**Back propagation algorithm**

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**Build an Artificial Neural Network by implementing the Back propagation algorithm and test the same using appropriate data sets.**

**Aim:**

To build an Artificial Neural Network (ANN) using the Backpropagation algorithm and test it using the XOR dataset.

**Algorithm:**

**Step 1: Initialization**

* Initialize the weights and biases for input-hidden and hidden-output layers randomly.
* Choose learning rate and number of epochs.

**Step 2: Activation Function**

* Use Sigmoid activation function:

**Step 3: Forward Propagation**

* Compute hidden layer activation:  
  hidden\_input = X . weights\_input\_hidden + bias\_hidden  
  hidden\_output = sigmoid(hidden\_input)
* Compute output layer activation:  
  final\_input = hidden\_output . weights\_hidden\_output + bias\_output  
  final\_output = sigmoid(final\_input)

**Step 4: Backpropagation**

* Calculate error:  
  error = y - final\_output
* Compute gradients and update weights:
  + Output layer delta:  
    output\_gradient = error \* sigmoid\_derivative(final\_output)
  + Hidden layer delta:  
    hidden\_gradient = (output\_gradient . weights\_hidden\_output.T) \* sigmoid\_derivative(hidden\_output)
  + Update weights:  
    weights += learning\_rate \* dot(inputs.T, gradient)

**Step 5: Repeat**

* Repeat Steps 3 & 4 for multiple epochs to train the network.

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" return 1 / (1 + np.exp(-x))\n",

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" return x \* (1 - x)"

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"y = np.array([[0], [1], [1], [0]])\n"

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"np.random.seed(42)\n",

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"hidden\_neurons = 2 # Two neurons in the hidden layer\n",

"output\_neurons = 1 # Single output neuron\n"

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"weights\_input\_hidden = np.random.uniform(size=(input\_neurons, hidden\_neurons))\n",

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"weights\_hidden\_output = np.random.uniform(size=(hidden\_neurons, output\_neurons))\n",

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"for epoch in range(epochs):\n",

" # Forward Pass\n",

" hidden\_input = np.dot(X, weights\_input\_hidden) + bias\_hidden\n",

" hidden\_output = sigmoid(hidden\_input)\n",

"\n",

" final\_input = np.dot(hidden\_output, weights\_hidden\_output) + bias\_output\n",

" predicted\_output = sigmoid(final\_input)\n",

"\n",

" # Compute Error\n",

" error = y - predicted\_output\n",

"\n",

" # Backpropagation\n",

" output\_gradient = error \* sigmoid\_derivative(predicted\_output)\n",

" hidden\_gradient = np.dot(output\_gradient, weights\_hidden\_output.T) \* sigmoid\_derivative(hidden\_output)\n",

"\n",

" # Update Weights and Biases\n",

" weights\_hidden\_output += np.dot(hidden\_output.T, output\_gradient) \* learning\_rate\n",

" bias\_output += np.sum(output\_gradient, axis=0, keepdims=True) \* learning\_rate\n",

" weights\_input\_hidden += np.dot(X.T, hidden\_gradient) \* learning\_rate\n",

" bias\_hidden += np.sum(hidden\_gradient, axis=0, keepdims=True) \* learning\_rate\n",

"\n",

" # Print Loss Every 1000 Epochs\n",

" if (epoch + 1) % 1000 == 0:\n",

" loss = np.mean(np.abs(error))\n",

" print(f'Epoch {epoch + 1}, Loss: {loss:.5f}')"

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"Epoch 5000, Loss: 0.08578\n",

"Epoch 6000, Loss: 0.07132\n",

"Epoch 7000, Loss: 0.06198\n",

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"hidden\_output = sigmoid(hidden\_input)\n",

"final\_input = np.dot(hidden\_output, weights\_hidden\_output) + bias\_output\n",

"predicted\_output = sigmoid(final\_input)\n",

"\n",

"print(\"\\nPredicted Output After Training:\")\n",

"print(predicted\_output)"

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" [0.04754195]]\n"

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**INPUT**

**The input is the XOR truth table:**

X = [[0, 0],

[0, 1],

[1, 0],

[1, 1]]

y = [[0], [1], [1], [0]]

**OUTPUT**

**After training for 10,000 epochs, the output will be close to the XOR logic:**

**Predicted Output After Training:**

[[0.01]

[0.98]

[0.98]

[0.01]]