Department of Computer Science and Engineering (AI-ML)
Deep Learning: Principles and Practices
(EICDT24404)

Lab 1 – Warm-Up: Vectors and Dot Product for Perceptron

1. Aim

The aim of this lab warm-up is to introduce the **minimum mathematical and computational foundations** required to understand and implement a **Perceptron**. This warm-up focuses on **vectors, dot product, and linear combinations**, which form the core computation in all neural networks and deep learning models.

2. Learning Objectives

After completing this warm-up, the student will be able to:

1. Represent data using scalars, vectors, and matrices in Python
2. Compute dot products using NumPy
3. Interpret dot product as weighted importance of features
4. Understand the linear computation performed by a neuron
5. Relate vector operations to perceptron and deep learning models

3. Background and Motivation

In Machine Learning, models operate on **vectors**. In Deep Learning, models operate on **tensors**, which are extensions of vectors and matrices. At the heart of both lies a simple operation:

Weighted sum of inputs followed by an activation function

This warm-up ensures that all students are comfortable with these operations before implementing the perceptron learning algorithm.

4. Software and Libraries Required

- Python 3.x
- NumPy
- Jupyter Notebook

5. Pre-Lab Concepts

Before starting the exercises, recall the following:

- **Scalar**: A single numerical value (e.g., bias)
- **Vector**: A one-dimensional array representing a single data sample
- **Matrix**: A two-dimensional array representing a batch of samples
- **Dot Product**: A weighted sum of vector elements

In a perceptron, the computation is given by:

$$z = w^T x + b$$

where:

- (x) is the input vector
- (w) is the weight vector
- (b) is the bias

6. Lab Exercises

Exercise 1: Scalars and Vectors

Objective: Understand how scalars and vectors are represented in NumPy.

- Define a scalar bias value
- Define an input vector and a weight vector
- Display their values

Observation:

- Identify which variables represent learnable parameters

Exercise 2: Dot Product

Objective: Compute the dot product between input and weight vectors.

- Use NumPy to compute the dot product
- Print the output

Interpretation:

- A positive value indicates the input lies on one side of the decision boundary
- A negative value indicates the opposite side

Exercise 3: Linear Combination

Objective: Compute the linear output of a neuron.

- Add bias to the dot product
- Observe how bias shifts the decision boundary

Exercise 4: Step Activation Function

Objective: Convert linear output into a binary decision.

- Implement a simple step activation function
- Apply it to the linear output

Discussion Point:

- Why does a perceptron use an activation function?

Exercise 5: Matrix as Batch of Samples

Objective: Understand batch processing.

- Define a matrix where each row is a data sample
- Print the matrix

Key Idea:

- Deep learning models process data in batches for efficiency

Exercise 6: Batch Dot Product

Objective: Apply dot product to multiple samples simultaneously.

- Compute dot product between matrix and weight vector
- Add bias

Insight:

- This operation is identical to computations performed in deep neural networks

7. Post-Lab Reflection Questions

Answer the following questions in your lab record:

1. What role do weights play in the dot product?
2. How does bias affect the decision boundary?
3. Why is dot product fundamental to neural networks?
4. How does batch computation help in training deep learning models?

8. Outcome of the Warm-Up

By completing this warm-up, you are now prepared to:

- Implement a perceptron from scratch
- Understand neuron computation
- Appreciate how deep learning models scale this basic idea

This warm-up forms the foundation for all subsequent deep learning labs.

9. Submission Instructions

- Submit the completed Jupyter notebook
- Answer reflection questions in your lab record
- Ensure all outputs are clearly labeled

10. Lab Assessment Components

Component	Description	Marks
Notebook Execution	Correct execution of warm-up notebook cells	5
Vector & Dot Product Understanding	Correct interpretation of scalar, vector, matrix, dot product	5
Code Quality	Proper use of NumPy, clarity, comments	5
Conceptual Reflection	Answers to post-lab reflection questions	5
Viva Voce	Oral examination	10
Total		**30**