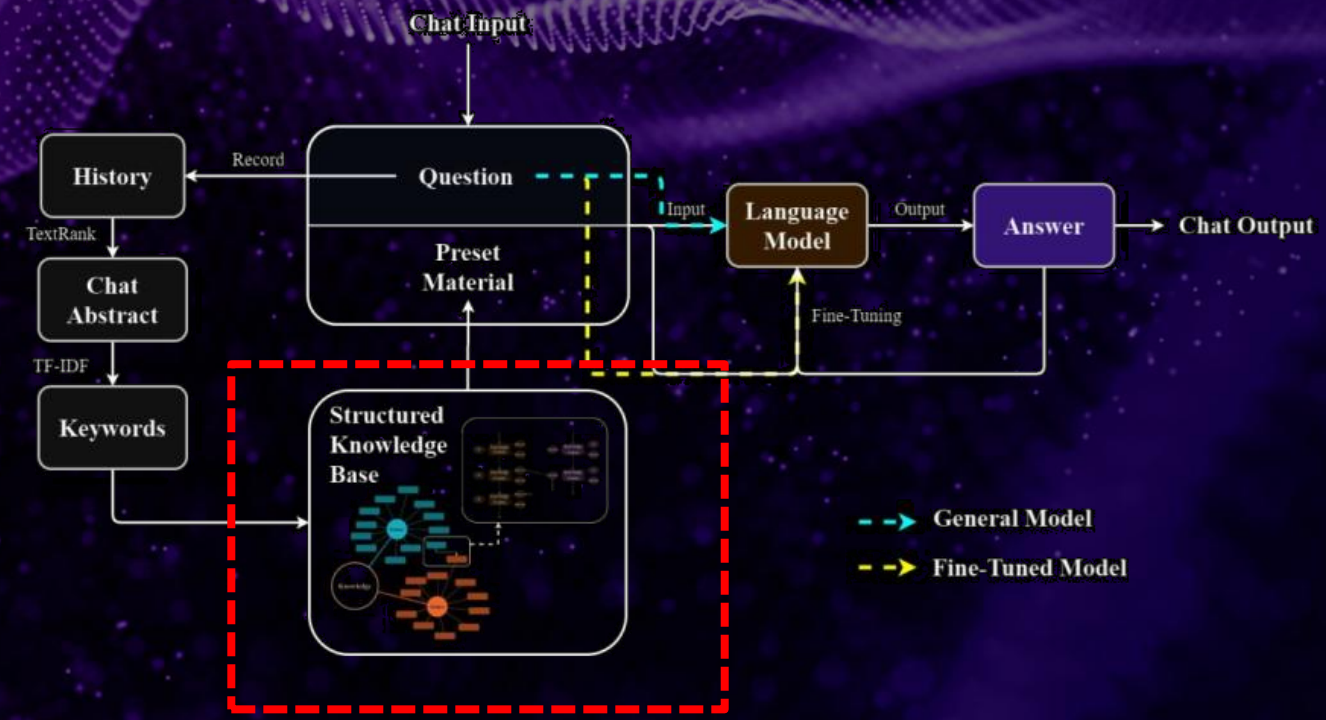

Zhang, H., Qiao, Z., Wang, H., Duan, B., & Yin, J. (2024). VCounselor: a psychological intervention chat agent based on a knowledge-enhanced large language model. *Multimedia Systems*, *30*(6), 363.

AI as psychological assistants & therapists

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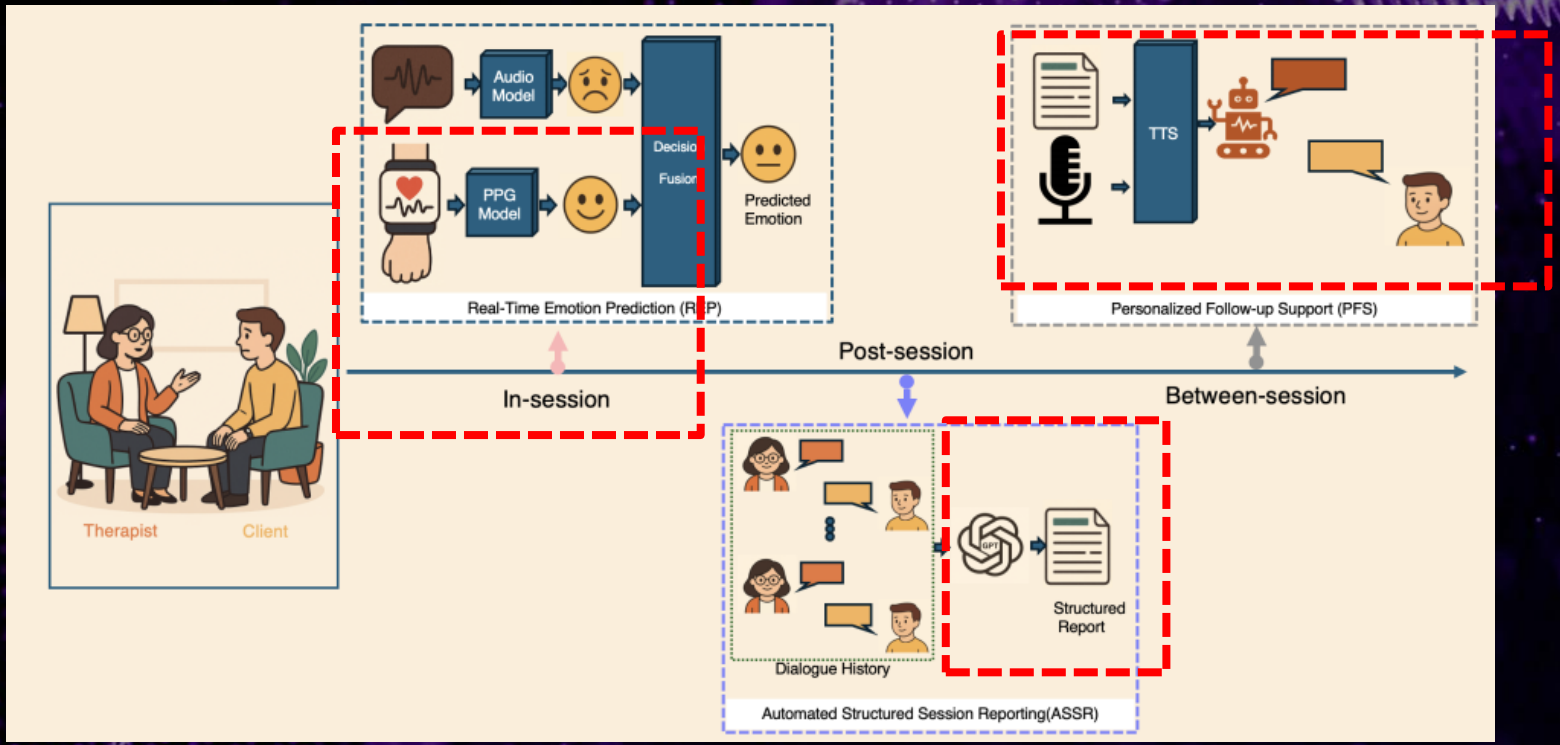


Liu, X., Xu, J., & Sun, T. (2025). PsyCounAssist: A Full-Cycle AI-Powered Psychological Counseling Assistant System. arXiv preprint arXiv:2504.16573.

Model	Dataset	Accuracy	F1 Score
Random Forest	Validation	0.954	0.957
	Test	0.963	0.964
Gradient Boosting	Validation	0.844	0.858
	Test	0.847	0.858
AdaBoost	Validation	0.711	0.747
	Test	0.717	0.749
Support Vector Machine	Validation	0.559	0.708
	Test	0.553	0.701
Naive Bayes	Validation	0.558	0.707
	Test	0.554	0.702

AI as psychological assistants & therapists: Rogerian psychotherapy

Rogerian psychotherapy is as person-centered, client-centered, or non-directive therapy:

- Non-directive: The therapist listens closely, reflects feelings, clarifies thoughts, but doesn't interpret, advise, or diagnose Provides a supportive, empathic environment,
- Patients gain self-awareness and move toward congruence, bridging the gap between their real and ideal selves

ELIZA was one of the earliest chatbot attempts to embody Rogerian therapy.

- Created in the mid-1960s by Joseph Weizenbaum (MIT), ELIZA employed a script named DOCTOR to mimic a non-directive, reflective Rogerian psychotherapist
- Issue: ELIZA quickly breaks on conversations after some time

Vibe coding to create an ELIZA Rogerian psychotherapy prototype

What is vibe coding?

- New paradigm in programming: intentions are expressed in natural language and AI tools generate the corresponding code.
- Coined by Andrej Karpathy in 2025
- Shifts focus from syntax to creative design
- Makes coding more accessible and intuitive

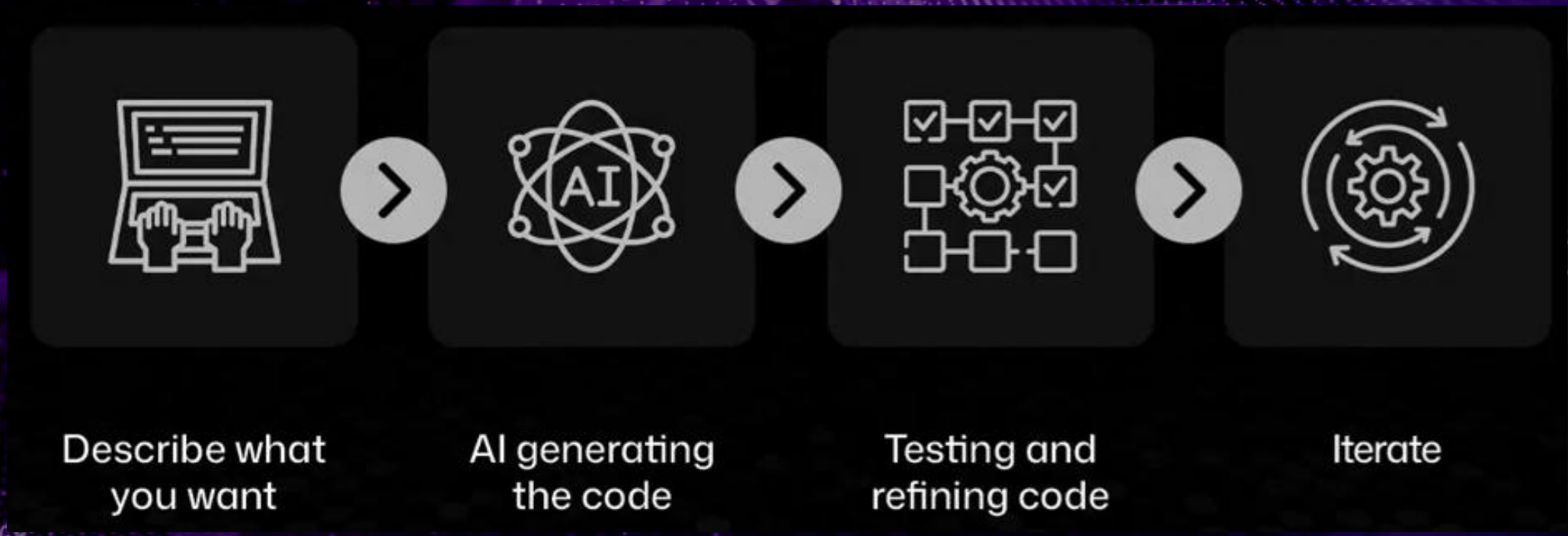
Vibe coding to create an ELIZA Rogerian psychotherapy prototype

Vibe coding emphasizes the creative 'vibe' of development over traditional rules:

- Encourages human-AI collaboration
- Lowers the barrier for non-programmers
- Focuses on high-level logic and design

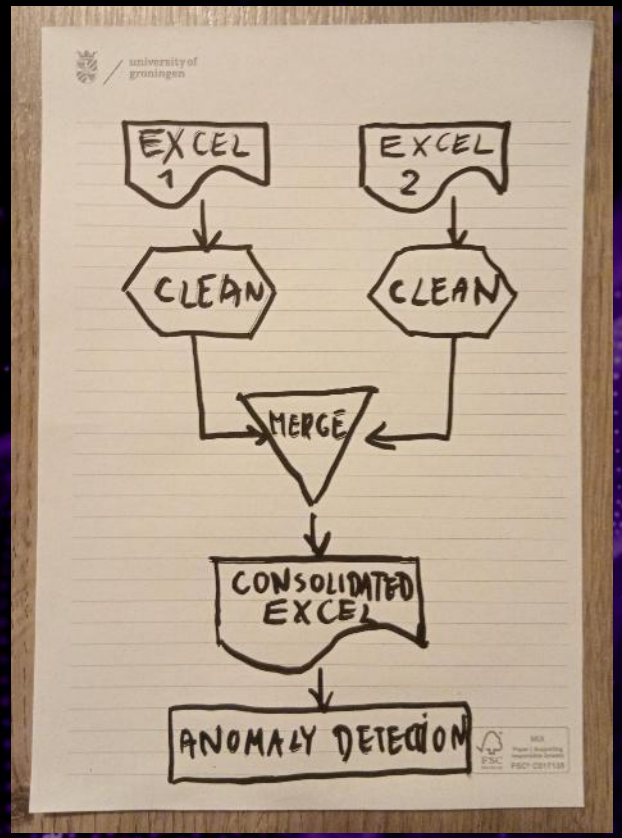
Vibe coding to create an ELIZA Rogerian psychotherapy prototype

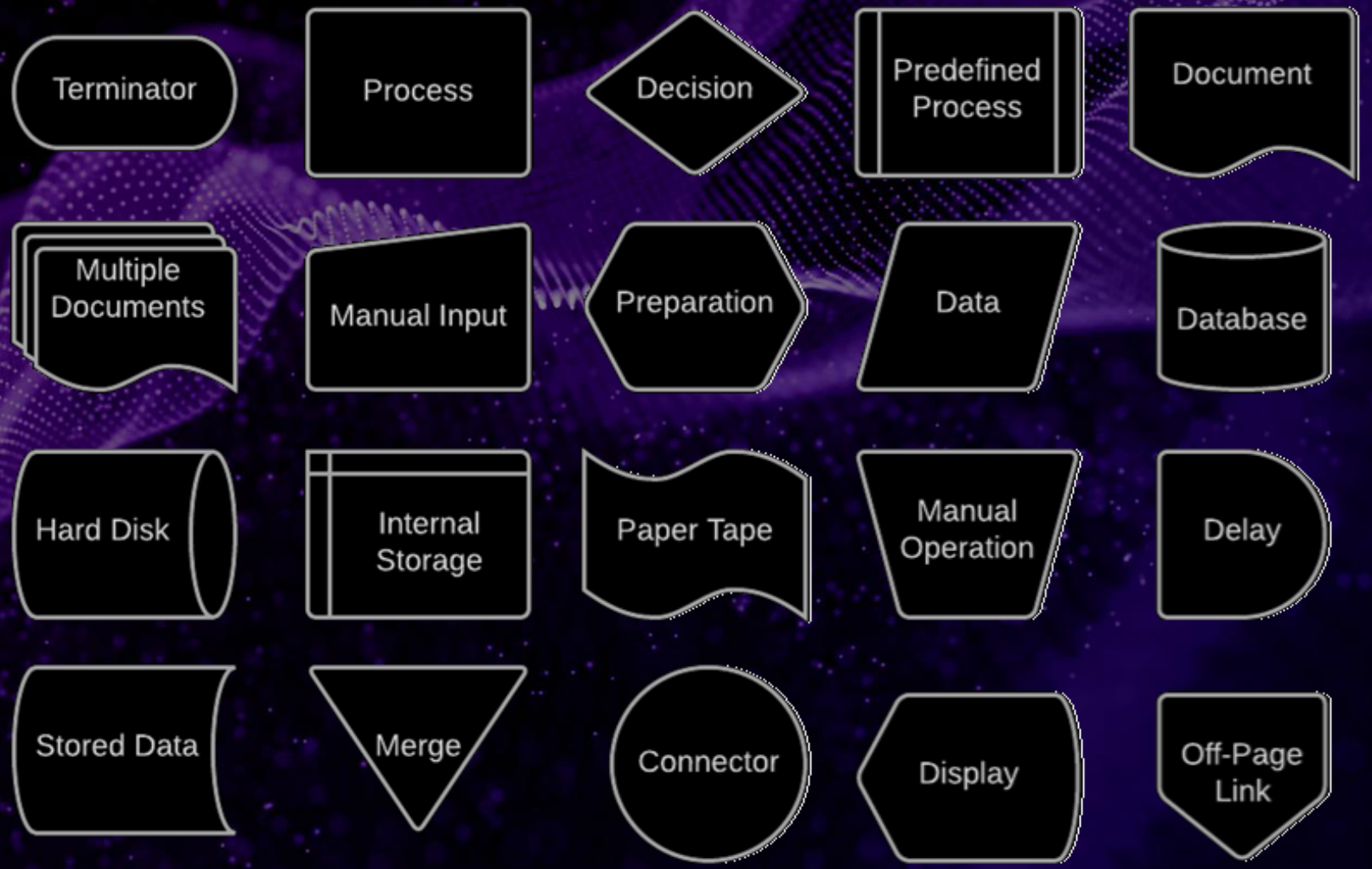
How to Vibe Code in Python?



Vibe coding with Python in Practice

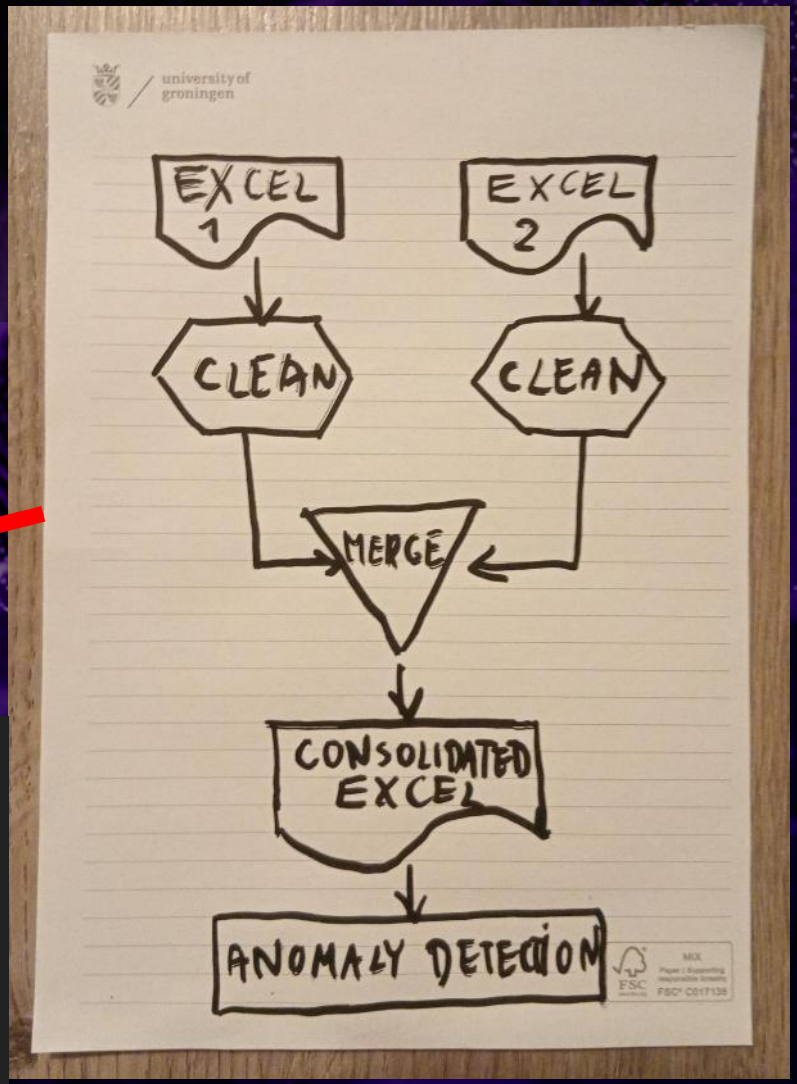
Automatizing flowchart's design





Vibe coding with Python

Automatizing flowchart's design



make a flowchart in Tikz and a script in python based on the figure attached

+ Tools

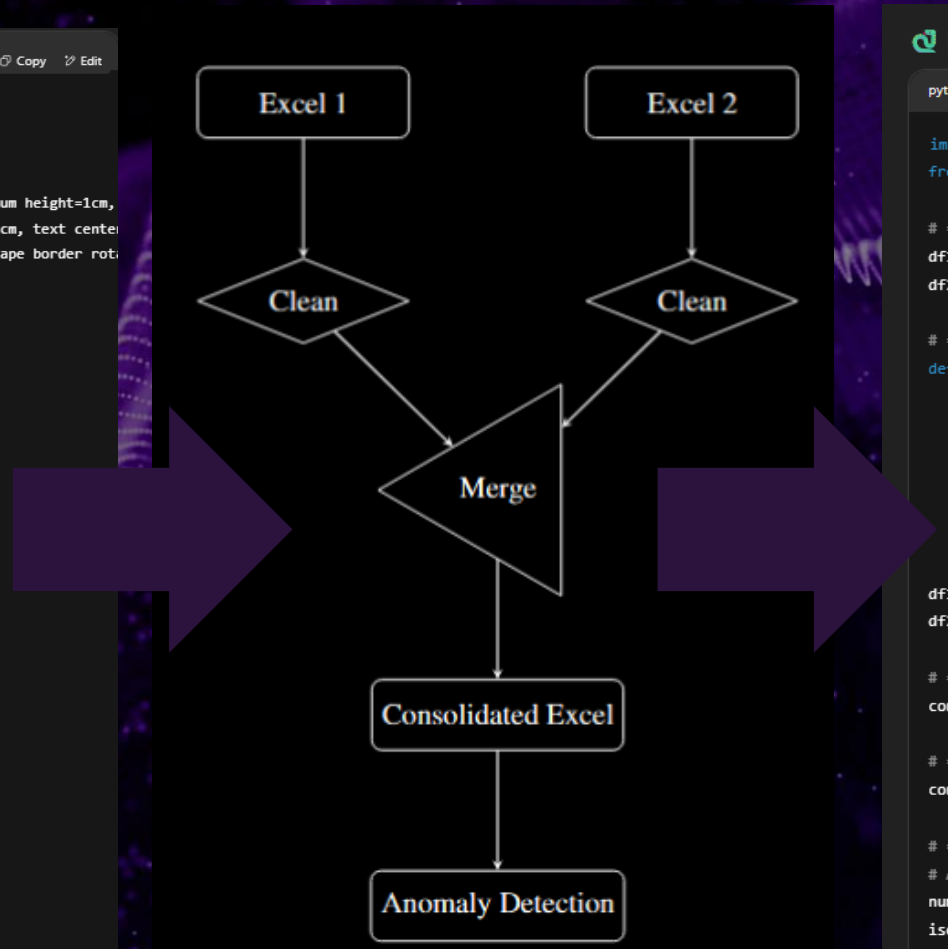
Vibe coding with Python

Automatizing flowchart's design with ChatGPT

latex

Copy Edit

```latex
\documentclass{article}
\usepackage{tikz}
\usetikzlibrary{shapes.geometric, arrows.meta, positioning}

\tikzstyle{startstop} = [draw, rectangle, rounded corners, minimum width=3cm, minimum height=1cm,
\tikzstyle{process} = [draw, diamond, aspect=2, minimum width=3cm, minimum height=1cm, text cente
\tikzstyle{merge} = [draw, isosceles triangle, isosceles triangle apex angle=60, shape border rot
\tikzstyle{arrow} = [thick, ->, >=stealth]

\begin{document}

\begin{tikzpicture}[node distance=1.7cm and 2.5cm]

% Top row
\node (excel1) [startstop] {Excel 1};
\node (excel2) [startstop, right=of excel1] {Excel 2};

% Cleaning
\node (clean1) [process, below=of excel1] {Clean};
\node (clean2) [process, below=of excel2] {Clean};

% Center anchor
\path (clean1) -- (clean2) coordinate[midway] (middle);

% Merge node centered under clean1 and clean2
\node (merge) [merge, below=1.7cm of middle] {Merge};

% Output nodes
\node (consolidated) [startstop, below=of merge] {Consolidated Excel};
\node (anomaly) [startstop, below=of consolidated] {Anomaly Detection};

% Arrows
\draw [arrow] (excel1) -- (clean1);
\draw [arrow] (excel2) -- (clean2);
\draw [arrow] (clean1) -- (merge);
```



Python Script:

python

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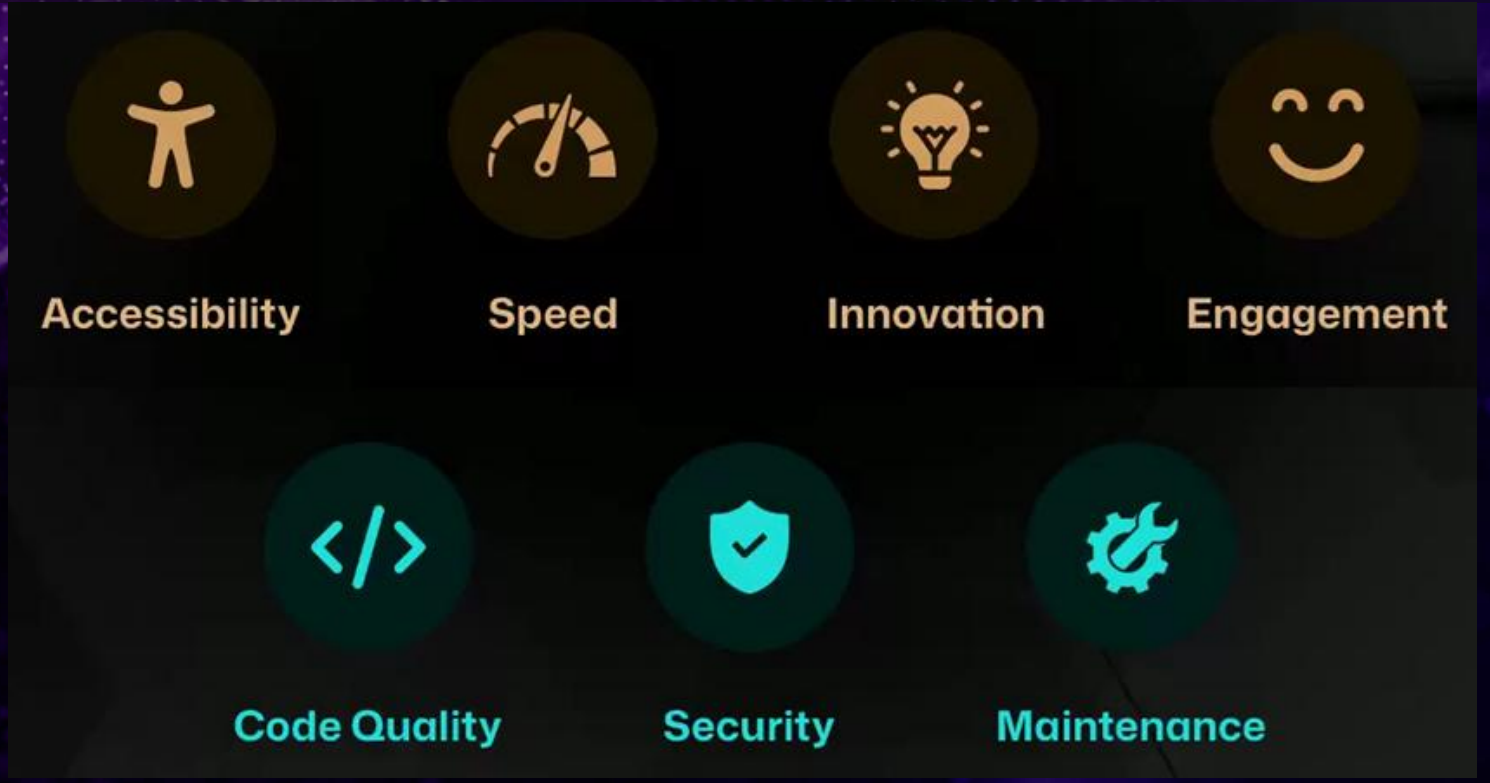
```python
import pandas as pd
from sklearn.ensemble import IsolationForest

# === Step 1: Load Excel Files ===
df1 = pd.read_excel('excel1.xlsx')
df2 = pd.read_excel('excel2.xlsx')

# === Step 2: Clean Function ===
def clean_data(df):
    # Remove text qualifiers, trim spaces, drop empty rows
    df.columns = df.columns.str.strip().str.replace('"', '')
    for col in df.select_dtypes(include='object').columns:
        df[col] = df[col].str.strip().str.replace('"', '')
    df.dropna(how='all', inplace=True)
    return df

df1_clean = clean_data(df1)
df2_clean = clean_data(df2)

# === Step 3: Merge Files ===
consolidated = pd.concat([df1_clean, df2_clean], ignore_index=True)

# === Step 4: Save Consolidated Excel ===
consolidated.to_excel('consolidated.xlsx', index=False)

# === Step 5: Anomaly Detection ===
# Assume numerical columns for anomaly detection
num_cols = consolidated.select_dtypes(include='number').columns
iso_forest = IsolationForest(contamination=0.05, random_state=42)
consolidated['anomaly'] = iso_forest.fit_predi[illegible](consolidated[num_cols])
```

Vibe coding with Python

Vibe coding:
Pros and cons

- ✔ Fast development and prototyping
- ✔ Lower entry barrier for beginners
- ✔ Focus on ideas over syntax

- ⚠ Requires testing and review (debugging)
- ⚠ Potential over-dependence on AI
- ⚠ Security and code quality concerns



Key takeaways

1. Is artificial intelligence really "intelligent"?
2. What is the difference between traditional statistical/econometric modelling and machine learning (hint: think about partitions)
3. Will AI replace humans and displaced jobs?