K-Nearest Neighbors (KNN) Algorithm in Machine Learning

Rewan Khaled

August 29, 2025

1 Introduction

K-Nearest Neighbors (KNN) is a simple, non-parametric, instance-based learning algorithm used for classification and regression. It predicts the label of a new data point based on the majority label of its k nearest neighbors in the feature space.

2 Algorithm Steps

1. Choose the number of neighbors, k.
2. Compute the distance between the new instance and all training points (e.g., Euclidean distance):
$$d(x_i, x_j) = \sqrt{\sum_{l=1}^{n} (x_i^{(l)} - x_j^{(l)})^2}$$
3. Identify the k nearest neighbors with the smallest distances.
4. Assign the most common label among these neighbors (for classification).
5. For regression, take the average value of neighbors.

3 Distance Metrics

Common distance metrics in KNN include:

- **Euclidean distance** (default)
- **Manhattan distance**
- **Minkowski distance**

4 Hyperparameters

- k **value:** too small leads to noisy predictions, too large may smooth over patterns.
- **Distance metric:** affects neighbor selection.
- **Weighting:** neighbors can be weighted by distance to improve predictions.

5 Advantages and Limitations

Advantages:

- Simple and intuitive
- Non-parametric, no assumption about data distribution
- Naturally handles multi-class classification

Limitations:

- Computationally expensive for large datasets
- Sensitive to irrelevant features and feature scaling
- Performance depends on choice of k and distance metric

6 Applications

KNN is used in:

- Recommender systems
- Image and pattern recognition
- Anomaly detection
- Medical diagnostics

7 Conclusion

KNN is a straightforward and versatile algorithm in machine learning. By examining nearby instances, it predicts outcomes without learning a model explicitly, making it effective for many practical tasks with properly scaled features.