WEEK 2: MACHINE LEARNING CONCEPTS

DAY 9 (03/07/2025)

Model Training, Evaluation & Bias-Variance Tradeoff:

After preparing the data, the next step is **training and evaluating the model** to check how well it performs and generalizes.

1. Model Training

Training involves feeding data into an algorithm and allowing it to **find patterns or relationships** between input (X) and output (Y).
Each algorithm adjusts its internal parameters to minimize the difference between predicted and actual outputs.

Example:

A linear regression model learns the best-fit line that predicts house price (Y) based on area and location (X).

2. Model Evaluation

After training, we must test how well the model performs using metrics suited to the task.

For Classification Models (Categorical Output):

- **Accuracy:** Percentage of correct predictions.
- **Precision:** Out of all positive predictions, how many were actually positive.
- **Recall:** Out of all actual positives, how many did the model identify correctly.
- **F1-Score:** Harmonic mean of precision and recall.

For Regression Models (Continuous Output):

- **Mean Squared Error (MSE):** Average of squared errors between actual and predicted values.
- **Mean Absolute Error (MAE):** Average of absolute differences.
- **R^2 Score:** Measures how well the model explains data variability.

3. Confusion Matrix

A **confusion matrix** visualizes model performance in classification.
It shows:

- True Positives (correctly identified positive cases)
- True Negatives (correctly identified negatives)
- False Positives (wrongly identified as positive)
- False Negatives (missed positive cases)

Example:

In spam detection,

- True Positive = Correctly labeled as spam
- False Negative = Spam email marked as not spam

4. Bias-Variance Tradeoff

This is a key concept that explains **why models fail to generalize**.

Type	Description	Result
High Bias	The model is too simple and ignores important patterns.	Underfitting
High Variance	The model is too complex and memorizes training data.	Overfitting
Balanced Tradeoff	The model captures patterns but not noise.	Good Generalization

Example:

A student who memorizes answers (high variance) fails new questions, while one who barely studies (high bias) performs poorly everywhere.
A good model “understands” the concepts and applies them flexibly.

Reflection

Today reinforced that **training and evaluation are about balance** — not just accuracy, but also how well the model performs on unseen data. The bias-variance tradeoff is the heart of model reliability.