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Batch:SC_5 Roll No.: 16010123022
Experiment No. : 04
Grade: AA / AB / BB / BC / CC / CD /DD
Signature of the Staff In-charge with date

Title: Implementation of Perceptron net for an AND function with bipolar inputs and targets.

Objective: To write a program to implement the perceptron learning rule

Expected Outcome of Experiment:

CO2 : Understand perceptron's and counter propagation networks

Books/ Journals/ Websites referred:

Pre Lab/ Prior Concepts:

Learning

Types of learning

Perceptron learning rule.

Steps of Perceptron learning algorithm/approach for binary classification

Initialize the weights (including bias) to small random or zero values.

Repeat for each training sample:
a. Compute the net input: net = w.x
b. Apply activation: y = +1 if net >=0, else -1
c. Update weights : w = w + n.(t-y).x
Repeat the process over multiple epochs until the weights converge (no error).

Single layer perceptron network for AND logic function

Implementation Details:

Task to be done:

Write a program to implement a Perceptron network for the AND logic function using bipolar inputs and targets. Test the Perceptron with different learning rates and initial weights. Additionally, explore multiple epochs until the weights converge

CODE :

```
import numpy as np

inputs = np.array([
   [1, -1, -1],
   [1, -1,  1],
   [1,  1, -1],
   [1,  1,  1]
])

targets = np.array([-1, -1, -1, 1])

learning_rate = float(input("Enter learning rate: "))
weights = np.array([
   float(input("Enter bias: ")),
```

```
    float(input("Enter initial weight w1: ")),
    float(input("Enter initial weight w2: "))
])

converged = False
print("\nTraining steps:\n")
while not converged:
    converged = True
    for x, t in zip(inputs, targets):
        net = np.dot(weights, x)
        y = 1 if net >= 0 else -1
        e = t - y
        if e != 0:
            weights += learning_rate * e * x
            converged = False
        w_str = ' '.join([f"{w:.2f}" for w in weights])
        print(f"x1: {x[1]:>2}  x2: {x[2]:>2}  target: {t:>2}  weights: {w_str}")

print("\nFinal outputs:\n")
for x in inputs:
    output = 1 if np.dot(weights, x) >= 0 else -1
    print(f"x1: {x[1]:>2}  x2: {x[2]:>2}  output: {output}")
```

Output :

```
Enter learning rate: 0.1
Enter bias: 1
Enter initial weight w1: 0
Enter initial weight w2: 0

Training steps:

x1: -1  x2: -1  target: -1  weights: 0.80 0.20 0.20
x1: -1  x2:  1  target: -1  weights: 0.60 0.40 0.00
x1:  1  x2: -1  target: -1  weights: 0.40 0.20 0.20
x1:  1  x2:  1  target:  1  weights: 0.40 0.20 0.20
x1: -1  x2: -1  target: -1  weights: 0.20 0.40 0.40
x1: -1  x2:  1  target: -1  weights: 0.00 0.60 0.20
x1:  1  x2: -1  target: -1  weights: -0.20 0.40 0.40
x1:  1  x2:  1  target:  1  weights: -0.20 0.40 0.40
x1: -1  x2: -1  target: -1  weights: -0.20 0.40 0.40
x1: -1  x2:  1  target: -1  weights: -0.20 0.40 0.40
x1:  1  x2: -1  target: -1  weights: -0.20 0.40 0.40
x1:  1  x2:  1  target:  1  weights: -0.20 0.40 0.40

Final outputs:

x1: -1  x2: -1  output: -1
x1: -1  x2:  1  output: -1
x1:  1  x2: -1  output: -1
x1:  1  x2:  1  output: 1
```

Conclusion: Hence we have successfully implemented Perceptron network for AND.

Post Lab Descriptive Questions :

1. How is _the linear separability concept implemented using perceptron network
   Ans : The perceptron learns weights to form a linear decision boundary.
   If data is linearly separable, the perceptron converges to a solution.
   It adjusts weights to correctly classify all training inputs using that boundary.

2. Mention the application of the perceptron network.
   Ans : Perceptrons are used for binary classification tasks.
   They are applied in image recognition, sentiment analysis, and spam detection.
   They also serve as the building block for more complex neural networks.

3. The following is a training set for a 2-class (as 0 and 1) classification problem. Iterate the perception using the perceptron learning algorithm through the training set and obtain the weights. You may make a reasonable assumption if any.

INPUT		OUTPUT
X_1	X_2	Y
0.25	0.353	0
0.25	0.471	1
0.50	0.353	0
0.50	0.647	1
0.75	0.705	0
0.75	0.882	1
1.0	0.705	0
1.0	1.0	1

Output :

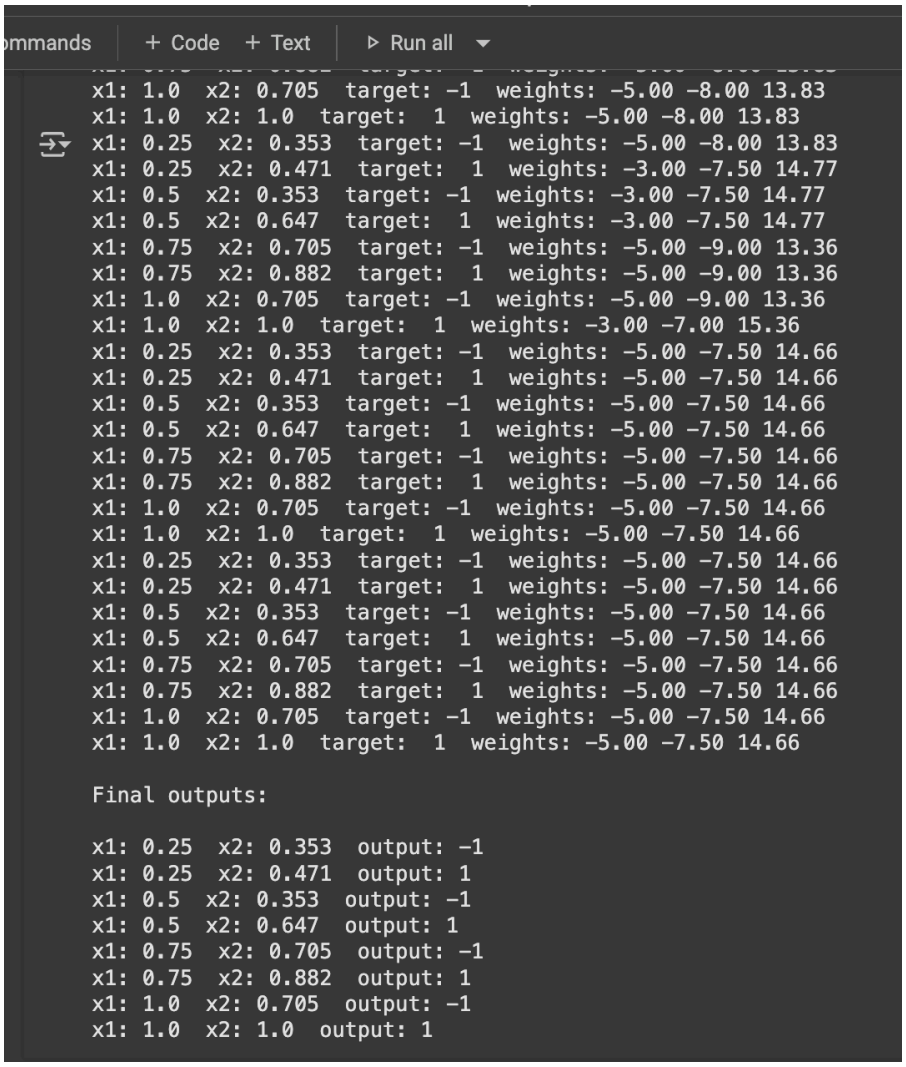
```
Enter learning rate: 1
Enter bias: 1
Enter initial weight w1: 0
Enter initial weight w2: 0

Training steps:

x1: 0.25  x2: 0.353  target: -1  weights: -1.00 -0.50 -0.71
x1: 0.25  x2: 0.471  target:  1  weights: 1.00 0.00 0.24
x1: 0.5  x2: 0.353  target: -1  weights: -1.00 -1.00 -0.47
x1: 0.5  x2: 0.647  target:  1  weights: 1.00 0.00 0.82
x1: 0.75  x2: 0.705  target: -1  weights: -1.00 -1.50 -0.59
x1: 0.75  x2: 0.882  target:  1  weights: 1.00 0.00 1.18
x1: 1.0  x2: 0.705  target: -1  weights: -1.00 -2.00 -0.23
x1: 1.0  x2: 1.0  target:  1  weights: 1.00 0.00 1.77
x1: 0.25  x2: 0.353  target: -1  weights: -1.00 -0.50 1.06
x1: 0.25  x2: 0.471  target:  1  weights: 1.00 0.00 2.00
x1: 0.5  x2: 0.353  target: -1  weights: -1.00 -1.00 1.30
x1: 0.5  x2: 0.647  target:  1  weights: 1.00 0.00 2.59
x1: 0.75  x2: 0.705  target: -1  weights: -1.00 -1.50 1.18
x1: 0.75  x2: 0.882  target:  1  weights: 1.00 0.00 2.95
x1: 1.0  x2: 0.705  target: -1  weights: -1.00 -2.00 1.54
x1: 1.0  x2: 1.0  target:  1  weights: 1.00 0.00 3.54
x1: 0.25  x2: 0.353  target: -1  weights: -1.00 -0.50 2.83
x1: 0.25  x2: 0.471  target:  1  weights: -1.00 -0.50 2.83
x1: 0.5  x2: 0.353  target: -1  weights: -1.00 -0.50 2.83
x1: 0.5  x2: 0.647  target:  1  weights: -1.00 -0.50 2.83
x1: 0.75  x2: 0.705  target: -1  weights: -3.00 -2.00 1.42
x1: 0.75  x2: 0.882  target:  1  weights: -1.00 -0.50 3.18
x1: 1.0  x2: 0.705  target: -1  weights: -3.00 -2.50 1.77
x1: 1.0  x2: 1.0  target:  1  weights: -1.00 -0.50 3.77
x1: 0.25  x2: 0.353  target: -1  weights: -3.00 -1.00 3.07
x1: 0.25  x2: 0.471  target:  1  weights: -1.00 -0.50 4.01
x1: 0.5  x2: 0.353  target: -1  weights: -3.00 -1.50 3.30
x1: 0.5  x2: 0.647  target:  1  weights: -1.00 -0.50 4.60
x1: 0.75  x2: 0.705  target: -1  weights: -3.00 -2.00 3.19
x1: 0.75  x2: 0.882  target:  1  weights: -1.00 -0.50 4.95
x1: 1.0  x2: 0.705  target: -1  weights: -3.00 -2.50 3.54
x1: 1.0  x2: 1.0  target:  1  weights: -1.00 -0.50 5.54
x1: 0.25  x2: 0.353  target: -1  weights: -3.00 -1.00 4.84
```

```
x1: 0.25  x2: 0.353  target: -1  weights: -3.00 -1.00 4.84
x1: 0.25  x2: 0.471  target:  1  weights: -1.00 -0.50 5.78
x1: 0.5  x2: 0.353  target: -1  weights: -3.00 -1.50 5.07
x1: 0.5  x2: 0.647  target:  1  weights: -1.00 -0.50 6.37
x1: 0.75  x2: 0.705  target: -1  weights: -3.00 -2.00 4.96
x1: 0.75  x2: 0.882  target:  1  weights: -1.00 -0.50 6.72
x1: 1.0  x2: 0.705  target: -1  weights: -3.00 -2.50 5.31
x1: 1.0  x2: 1.0  target:  1  weights: -1.00 -0.50 7.31
x1: 0.25  x2: 0.353  target: -1  weights: -3.00 -1.00 6.60
x1: 0.25  x2: 0.471  target:  1  weights: -1.00 -0.50 7.55
x1: 0.5  x2: 0.353  target: -1  weights: -3.00 -1.50 6.84
x1: 0.5  x2: 0.647  target:  1  weights: -3.00 -1.50 6.84
x1: 0.75  x2: 0.705  target: -1  weights: -5.00 -3.00 5.43
x1: 0.75  x2: 0.882  target:  1  weights: -3.00 -1.50 7.19
x1: 1.0  x2: 0.705  target: -1  weights: -5.00 -3.50 5.78
x1: 1.0  x2: 1.0  target:  1  weights: -3.00 -1.50 7.78
x1: 0.25  x2: 0.353  target: -1  weights: -3.00 -1.50 7.78
x1: 0.25  x2: 0.471  target:  1  weights: -3.00 -1.50 7.78
x1: 0.5  x2: 0.353  target: -1  weights: -3.00 -1.50 7.78
x1: 0.5  x2: 0.647  target:  1  weights: -3.00 -1.50 7.78
x1: 0.75  x2: 0.705  target: -1  weights: -5.00 -3.00 6.37
x1: 0.75  x2: 0.882  target:  1  weights: -3.00 -1.50 8.14
x1: 1.0  x2: 0.705  target: -1  weights: -5.00 -3.50 6.73
x1: 1.0  x2: 1.0  target:  1  weights: -3.00 -1.50 8.73
x1: 0.25  x2: 0.353  target: -1  weights: -3.00 -1.50 8.73
x1: 0.25  x2: 0.471  target:  1  weights: -3.00 -1.50 8.73
x1: 0.5  x2: 0.353  target: -1  weights: -3.00 -1.50 8.73
x1: 0.5  x2: 0.647  target:  1  weights: -3.00 -1.50 8.73
x1: 0.75  x2: 0.705  target: -1  weights: -5.00 -3.00 7.32
x1: 0.75  x2: 0.882  target:  1  weights: -3.00 -1.50 9.08
x1: 1.0  x2: 0.705  target: -1  weights: -5.00 -3.50 7.67
x1: 1.0  x2: 1.0  target:  1  weights: -3.00 -1.50 9.67
x1: 0.25  x2: 0.353  target: -1  weights: -5.00 -2.00 8.97
x1: 0.25  x2: 0.471  target:  1  weights: -3.00 -1.50 9.91
x1: 0.5  x2: 0.353  target: -1  weights: -3.00 -1.50 9.91
x1: 0.5  x2: 0.647  target:  1  weights: -3.00 -1.50 9.91
x1: 0.75  x2: 0.705  target: -1  weights: -5.00 -3.00 8.50
x1: 0.75  x2: 0.882  target:  1  weights: -5.00 -3.00 8.50
x1: 1.0  x2: 0.705  target: -1  weights: -5.00 -3.00 8.50
x1: 1.0  x2: 1.0  target:  1  weights: -5.00 -3.00 8.50
```

```
x1: 1.0  x2: 0.705  target: -1  weights: -5.00 -3.00 8.50
x1: 1.0  x2: 1.0  target:  1  weights: -5.00 -3.00 8.50
x1: 0.25  x2: 0.353  target: -1  weights: -5.00 -3.00 8.50
x1: 0.25  x2: 0.471  target:  1  weights: -3.00 -2.50 9.44
x1: 0.5  x2: 0.353  target: -1  weights: -3.00 -2.50 9.44
x1: 0.5  x2: 0.647  target:  1  weights: -3.00 -2.50 9.44
x1: 0.75  x2: 0.705  target: -1  weights: -5.00 -4.00 8.03
x1: 0.75  x2: 0.882  target:  1  weights: -3.00 -2.50 9.79
x1: 1.0  x2: 0.705  target: -1  weights: -5.00 -4.50 8.38
x1: 1.0  x2: 1.0  target:  1  weights: -3.00 -2.50 10.38
x1: 0.25  x2: 0.353  target: -1  weights: -5.00 -3.00 9.68
x1: 0.25  x2: 0.471  target:  1  weights: -3.00 -2.50 10.62
x1: 0.5  x2: 0.353  target: -1  weights: -3.00 -2.50 10.62
x1: 0.5  x2: 0.647  target:  1  weights: -3.00 -2.50 10.62
x1: 0.75  x2: 0.705  target: -1  weights: -5.00 -4.00 9.21
x1: 0.75  x2: 0.882  target:  1  weights: -5.00 -4.00 9.21
x1: 1.0  x2: 0.705  target: -1  weights: -5.00 -4.00 9.21
x1: 1.0  x2: 1.0  target:  1  weights: -5.00 -4.00 9.21
x1: 0.25  x2: 0.353  target: -1  weights: -5.00 -4.00 9.21
x1: 0.25  x2: 0.471  target:  1  weights: -3.00 -3.50 10.15
x1: 0.5  x2: 0.353  target: -1  weights: -3.00 -3.50 10.15
x1: 0.5  x2: 0.647  target:  1  weights: -3.00 -3.50 10.15
x1: 0.75  x2: 0.705  target: -1  weights: -5.00 -5.00 8.74
x1: 0.75  x2: 0.882  target:  1  weights: -3.00 -3.50 10.51
x1: 1.0  x2: 0.705  target: -1  weights: -5.00 -5.50 9.10
x1: 1.0  x2: 1.0  target:  1  weights: -3.00 -3.50 11.10
x1: 0.25  x2: 0.353  target: -1  weights: -5.00 -4.00 10.39
x1: 0.25  x2: 0.471  target:  1  weights: -3.00 -3.50 11.33
x1: 0.5  x2: 0.353  target: -1  weights: -3.00 -3.50 11.33
x1: 0.5  x2: 0.647  target:  1  weights: -3.00 -3.50 11.33
x1: 0.75  x2: 0.705  target: -1  weights: -5.00 -5.00 9.92
x1: 0.75  x2: 0.882  target:  1  weights: -5.00 -5.00 9.92
x1: 1.0  x2: 0.705  target: -1  weights: -5.00 -5.00 9.92
x1: 1.0  x2: 1.0  target:  1  weights: -3.00 -3.00 11.92
x1: 0.25  x2: 0.353  target: -1  weights: -5.00 -3.50 11.22
x1: 0.25  x2: 0.471  target:  1  weights: -3.00 -3.00 12.16
x1: 0.5  x2: 0.353  target: -1  weights: -3.00 -3.00 12.16
x1: 0.5  x2: 0.647  target:  1  weights: -3.00 -3.00 12.16
x1: 0.75  x2: 0.705  target: -1  weights: -5.00 -4.50 10.75
x1: 0.75  x2: 0.882  target:  1  weights: -5.00 -4.50 10.75
```



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Date: 04.08.2025 **Signature of faculty in-charge**