Overfitting vs Underfitting in Machine Learning

In machine learning, model performance depends heavily on how well a model learns from data. Two common problems that affect model generalization are **underfitting** and **overfitting**.

1. Underfitting

Underfitting occurs when a model is too simple to capture the underlying patterns in the data. Such a model performs poorly on both training and test datasets.

- **Characteristics:**
- High bias, low variance
- Poor training accuracy
- Fails to learn important relationships in data

Common Causes: Using overly simple models, insufficient training time, or ignoring important features.

2. Overfitting

Overfitting occurs when a model learns the training data too well, including noise and outliers. As a result, it performs very well on training data but poorly on unseen data.

- **Characteristics:**
- Low bias, high variance
- Very high training accuracy
- Poor test or validation performance

Common Causes: Complex models, too many features, small datasets, or training for too many epochs.

3. Key Differences

- Underfitting: Model is too simple and misses patterns.
- Overfitting: Model is too complex and memorizes data.
- Goal: Achieve a balance where the model generalizes well.

4. How to Fix Underfitting

- Use a more complex model
- Add more relevant features
- Train the model longer

5. How to Fix Overfitting

- Use regularization techniques
- Reduce model complexity
- Use cross-validation
- Collect more training data