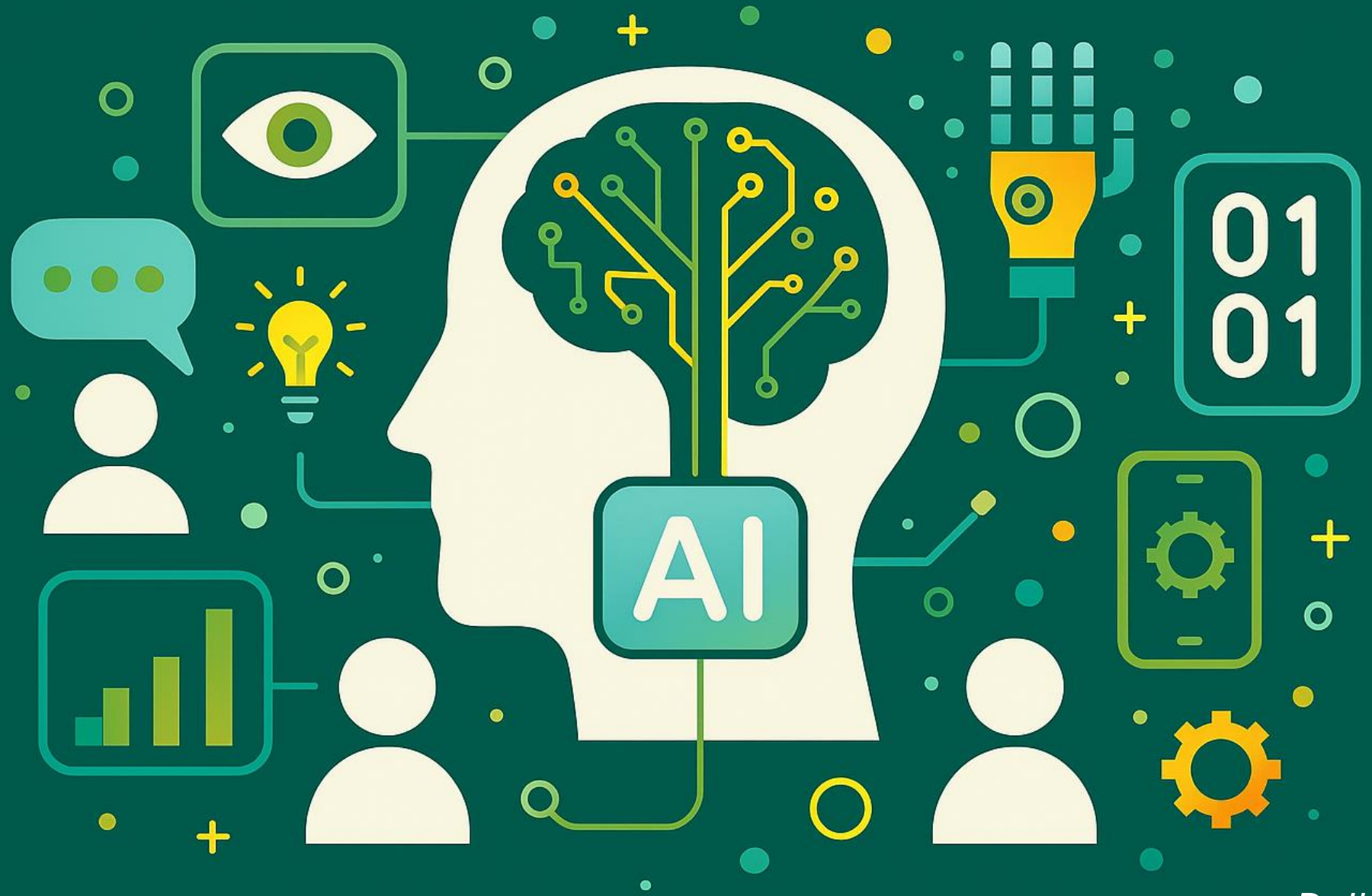
Data preprocessing



Dr Ibrahim Alsaggaf

Licence Disclaimer

Attribution Requirement

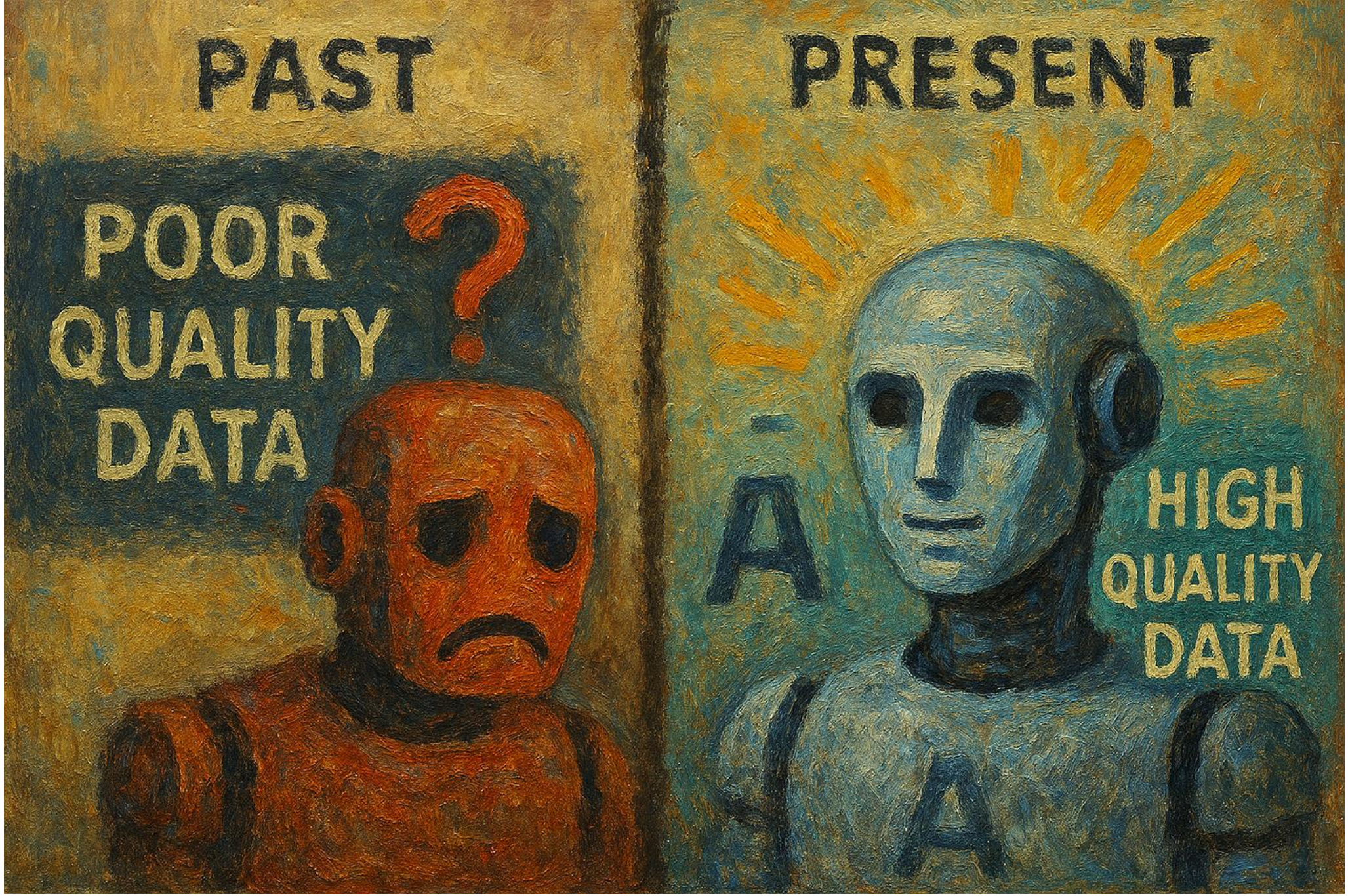
Content

- Data cleaning
- Data scaling
- Encoding
- Feature selection
- Q&A

Lab session: Implementing a data preprocessing pipeline

Data

1. How important is data in the success of AI projects?
2. To what extent does data quality influence the outcomes of AI initiatives?
3. What role does data play in determining the effectiveness of AI models?
4. Why does data matter so much in AI development?
5. Can AI succeed without high-quality data?



Generated using https://copilot.microsoft.com

Data cleaning

Data

- Availability
- Correctness
- Completeness
- Consistency
- Freshness

✓ Gather data

Data cleaning

Data

- Availability
- Correctness
- Completeness
- Consistency
- Freshness

✓ Fix errors
✓ Remove outliers

Data cleaning

Data

- Availability
- Correctness
- Completeness
- Consistency
- Freshness

✓ Impute nulls

Data cleaning

Data

- Availability
- Correctness
- Completeness
- Consistency
- Freshness

✓ Enforce standards

Data cleaning

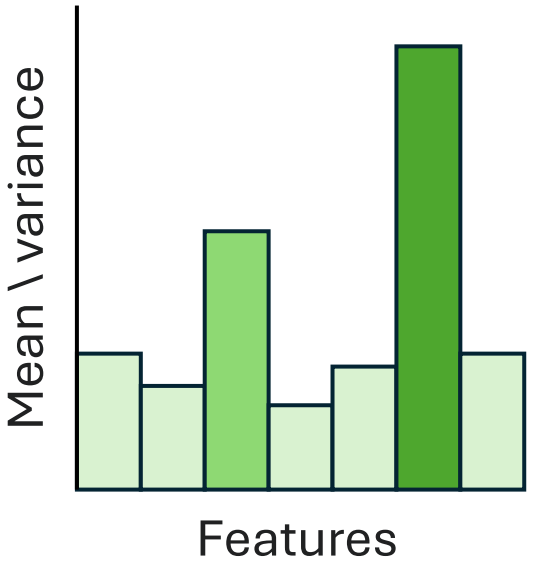
Data

- Availability
- Correctness
- Completeness
- Consistency
- Freshness

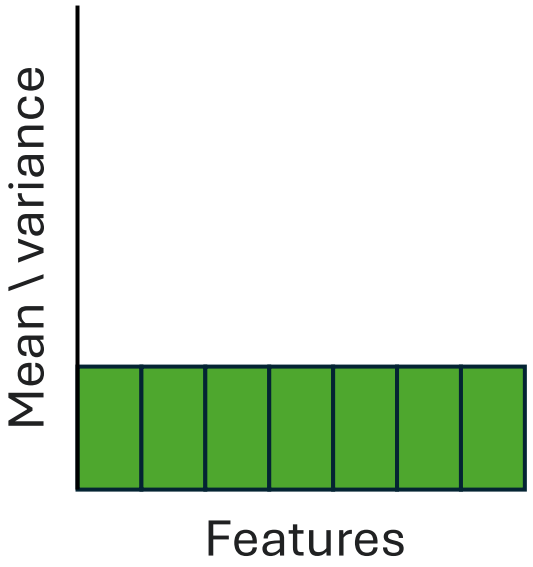
✓ Update frequency
✓ Streaming

Data scaling

Unscaled data



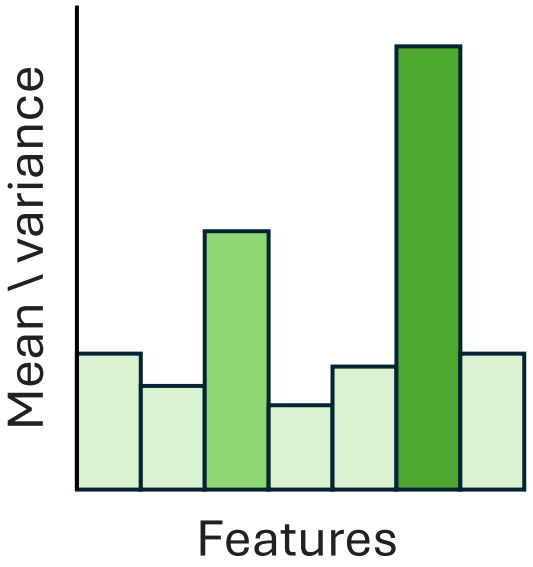
Scaled data

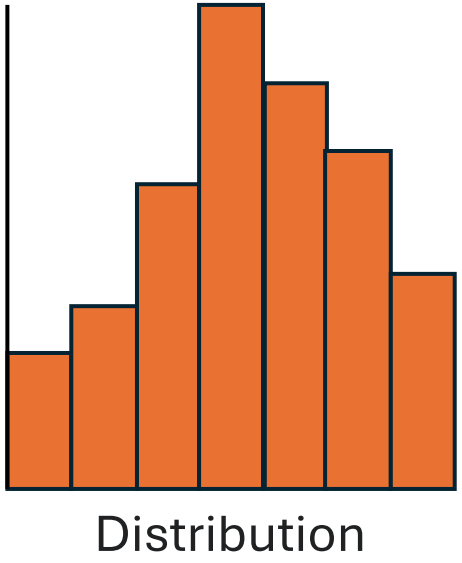


- ✓ Remove differences in statistical properties
- ✓ All features equally contribute to learning

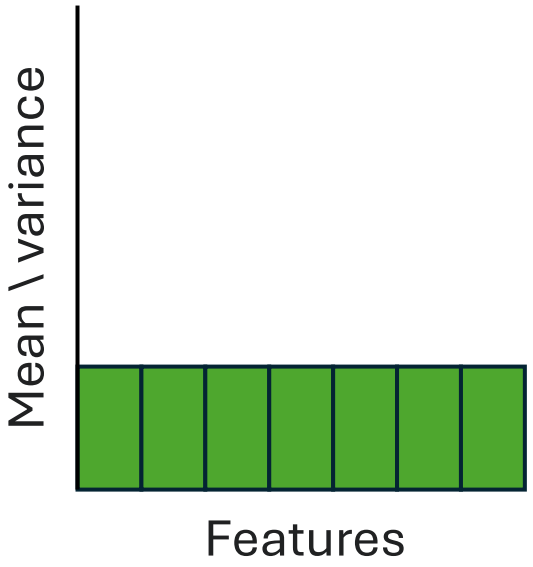
Data scaling

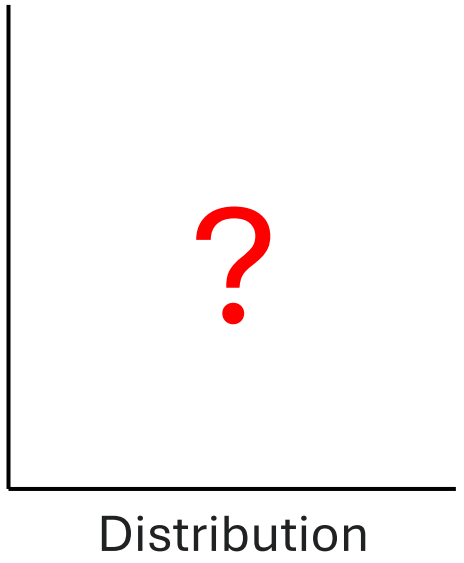
Unscaled data





Scaled data

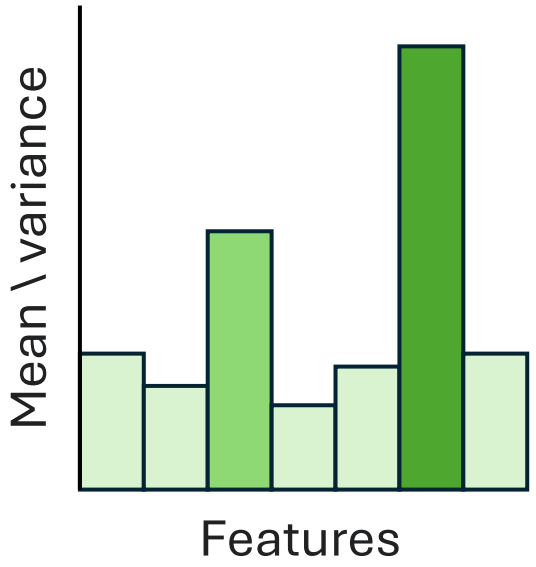


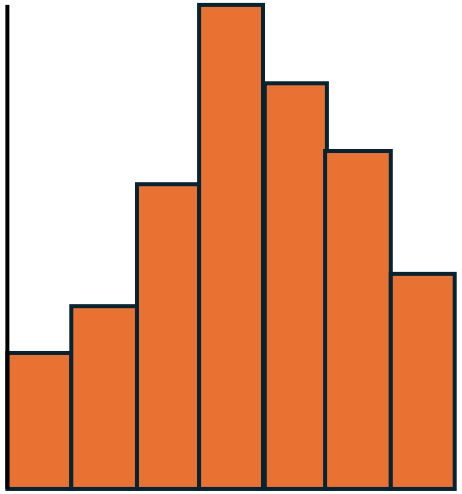


- ✓ Remove differences in statistical properties
- ✓ All features equally contribute to learning

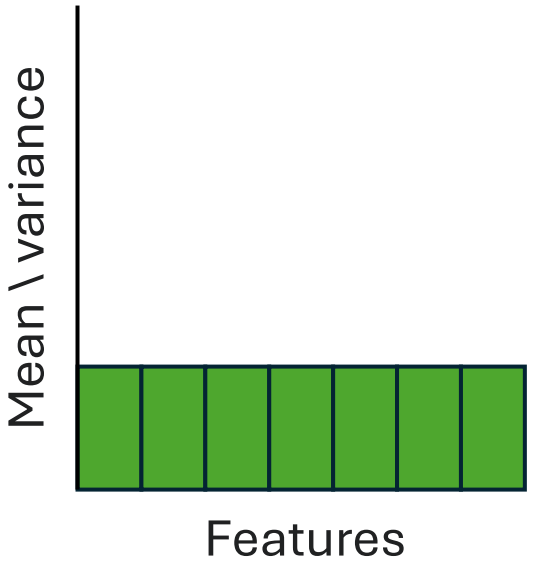
Data scaling

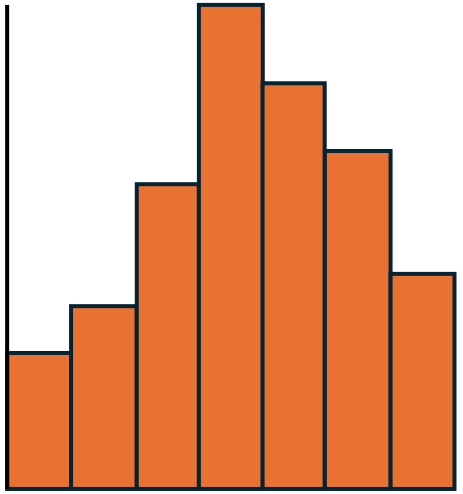
Unscaled data





Scaled data





- ✓ Remove differences in statistical properties
- ✓ All features equally contribute to learning
- ✓ Maintain feature distribution

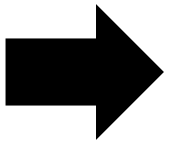
Encoding

y
Green
Red
Blue
Orange
Blue
Red
Green
Green
Orange

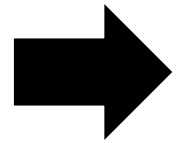
Machines cannot
understand natural language

Encoding

y
Green
Red
Blue
Orange
Blue
Red
Green
Green
Orange



Label encoding



```
{
    Blue: 0,
    Green: 1,
    Orange: 2,
    Red: 3
}
```

y
1
3
0
2
0
3
1
1
2

Encoding

y
Green
Red
Blue
Orange
Blue
Red
Green
Green
Orange

One-hot encoding

```
{
    Blue: 0,
    Green: 1,
    Orange: 2,
    Red: 3
}
```

Blue	Green	Orange	Red
y			
0	1	0	0
0	0	0	1
1	0	0	0
0	0	1	0
1	0	0	0
0	0	0	1
0	1	0	0
0	1	0	0
0	0	1	0

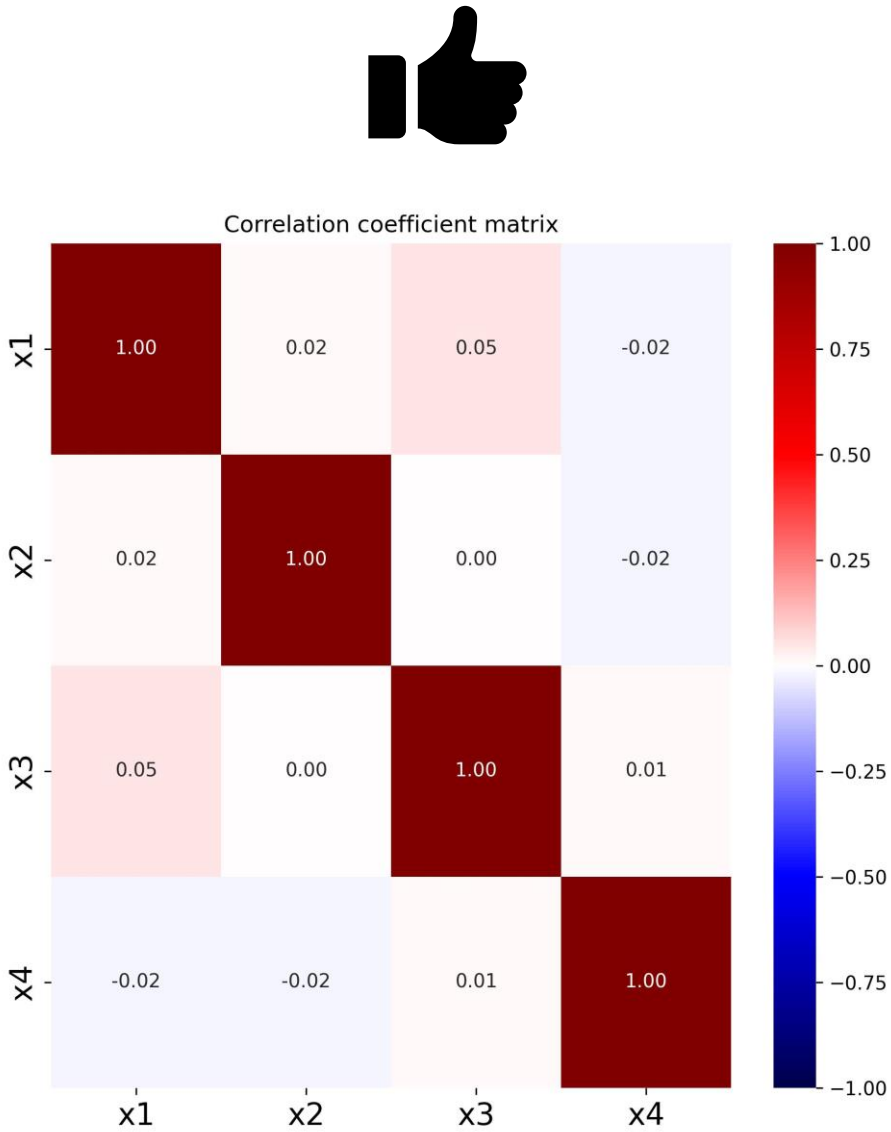
Are all features informative?

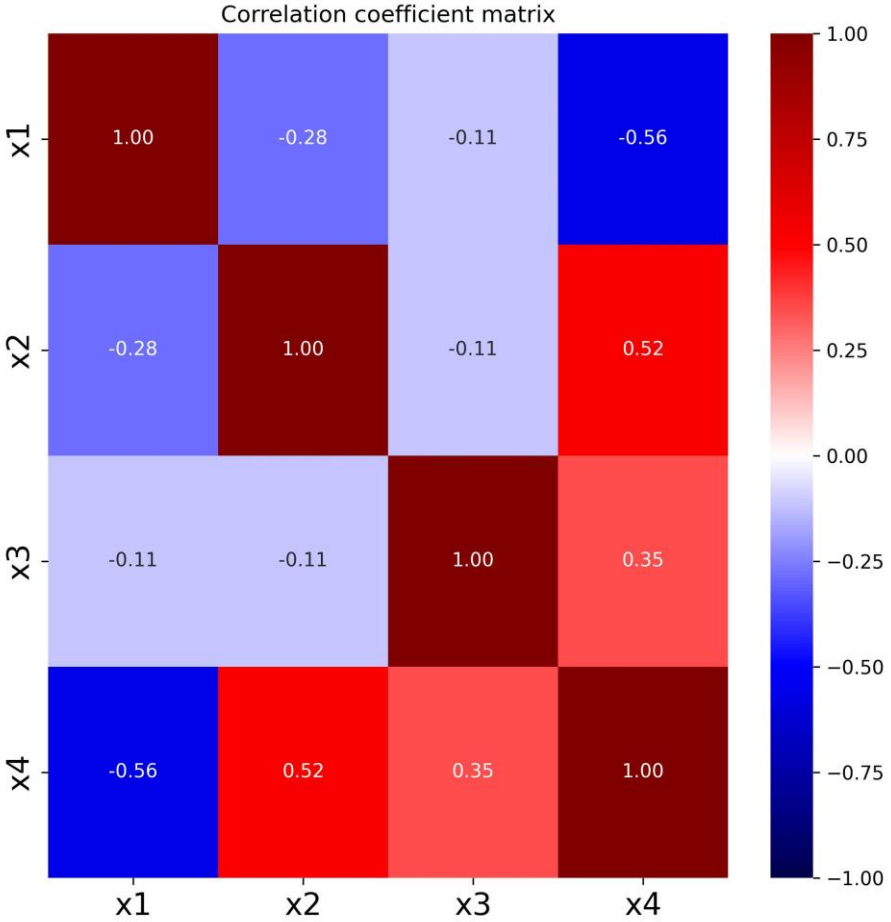
A sample of feature selection methods

Method	Type	Requires training	Expensive
Pearson's correlation coefficient	Statistical-based		
Analysis of Variance (ANOVA)	Statistical-based		
Recursive Feature Elimination (RFE)	Model-based	✓	✓
Tree-based models (e.g. Random Forest)	Model-based	✓	
…	…		

Pearson's correlation coefficient

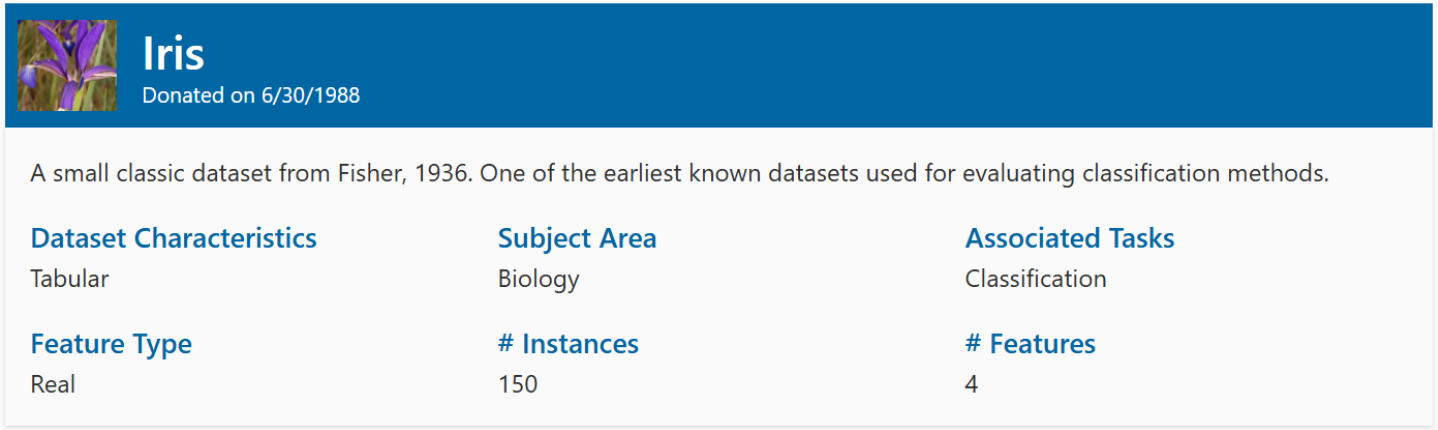
Feature selection



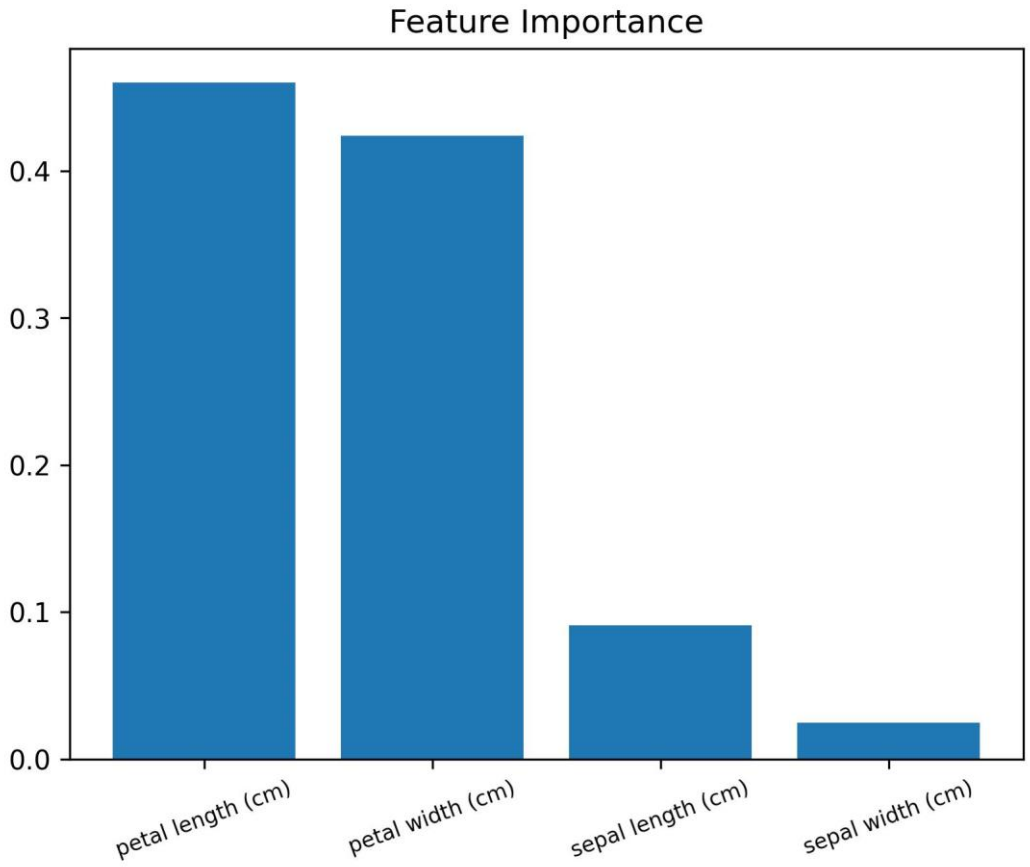


Tree-based model (Random Forest)

Feature selection



[Source] UCI Machine Learning Repository



Q&A

Lab Time

Lab 2: Implementing a data preprocessing pipeline

From Lab1 we know how to:

- [x] Install Python 3.14.2
- [x] Install Visual Studio Code
- [x] Verify the installation
- [x] Create a virtual environment

Lab 2: Dataset

8.1.2. Diabetes dataset

Ten baseline variables, age, sex, body mass index, average blood pressure, and six blood serum measurements were obtained for each of n = 442 diabetes patients, as well as the response of interest, a quantitative measure of disease progression one year after baseline.

Data Set Characteristics:

Number of Instances:	442
Number of Attributes:	First 10 columns are numeric predictive values
Target:	Column 11 is a quantitative measure of disease progression one year after baseline

	age	sex	bmi	bp	s1	s2	s3	s4	s5	s6	target
0	0.038076	0.050680	0.061696	0.021872	-0.044223	-0.034821	-0.043401	-0.002592	0.019907	-0.017646	151.0
1	-0.001882	-0.044642	-0.051474	-0.026328	-0.008449	-0.019163	0.074412	-0.039493	-0.068332	-0.092204	75.0
2	0.085299	0.050680	0.044451	-0.005670	-0.045599	-0.034194	-0.032356	-0.002592	0.002861	-0.025930	141.0
3	-0.089063	-0.044642	-0.011595	-0.036656	0.012191	0.024991	-0.036038	0.034309	0.022688	-0.009362	206.0
4	0.005383	-0.044642	-0.036385	0.021872	0.003935	0.015596	0.008142	-0.002592	-0.031988	-0.046641	135.0

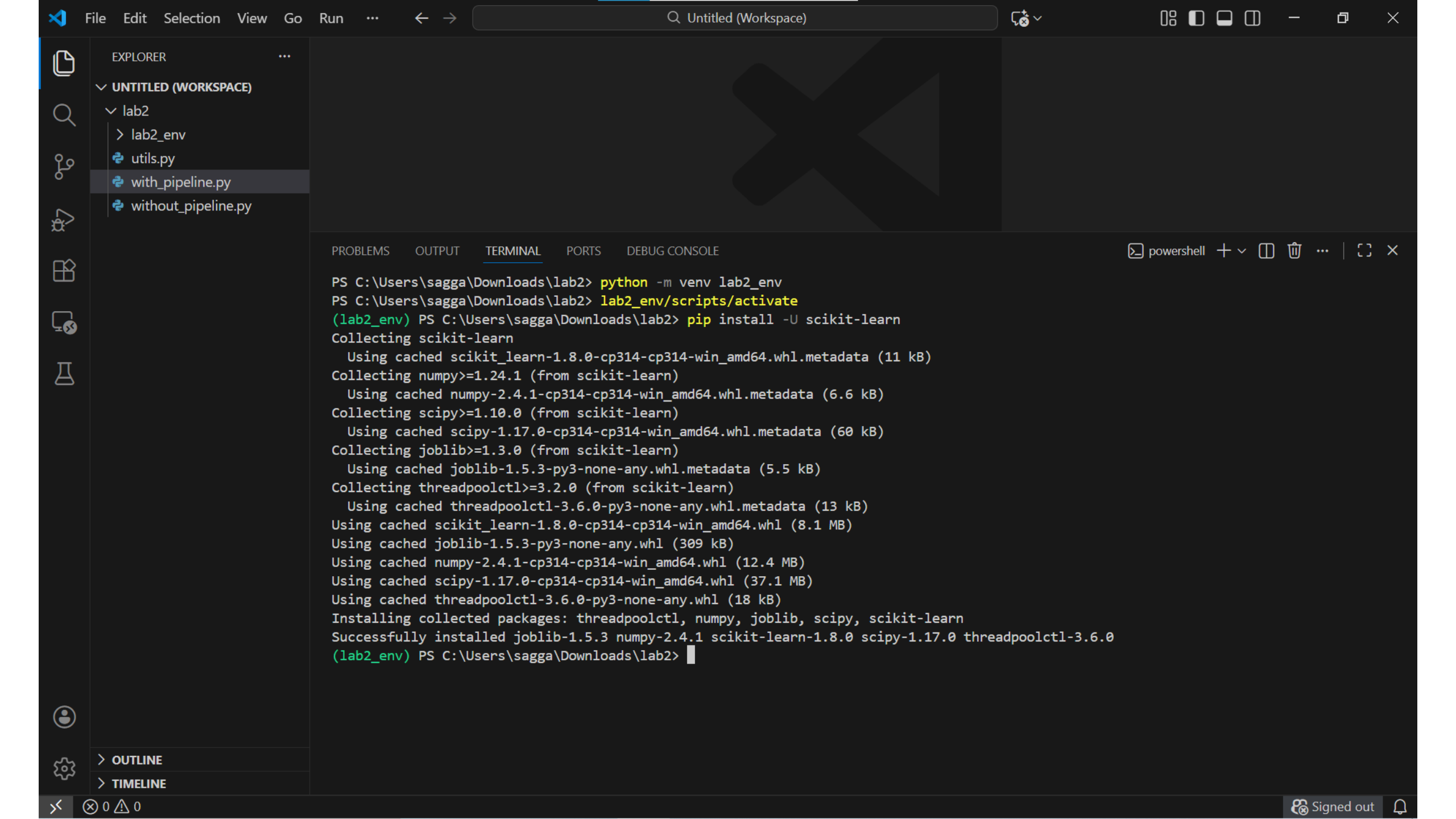
Step 1

- Download the Lab2 directory from the GitHub repository https://github.com/ibrahimsaggaf/Introduction-to-Artificial-Intelligence
- Open the Lab2 directory in Visual Studio Code.
- The Lab2 directory contains 3 python files:
  - ❑ without_pipeline.py
  - ❑ with_pipeline.py
  - ❑ utils.py

  Take your time examining the code in these files.

Step 2

- Create and activate a virtual environment under the name “lab2_env” (see Lab 1)
- Install the scikit-learn library inside the virtual environment by running the command:
  pip install -U scikit-learn

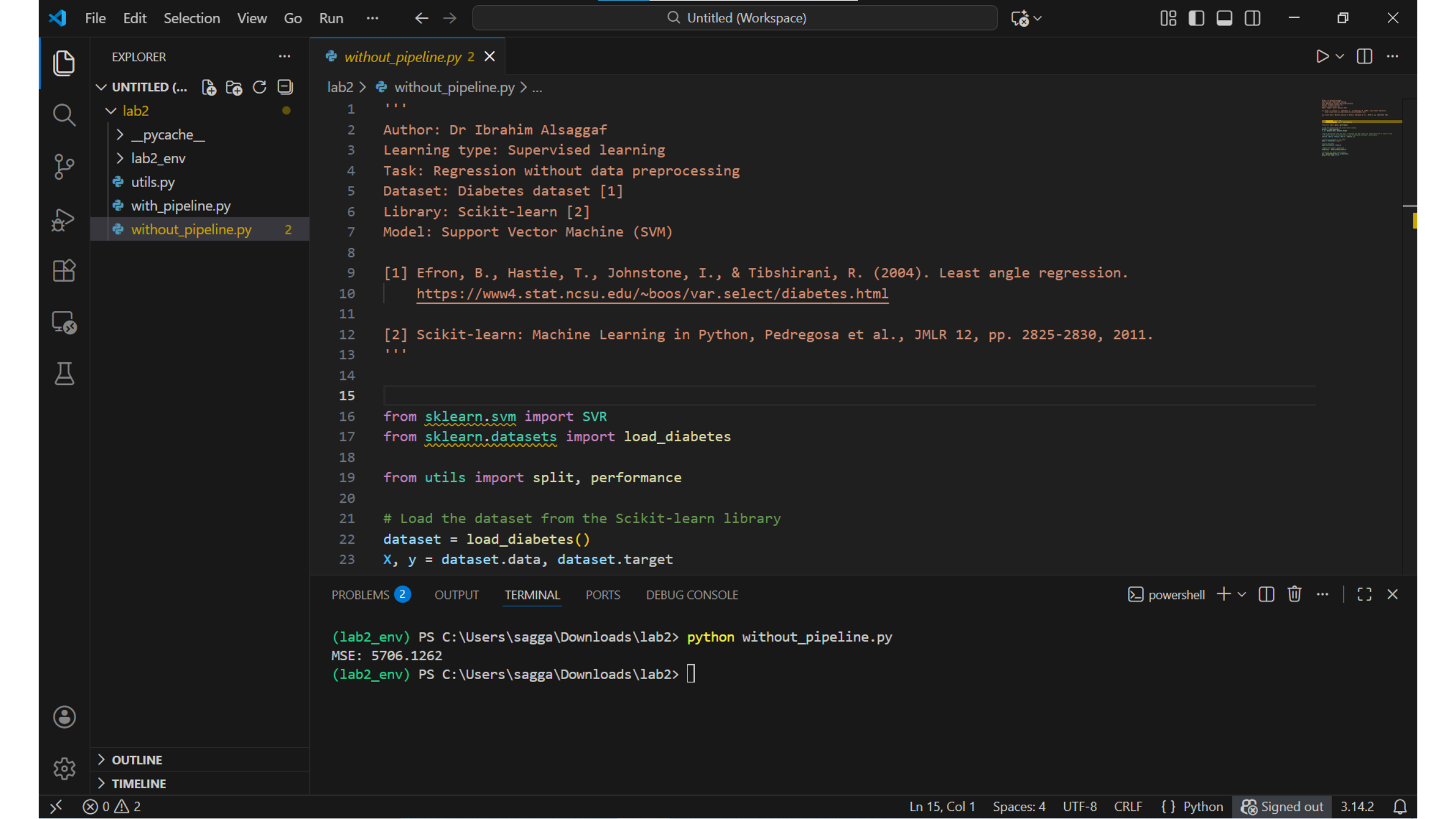

File Edit Selection View Go Run ···
Untitled (Workspace)
EXPLORER
UNTITLED (WORKSPACE)
lab2
lab2_env
utils.py
with_pipeline.py
without_pipeline.py
PROBLEMS OUTPUT TERMINAL PORTS DEBUG CONSOLE
powershell
PS C:\Users\sagga\Downloads\lab2> python -m venv lab2_env
PS C:\Users\sagga\Downloads\lab2> lab2_env/scripts/activate
(lab2_env) PS C:\Users\sagga\Downloads\lab2> pip install -U scikit-learn
Collecting scikit-learn
Using cached scikit_learn-1.8.0-cp314-cp314-win_amd64.whl.metadata (11 kB)
Collecting numpy>=1.24.1 (from scikit-learn)
Using cached numpy-2.4.1-cp314-cp314-win_amd64.whl.metadata (6.6 kB)
Collecting scipy>=1.10.0 (from scikit-learn)
Using cached scipy-1.17.0-cp314-cp314-win_amd64.whl.metadata (60 kB)
Collecting joblib>=1.3.0 (from scikit-learn)
Using cached joblib-1.5.3-py3-none-any.whl.metadata (5.5 kB)
Collecting threadpoolctl>=3.2.0 (from scikit-learn)
Using cached threadpoolctl-3.6.0-py3-none-any.whl.metadata (13 kB)
Using cached scikit_learn-1.8.0-cp314-cp314-win_amd64.whl (8.1 MB)
Using cached joblib-1.5.3-py3-none-any.whl (309 kB)
Using cached numpy-2.4.1-cp314-cp314-win_amd64.whl (12.4 MB)
Using cached scipy-1.17.0-cp314-cp314-win_amd64.whl (37.1 MB)
Using cached threadpoolctl-3.6.0-py3-none-any.whl (18 kB)
Installing collected packages: threadpoolctl, numpy, joblib, scipy, scikit-learn
Successfully installed joblib-1.5.3 numpy-2.4.1 scikit-learn-1.8.0 scipy-1.17.0 threadpoolctl-3.6.0
(lab2_env) PS C:\Users\sagga\Downloads\lab2>
OUTLINE
TIMELINE
0 0
Signed out

Step 3

- Run the command:
  python without_pipeline.py

This command evaluates a model's performance without applying data preprocessing:

1. Split the data into training and testing sets.
2. Train a Support Vector Machine (SVM) on the training set to solve a regression task – predicting disease progression one year after baseline.
3. Measure the model's performance on the testing set using Mean Squared Error (MSE).

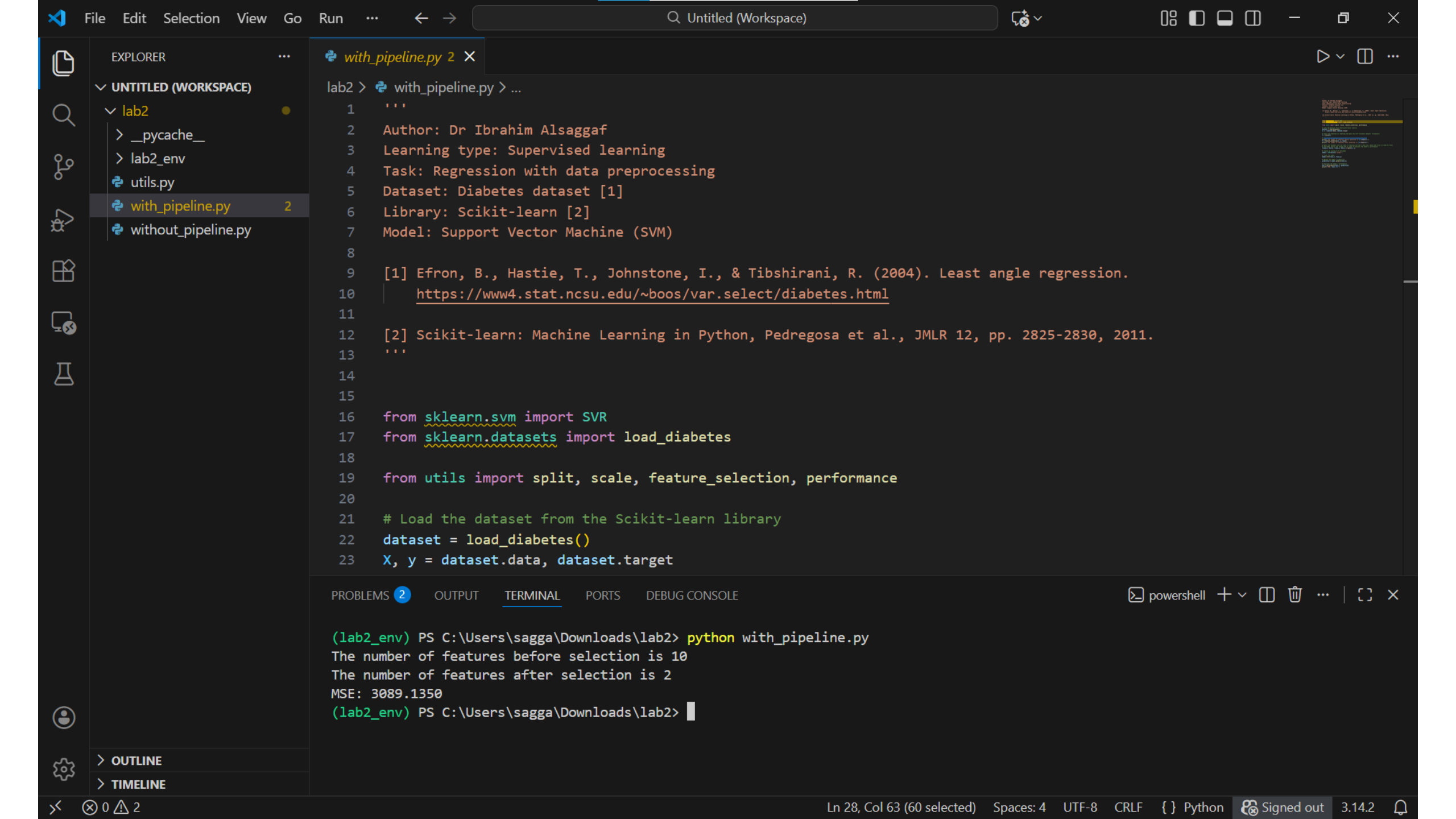

File Edit Selection View Go Run ···
Untitled (Workspace)
EXPLORER
UNTITLED (...
lab2
__pycache__
lab2_env
utils.py
with_pipeline.py
without_pipeline.py 2
without_pipeline.py 2
lab2 > without_pipeline.py > ...
'''
Author: Dr Ibrahim Alsaggaf
Learning type: Supervised learning
Task: Regression without data preprocessing
Dataset: Diabetes dataset [1]
Library: Scikit-learn [2]
Model: Support Vector Machine (SVM)
[1] Efron, B., Hastie, T., Johnstone, I., & Tibshirani, R. (2004). Least angle regression.
https://www4.stat.ncsu.edu/~boos/var.select/diabetes.html
[2] Scikit-learn: Machine Learning in Python, Pedregosa et al., JMLR 12, pp. 2825-2830, 2011.
'''
from sklearn.svm import SVR
from sklearn.datasets import load_diabetes
from utils import split, performance
# Load the dataset from the Scikit-learn library
dataset = load_diabetes()
X, y = dataset.data, dataset.target
PROBLEMS 2
OUTPUT
TERMINAL
PORTS
DEBUG CONSOLE
powershell
(lab2_env) PS C:\Users\sagga\Downloads\lab2> python without_pipeline.py
MSE: 5706.1262
(lab2_env) PS C:\Users\sagga\Downloads\lab2>
OUTLINE
TIMELINE
0 2
Ln 15, Col 1
Spaces: 4
UTF-8
CRLF
{ } Python
Signed out
3.14.2

Step 4

- Run the command:
  python with_pipeline.py

This command evaluates a model's performance with applying data preprocessing :

1. Scale the features.
2. Select the top 2 important features using a tree-based model.
3. Split the data into training and testing sets.
4. Train a Support Vector Machine (SVM) on the training set to solve a regression task – predicting disease progression one year after baseline.
5. Measure the model's performance on the testing set using Mean Squared Error (MSE).


File Edit Selection View Go Run
Untitled (Workspace)
EXPLORER
UNTITLED (WORKSPACE)
lab2
__pycache__
lab2_env
utils.py
with_pipeline.py 2
without_pipeline.py
with_pipeline.py 2
lab2 > with_pipeline.py > ...
'''
Author: Dr Ibrahim Alsaggaf
Learning type: Supervised learning
Task: Regression with data preprocessing
Dataset: Diabetes dataset [1]
Library: Scikit-learn [2]
Model: Support Vector Machine (SVM)
[1] Efron, B., Hastie, T., Johnstone, I., & Tibshirani, R. (2004). Least angle regression.
https://www4.stat.ncsu.edu/~boos/var.select/diabetes.html
[2] Scikit-learn: Machine Learning in Python, Pedregosa et al., JMLR 12, pp. 2825-2830, 2011.
'''
from sklearn.svm import SVR
from sklearn.datasets import load_diabetes
from utils import split, scale, feature_selection, performance
# Load the dataset from the Scikit-learn library
dataset = load_diabetes()
X, y = dataset.data, dataset.target
PROBLEMS 2
OUTPUT
TERMINAL
PORTS
DEBUG CONSOLE
powershell
(lab2_env) PS C:\Users\sagga\Downloads\lab2> python with_pipeline.py
The number of features before selection is 10
The number of features after selection is 2
MSE: 3089.1350
(lab2_env) PS C:\Users\sagga\Downloads\lab2>
OUTLINE
TIMELINE
0 2
Ln 28, Col 63 (60 selected)
Spaces: 4
UTF-8
CRLF
Python
Signed out
3.14.2

Lab 2: Data preprocessing pipeline

Congrats! 

- [x] Install the scikit-learn library
- [x] Implement a data preprocessing pipeline

Quiz 1

Q1: Which statement correctly defines outliers?

A) Outliers are data errors resulting from invalid inputs or irrelevant observations

B) Outliers are genuine data points that represent extreme or unusual cases and may offer valuable insights

C) Either A or B

D) Both A and B

Q2: In this lab, what conclusion can be drawn about the impact of applying data preprocessing?

A) Improved performance but increased runtime

B) Improved performance and decreased runtime

C) Worse performance but decreased runtime

D) Worse performance and increased runtime

Reading list

What is Data Imputation
https://www.geeksforgeeks.org/machine-learning/what-is-data-imputation

Recursive Feature Elimination (RFE) for Feature Selection in Python
https://machinelearningmastery.com/rfe-feature-selection-in-python