EX.NO:06 IMPLEMENT GRADIENT DESCENT & BACK
09.09.25 PROPAGATION IN DEEP NEURAL NETWORK

AIM

To implement gradient descent and backpropagation algorithm in a deep neural network and study their role in gaining.

OBJECTIVE

To understand the working of gradient optimization.

To implement backpropagation for updating neural network weights

To observe the effect of iterations (epochs) on loss reduction.

PSEUDOCODE

Initialize weights and bias randomly

for each epoch

a. forward pass

compute weighted sum

$(z = (w * x + b)$

Apply activation function

$(A = f(z))$

b. compute Loss

L = difference b/w predicted & actual

c. Backward pass

⇒ compute gradients of loss w.r.t weights & biases

⇒ update weights : $w = w - \eta * dL/dw$

Sample

Epoch	Training Loss	Accuracy	Remark
1	0.95	65.0	High error, random limit
9	0.48	82.3	Loss decreasing
10	0.25	90.1	Faster convergence
20	0.12	95.5	Model stabilized

Epoch	Loss
0	0.0134
500	0.0107
1000	0.0088
1500	0.0075
2000	0.0065
2500	0.0057
3000	0.0051
3500	0.0046
4000	0.0042
4500	0.0038

⇒ update biases : $b = b - \mu * dL/db$

3. Repeat until converges

Formula used

$$z = w \cdot x + b$$

$$L = 1/n \sum (y - \hat{y})^2$$

$$w = w - \mu \frac{dL}{dw}$$

OBSERVATION

1. Initially, the model started with random weights leading to high loss and low accuracy.

2. With each epoch, gradient descent gradually reduced the loss, showing effect of iterative weight update.

3. Backpropagation efficiently adjusted weights layer by layer, improving model accuracy.

4. The choice of learning state and number of epochs strongly influenced convergence speed and final accuracy.

RESULT

Implemented gradient descent & Backpropagation in DNN.

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Code Notebook Python 3 (ipykernel)

[1]:
```python
import torch
import torch.nn.functional as F
import matplotlib.pyplot as plt
```

[2]:
```python
X = torch.tensor([[0, 0],
                  [0, 1],
                  [1, 0],
                  [1, 1]], dtype=torch.float32)
y = torch.tensor([[0], [1], [1], [0]], dtype=torch.float32)
```

[3]:
```python
torch.manual_seed(42)
input_size = 2
hidden1 = 4
hidden2 = 4
output_size = 1
```

[4]:
```python
W1 = torch.randn(input_size, hidden1, requires_grad=True)
b1 = torch.zeros(hidden1, requires_grad=True)
```

[5]:
```python
W2 = torch.randn(hidden1, hidden2, requires_grad=True)
b2 = torch.zeros(hidden2, requires_grad=True)
```

[6]:
```python
W3 = torch.randn(hidden2, output_size, requires_grad=True)
b3 = torch.zeros(output_size, requires_grad=True)
```

[7]:
```python
lr = 0.1
epochs = 5000
loss_history = []
```

[11]:
```python
for epoch in range(epochs):
    z1 = X @ W1 + b1
```

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[9]:

```python
lr = 0.1
epochs = 5000
loss_history = []
```

[14]:

```python
for epoch in range(epochs):
    z1 = X @ W1 + b1
    a1 = torch.sigmoid(z1)
    z2 = a1 @ W2 + b2
    a2 = torch.sigmoid(z2)
    z3 = a2 @ W3 + b3
    y_pred = torch.sigmoid(z3)
    loss = F.binary_cross_entropy(y_pred, y)
    loss.backward()
    with torch.no_grad():
        W1 -= lr * W1.grad
        b1 -= lr * b1.grad
        W2 -= lr * W2.grad
        b2 -= lr * b2.grad
        W3 -= lr * W3.grad
        b3 -= lr * b3.grad
        W1.grad.zero_()
        b1.grad.zero_()
        W2.grad.zero_()
        b2.grad.zero_()
        W3.grad.zero_()
        b3.grad.zero_()
    loss_history.append(loss.item())
    if epoch % 500 == 0:
```

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Code — Notebook — Python 3 (ipykernel)

```
        b1 -= lr * b1.grad
        W2 -= lr * W2.grad
        b2 -= lr * b2.grad
        W3 -= lr * W3.grad
        b3 -= lr * b3.grad
        W1.grad.zero_()
        b1.grad.zero_()
        W2.grad.zero_()
        b2.grad.zero_()
        W3.grad.zero_()
        b3.grad.zero_()
    loss_history.append(loss.item())
    if epoch % 500 == 0:
        print(f"Epoch {epoch} - Loss: {loss.item():.4f}")
```

```
Epoch 0 - Loss: 0.0134
Epoch 500 - Loss: 0.0107
Epoch 1000 - Loss: 0.0088
Epoch 1500 - Loss: 0.0075
Epoch 2000 - Loss: 0.0065
Epoch 2500 - Loss: 0.0057
Epoch 3000 - Loss: 0.0051
Epoch 3500 - Loss: 0.0046
Epoch 4000 - Loss: 0.0042
Epoch 4500 - Loss: 0.0038
```

[9]:
```
plt.plot(loss_history)
plt.title("Loss over Epochs")
plt.xlabel("Epoch")
plt.ylabel("Binary Cross Entropy Loss")
plt.grid(True)
plt.show()
```

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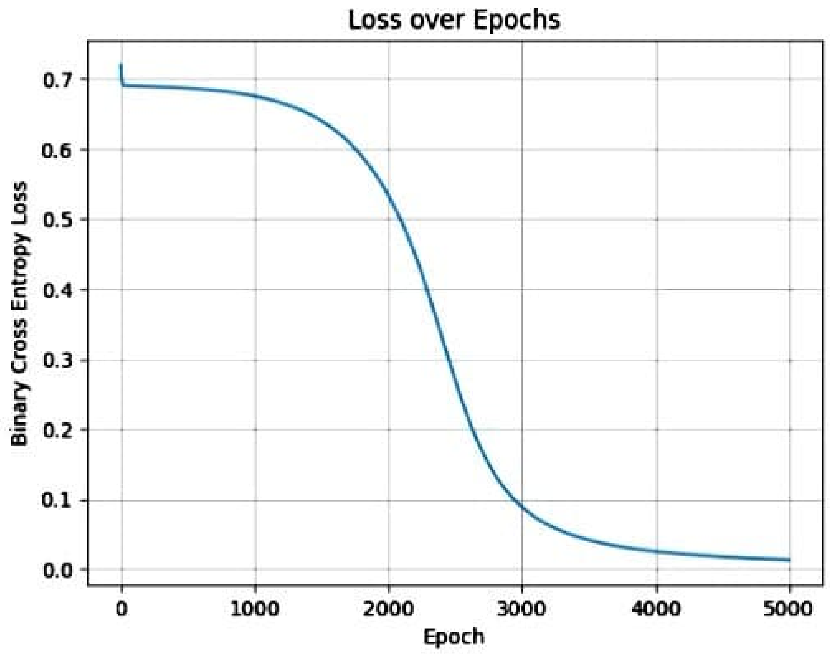
Code Notebook Python 3 (ipykernel)



[10]:
```
with torch.no_grad():
    z1 = X @ W1 + b1
    a1 = torch.sigmoid(z1)

    z2 = a1 @ W2 + b2
```

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Epoch

[10]:
```
with torch.no_grad():
    z1 = X @ W1 + b1
    a1 = torch.sigmoid(z1)

    z2 = a1 @ W2 + b2
    a2 = torch.sigmoid(z2)

    z3 = a2 @ W3 + b3
    y_pred = torch.sigmoid(z3)
    predicted = (y_pred > 0.5).float()

print("Predictions:\n", predicted)
print("Ground Truth:\n", y)
```

```
Predictions:
 tensor([[0.],
        [1.],
        [1.],
        [0.]])
Ground Truth:
 tensor([[0.],
        [1.],
        [1.],
        [0.]])
```

[ ]: