K-Nearest Neighbors (KNN) Classifier and Imputation using KNN

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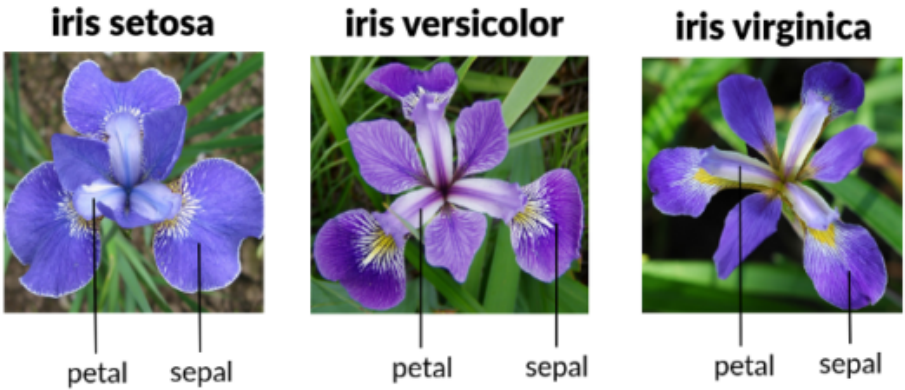
- Commonly used for classification tasks, especially with labeled data.
- We'll use the Iris dataset, which has flower measurements.

Iris Flower Types



Iris Dataset Sample Features

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Iris Dataset Sample Features

- The dataset includes four features:
  - Sepal Length
  - Sepal Width
  - Petal Length
  - Petal Width
- Target class is the Iris flower type: Setosa, Versicolor, or Virginica.

Sample Data Points

In original dataset there are 150 instances which has four features sepal length, sepal width, petal length and petal width and three classes Iris-setosa, Iris-versicolor and Irish-virginica. For the sake of simplicity, I have only take only ten instances in which nine are labeled and one is not labeled. Nine instances will be used for training and one will be used for testing.

S. No.	Sepal Len. (cm)	Sepal Width (cm)	Petal Len. (cm)	Petal Width (cm)	Label
1	4.6	3.4	1.4	0.3	Iris-setosa
2	5.0	3.4	1.5	0.2	Iris-setosa
3	4.4	2.9	1.4	0.2	Iris-setosa
4	7.0	3.2	4.7	1.4	Iris-versicolor
5	6.4	3.2	4.5	1.5	Iris-versicolor
6	6.9	3.1	4.9	1.5	Iris-versicolor
7	6.3	3.3	6.0	2.5	Iris-virginica
8	5.8	2.7	5.1	1.9	Iris-virginica
9	7.1	3.0	5.9	2.1	Iris-virginica
10	5.0	3.3	1.4	0.2	Unknown

Understanding KNN with Distance Calculation

From the data set you can see nine instances having labels and the tenth has not a label. To train the model, distance will be calculated from instance 10 to all other instances, and the value of k should be chosen.

$$d(1,10) = \sqrt{(sl_1 - sl_{10})^2 + (sw_1 - sw_{10})^2 + (pl_1 - pl_{10})^2 + (pw_1 - pw_{10})^2}$$

$$d(1,10) = \sqrt{(4.6 - 5.0)^2 + (3.4 - 3.3)^2 + (1.4 - 1.4)^2 + (0.3 - 0.2)^2} = 0.424$$

In the above equation

- sl: Sepal Length,
- sw: Sepal Width,
- pl: Petal Length,
- pw: Petal Width.

Distances from Instance 10

The same way, other distances are calculated as:

$$
\begin{aligned}
d(2,10) &= 0.141 \\
d(3,10) &= 0.721 \\
d(4,10) &= 4.042 \\
d(5,10) &= 3.643 \\
d(6,10) &= 4.194 \\
d(7,10) &= 5.305 \\
d(8,10) &= 4.193 \\
d(9,10) &= 5.325 \\
d(10,10) &= 0
\end{aligned}
$$

Conclusion with k = 3

If we take $k = 3$, the three nearest distances are:

- 0.141 (Iris-Setosa),
- 0.424 (Iris-Setosa),
- 0.721 (Iris-Setosa).

So, if $k = 3$, the majority of Iris-Setosa instances are nearest to instance number 10. Hence, we can classify instance 10 as **Iris-Setosa**.

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- Display the result: `Predicted = modal.predict(X_pred)`

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- Distance is calculated using available features (e.g., Euclidean).
- The missing value is imputed using the average or most frequent value among neighbors.
- Suitable when patterns exist in similar rows.

Sample Dataset

- Consider the following data:

ID	Height (cm)	Weight (kg)	Age
1	160	55	25
2	165	60	27
3	**NaN**	62	28
4	170	65	29
5	158	54	24

Sample Dataset

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ID	Height (cm)	Weight (kg)	Age
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- Row 3 is missing a value in Height.

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- Compute distance to other rows using Weight and Age only.
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- Heights of neighbors = 165 and 170
- Imputed Height = $\frac{165+170}{2} = 167.5$

Final Imputed Dataset

ID	Height (cm)	Weight (kg)	Age
1	160	55	25
2	165	60	27
3	**167.5**	62	28
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- The missing height has been filled using KNN with $k = 2$.

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- Choose an appropriate ‘k‘ based on dataset size and similarity.
- Normalize features before applying KNN for consistent results.

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- Drop the "ID" column to exclude it from distance calculations.
- Apply `KNNImputer` with `n_neighbors=2` and `metric='nan_euclidean'`.
- Reconstruct the imputed DataFrame and reinsert the "ID" column.
- Display the imputed dataset with the missing height value filled.

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