Lecture 5: Preprocessing and sklearn pipelines

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Announcements

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Recap

- Decision trees: Split data into subsets based on feature values to create decision rules
- k-NNs: Classify based on the majority vote from k nearest neighbors
- SVM RBFs: Create a boundary using an RBF kernel to separate classes

Synthesizing existing knowledge

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Recap

Aspect	Decision Trees	K-Nearest Neighbors (KNN)	Support Vector Machines (SVM) with RBF Kernel
Main hyperparameters	Max depth, min samples split	Number of neighbors (k)	C (regularization), Gamma (RBF kernel width)
Interpretability			
Handling of Non-linearity			
Scalability			

Recap

Aspect	Decision Trees	K-Nearest Neighbors (KNN)	Support Vector Machines (SVM) with RBF Kernel
Sensitivity to Outliers			
Memory Usage			
Training Time			
Prediction Time			
Multiclass support			

(iClicker) Exercise 5.1

iClicker cloud join link: **https://join.iclicker.com/YJHS**

Take a guess: In your machine learning project, how much time will you typically spend on data preparation and transformation?

- a. ~80% of the project time
- b. ~20% of the project time
- c. ~50% of the project time
- d. None. Most of the time will be spent on model building

The question is adapted from here.

(iClicker) Exercise 5.2

iClicker cloud join link: **https://join.iclicker.com/YJHS**

Select all of the following statements which are TRUE.

- a. StandardScaler ensures a fixed range (i.e., minimum and maximum values) for the features.
- b. StandardScaler calculates mean and standard deviation for each feature separately.
- c. In general, it's a good idea to apply scaling on numeric features before training k-NN or SVM RBF models.
- d. The transformed feature values might be hard to interpret for humans.

After applying SimpleImputer The transformed data has a different shape than the original data.

(iClicker) Exercise 5.3

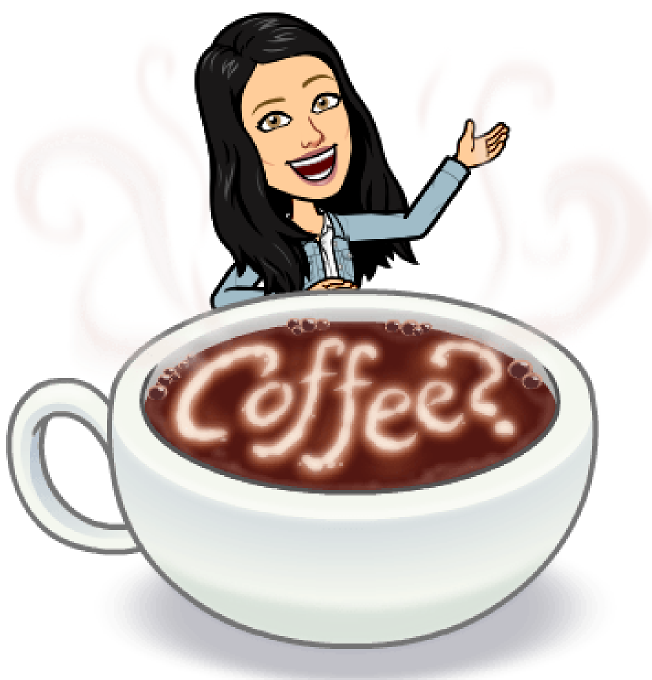
iClicker cloud join link: **https://join.iclicker.com/YJHS**

Select all of the following statements which are TRUE.

- a. You can have scaling of numeric features, one-hot encoding of categorical features, and scikit-learn estimator within a single pipeline.
- b. Once you have a scikit-learn pipeline object with an estimator as the last step, you can call fit, predict, and score on it.
- c. You can carry out data splitting within scikit-learn pipeline.
- d. We have to be careful of the order we put each transformation and model in a pipeline.

Break

Let’s take a break!



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Preprocessing motivation: example

You’re trying to find a suitable date based on:

- Age (closer to yours is better).
- Number of Facebook Friends (closer to your social circle is ideal).

Preprocessing motivation: example

- You are 30 years old and have 250 Facebook friends.

Person	Age	#FB Friends	Euclidean Distance Calculation	Distance
A	25	400	$\sqrt{(5^2 + 150^2)}$	150.08
B	27	300	$\sqrt{(3^2 + 50^2)}$	50.09
C	30	500	$\sqrt{(0^2 + 250^2)}$	250.00
D	60	250	$\sqrt{(30^2 + 0^2)}$	30.00

Based on the distances, the two nearest neighbors (2-NN) are:

- **Person D** (Distance: 30.00)
- **Person B** (Distance: 50.09)

What's the problem here?

Common transformations

Imputation: Fill the gaps! (🟩 🟧 🟦)

Fill in missing data using a chosen strategy:

- **Mean**: Replace missing values with the average of the available data.
- **Median**: Use the middle value.
- **Most Frequent**: Use the most common value (mode).
- **KNN Imputation**: Fill based on similar neighbors.

Example:

Fill in missing values like filling empty seats in a classroom with the average student.

```
from sklearn.impute import SimpleImputer
imputer = SimpleImputer(strategy='mean')
X_imputed = imputer.fit_transform(X)
```

Scaling: Everything to the same range! (📉 📈)

Ensure all features have a comparable range.

- **StandardScaler**: Mean = 0, Standard Deviation = 1.
- **MinMaxScaler**: Scales features to a [0, 1] range.
- **RobustScaler**: Scales features using median and quantiles.

Example:

Rescaling everyone's height to make basketball players and gymnasts comparable.

```python
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
X_scaled = scaler.fit_transform(X)
```

One-Hot encoding: 🍎 → 1️⃣ 0️⃣ 0️⃣

Convert categorical features into binary columns.

- Creates new binary columns for each category.
- Useful for handling categorical data in machine learning models.

Example:

Turn “Apple, Banana, Orange” into binary columns:

Fruit	🍎	🍌	🍊
Apple 🍎	1	0	0
Banana 🍌	0	1	0
Orange 🍊	0	0	1

```
from sklearn.preprocessing import OneHotEncoder
encoder = OneHotEncoder()
X_encoded = encoder.fit_transform(X)
```

Ordinal encoding: Ranking matters! (⭐⭐⭐⭐⭐ → 1️⃣)

Convert categories into integer values that have a meaningful order.

- Assign integers based on order or rank.
- Useful when there is an inherent ranking in the data.

Example:

Turn “Poor, Average, Good” into 1, 2, 3:

Rating	Ordinal
Poor	1
Average	2
Good	3

```
from sklearn.preprocessing import OrdinalEncoder
encoder = OrdinalEncoder()
X_ordinal = encoder.fit_transform(X)
```

`sklearn` Transformers vs Estimators

Transformers

- Are used to transform or preprocess data.
- Implement the `fit` and `transform` methods.
  - `fit(X)`: Learns parameters from the data.
  - `transform(X)`: Applies the learned transformation to the data.
- **Examples**:
  - **Imputation** (`SimpleImputer`): Fills missing values.
  - **Scaling** (`StandardScaler`): Standardizes features.

Estimators

- Used to make predictions.
- Implement `fit` and `predict` methods.
  - `fit(X, y)`: Learns from labeled data.
  - `predict(X)`: Makes predictions on new data.
- Examples: `DecisionTreeClassifier`, `SVC`, `KNeighborsClassifier`

```
from sklearn.tree import DecisionTreeClassifier
tree_clf = DecisionTreeClassifier()
```

The golden rule in feature transformations

- **Never** transform the entire dataset at once!
- **Why**? It leads to **data leakage** — using information from the test set in your training process, which can artificially inflate model performance.
- **Fit** transformers like scalers and imputers on the **training set only**.
- **Apply** the transformations to both the training and test sets **separately**.

Example:

```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)
```

`sklearn` Pipelines

- Pipeline is a way to chain multiple steps (e.g., preprocessing + model fitting) into a single workflow.
- Simplify the code and improves readability.
- Reduce the risk of data leakage by ensuring proper transformation of the training and test sets.
- Automatically apply transformations in sequence.

Example:

Chaining a `StandardScaler` with a `KNeighborsClassifier` model.

```
from sklearn.pipeline import make_pipeline
from sklearn.preprocessing import StandardScaler
from sklearn.neighbors import KNeighborsClassifier

pipeline = make_pipeline(StandardScaler(), KNeighborsClassifier())

pipeline.fit(X_train, y_train)
y_pred = pipeline.predict(X_test)
```

See you next week!

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