**Lab Exercise**

**Backpropagation in a Neural Network**

**Objective:**

* To implement and analyze back propagation of a simple neural network.
* To understand how weights are updated and error convergence occurs over multiple iterations.
* To visualize the learning process using graphs.

**Problem Statement:**

You are given a feedforward neural network with (use **the initial values for input weight and bias in we discussed in the class)**

* **Input layer:** 3 neurons
* **Hidden layer:** 2 neurons (**Sigmoid activation**)
* **Output layer:** 1 neuron (**Sigmoid activation**)
* **Target output:** 1
* **Learning rate:** Experiment with 0.01, 0.1, and 0.5

implement **backpropagation**, train the network for **1000 iterations**, and analyze how weights and errors change over time.

**Tasks**

**1. Initialize the Neural Network**

**2. Implement Forward Propagation**

**3. Compute Error**

**4. Perform Backpropagation**

**5. Run Multiple Iterations**

* Repeat **forward and backward propagation** for **1000 iterations**.
* Record how the **error decreases** over time.

**Analysis and Visualization Tasks**

**1. Error vs. Iterations Graph (Required)**

* **Plot:** Number of iterations (X-axis) vs. Error (Y-axis).
* **Observation:**
  + Does the error decrease gradually?
  + Does it oscillate due to an improper learning rate?

**2. Weight Updates Over Iterations**

**Plot:** Number of iterations (X-axis) vs. Selected weight value (Y-axis).

* **Observation:**
  + Do weights stabilize over time?
  + Do they oscillate due to a large learning rate?

**3. Learning Rate Comparison (Recommended)**

* **Plot:** Error vs. Iterations for **learning rates 0.01, 0.1, and 0.5** (all on the same graph).
* **Observation:**
  + Which learning rate achieves faster convergence?
  + Does a high learning rate cause oscillations?

**4. Decision Boundary Visualization**

visualize the decision boundary before and after training.

Modify the network to use **ReLU activation** instead of sigmoid and compare performance.