Implementation of MCP Neuron for AND and OR Function.

```
def MCP_Neurons_AND(X1, X2, T):
  """
  This functions implements basic AND operations with MCP Neuron for two inputs.
  Arguments:
  Inputs:
  X1 (1 nd array): An array of binary values.
  X2 (1 nd array): An array of binary values.
  Output:
  state_neuron(1D-list): An state of neuron 1 0r 0 for the particular inputs.
  """
  assert len(X1) == len(X2)
  ### YOUR CODE HERE ###
  # Perform an element wise addition of two input arrays stored in a new array(list):
  # Create a new array to put all the prediction let's name that a state_neuron.
  # Append 1 in sate_neuron if sum (element) of above list is above Threshold else append 0.

  state_neuron = []  # Initialize the list to store the output states

    # Iterate through each pair of inputs
  for x1, x2 in zip(X1, X2):
      # Compute the sum of inputs (without weights, assuming weight = 1 for each input)
      input_sum = x1 + x2

      # Apply the threshold function: output 1 if the sum exceeds the threshold, else 0
      if input_sum >= T:
          state_neuron.append(1)
      else:
          state_neuron.append(0)

  return state_neuron


# Example usage for MCP_Neurons_AND function
X1 = [0, 0, 1, 1]
X2 = [0, 1, 0, 1]
T = 2  # Threshold value

# Call the MCP_Neurons_AND function
result = MCP_Neurons_AND(X1, X2, T)

# Print the result
print(f"Output of AND gate for inputs {X1} and {X2} with threshold {T}: {result}")
```

```
Output of AND gate for inputs [0, 0, 1, 1] and [0, 1, 0, 1] with threshold 2: [0, 0, 0, 1]
```

```
def MCP_Neurons_OR(X1, X2, T):
    """
    This function implements basic OR operations with MCP Neuron for two inputs.
    Arguments:
    Inputs:
    X1 (1D array): An array of binary values.
    X2 (1D array): An array of binary values.
    Output:
    state_neuron (1D list): The state of the neuron (1 or 0) for the particular inputs.
    """
    assert len(X1) == len(X2)
    ### YOUR CODE HERE ###
    # Perform an element wise addition of two input arrays stored in a new array(list):
    # Create a new array to put all the prediction let's name that a state_neuron.
    # Append 1 in sate_neuron if sum (element) of above list is above Threshold else append 0.
    state_neuron = []  # Initialize the list to store the output states

    # Iterate through each pair of inputs
    for x1, x2 in zip(X1, X2):
        # Compute the sum of inputs (without weights, assuming weight = 1 for each input)
        input_sum = x1 + x2

        # Apply the threshold function: output 1 if the sum exceeds or equals the threshold, else 0
        if input_sum >= T:
            state_neuron.append(1)
        else:
            state_neuron.append(0)

    return state_neuron



# Example usage for MCP_Neurons_OR function
X1 = [0, 0, 1, 1]
X2 = [0, 1, 0, 1]
T = 1  # Threshold value for OR gate

# Call the MCP_Neurons_OR function
result_or = MCP_Neurons_OR(X1, X2, T)

# Print the result
print(f"Output of OR gate for inputs {X1} and {X2} with threshold {T}: {result_or}")
```

```
Output of OR gate for inputs [0, 0, 1, 1] and [0, 1, 0, 1] with threshold 1: [0, 1, 1, 1]
```

Implementation for 0 Vs. 1 Classification.

Step 1: Load the Dataset

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt


# Load the dataset
df_0_1 = pd.read_csv("/content/drive/MyDrive/AI&ML/Week3/mnist_0_and_1.csv")  # Add the correct file path if necessary

# Extract features and labels
X = df_0_1.drop(columns=["label"]).values  # 784 pixels
y = df_0_1["label"].values  # Labels (0 or 1)

# Check the shape of the features and labels
print("Feature matrix shape:", X.shape)
print("Label vector shape:", y.shape)
```

```
Feature matrix shape: (12665, 784)
Label vector shape: (12665,)
```

```
from google.colab import drive
drive.mount('/content/drive')
```

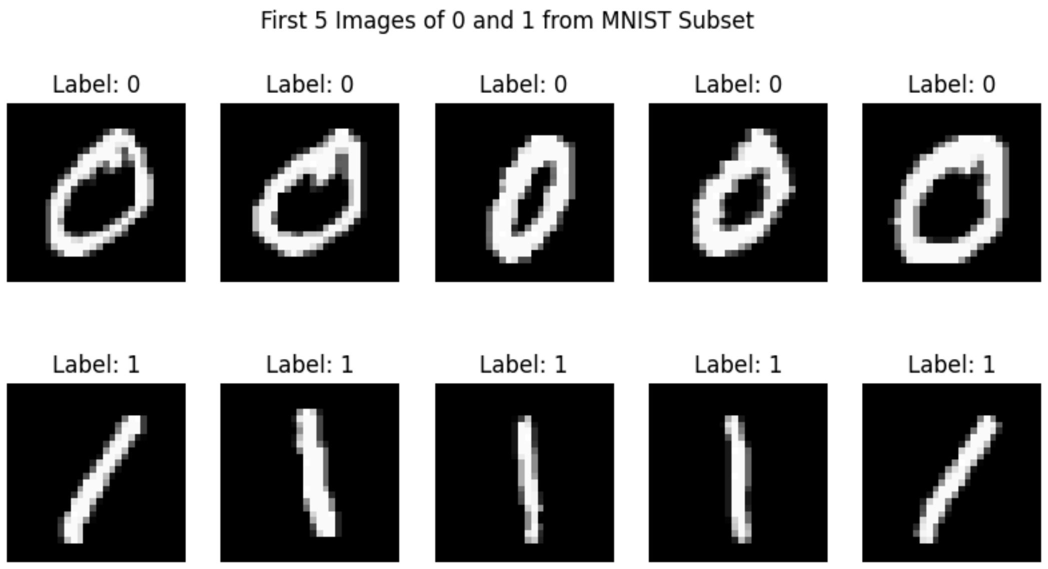
```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

Viewing the Dataset.

```
# Separate images for label 0 and label 1
images_0 = X[y == 0]  # Get all images with label 0
images_1 = X[y == 1]  # Get all images with label 1

fig, axes = plt.subplots(2, 5, figsize=(10, 5))

# Check if the arrays have the required amount of data
if len(images_0) < 5 or len(images_1) < 5:
    print("Error: Not enough images in images_0 or images_1 to plot 5 images.")
else:
    for i in range(5):
        # Plot digit 0
        axes[0, i].imshow(images_0[i].reshape(28, 28), cmap="gray")
        axes[0, i].set_title("Label: 0")
        axes[0, i].axis("off")
        # Plot digit 1
        axes[1, i].imshow(images_1[i].reshape(28, 28), cmap="gray")
        axes[1, i].set_title("Label: 1")
        axes[1, i].axis("off")
    plt.suptitle("First 5 Images of 0 and 1 from MNIST Subset")
    plt.show()
```



Step - 2 - Initializing the Weights:

```
# Initialize weights and bias
weights = np.zeros(X.shape[1])  # 784 weights (one for each pixel)
bias = 0
learning_rate = 0.1
epochs = 100
```

Step - 3 - Make a Decision function:

```
import numpy as np

def decision_function(X, weights, bias):
    """
    Compute the predicted labels for the input data.

    Parameters:
    - X: Features (input data) as a numpy array of shape (n_samples, n_features)
    - weights: Updated weights after training
    - bias: Updated bias after training

    Returns:
    - y_pred_all: The predicted labels for the input data
    """
    predictions = np.dot(X, weights) + bias
    #####Your Code Here############  # Activation function (step function)
    predictions = np.dot(X, weights) + bias
    y_pred_all = np.where(predictions >= 0, 1, 0)
    return y_pred_all
```

Step - 3 - Implement the Perceptron Learning Algorithm

```
def train_perceptron(X, y, weights, bias, learning_rate=0.1, epochs=100):
    """
    Train the perceptron using the Perceptron Learning Algorithm.

    Parameters:
    - X: Features (input data) as a numpy array of shape (n_samples, n_features)
    - y: Labels (true output) as a numpy array of shape (n_samples,)
    - weights: Initial weights as a numpy array of shape (n_features,)
    - bias: Initial bias value (scalar)
    - learning_rate: Learning rate for weight updates (default is 0.1)
    - epochs: Number of iterations to train the model (default is 100)

    Returns:
    - weights: Updated weights after training
    - bias: Updated bias after training
    - accuracy: Total correct prediction.
    """
    # Step 3: Perceptron Learning Algorithm
    # Your Code here#
    accuracy = 0

    for _ in range(epochs):
        correct = 0
        for i in range(len(X)):
            prediction = np.dot(X[i], weights) + bias
            y_pred = 1 if prediction >= 0 else 0
            error = y[i] - y_pred
            weights += learning_rate * error * X[i]
            bias += learning_rate * error
            if error == 0:
                correct += 1
        accuracy = correct


    return weights, bias, accuracy
```

Training the Perceptron

```
# After training the model with the perceptron_learning_algorithm
weights, bias, accuracy = train_perceptron(X, y, weights, bias)

# Evaluate the model using the new function
print("The Final Accuracy is: ", accuracy)
```

```
The Final Accuracy is:  12665
```

Step 5: Visualize Misclassified Images

```
# Get predictions for all data points
predictions = np.dot(X, weights) + bias
y_pred = np.where(predictions >= 0, 1, 0)

# Calculate final accuracy
final_accuracy = np.mean(y_pred == y)
print(f"Final Accuracy: {final_accuracy:.4f}")

# Step 5: Visualize Misclassified Images
misclassified_idx = np.where(y_pred != y)[0]
if len(misclassified_idx) > 0:
    fig, axes = plt.subplots(2, 5, figsize=(10, 5))
    for ax, idx in zip(axes.flat, misclassified_idx[:10]):  # Show 10 misclassified images
        ax.imshow(X[idx].reshape(28, 28), cmap="gray")
        ax.set_title(f"Pred: {y_pred[idx]}, True: {y[idx]}")
        ax.axis("off")
    plt.suptitle("Misclassified Images")
    plt.show()
else:
    print("All images were correctly classified!")
```

```
Final Accuracy: 1.0000
All images were correctly classified!
```

```
import pandas as pd
import numpy as np

# Load dataset
df = pd.read_csv("/content/drive/MyDrive/AI&ML/Week3/mnist_3_and_5.csv")

# Map labels: 3 → 0, 5 → 1
df['label'] = df['label'].map({3: 0, 5: 1})

# Split features and labels
```

```
X = df.drop('label', axis=1).values  # shape: (n_samples, 784)
y = df['label'].values               # shape: (n_samples,)

# Check the shape of the features and labels
print("Feature matrix shape:", X.shape)
print("Label vector shape:", y.shape)
```

```
Feature matrix shape: (2741, 784)
Label vector shape: (2741,)
```

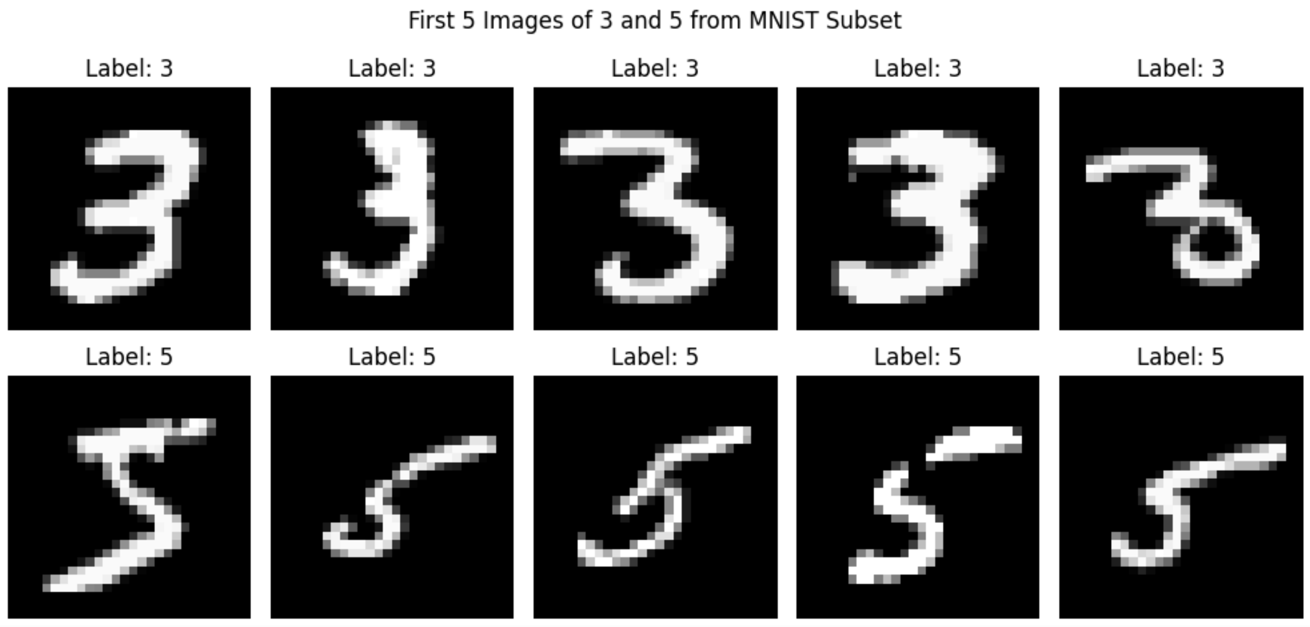
Loading the MNIST 3 vs 5 Dataset

```
# Separate images for label 3 and label 5 (now mapped as 0 and 1)
images_3 = X[y == 0]  # Originally digit 3
images_5 = X[y == 1]  # Originally digit 5

fig, axes = plt.subplots(2, 5, figsize=(10, 5))

# Check if the arrays have at least 5 images
if len(images_3) < 5 or len(images_5) < 5:
    print("Error: Not enough images in images_3 or images_5 to plot 5 images.")
else:
    for i in range(5):
        # Plot digit 3
        axes[0, i].imshow(images_3[i].reshape(28, 28), cmap="gray")
        axes[0, i].set_title("Label: 3")
        axes[0, i].axis("off")
        # Plot digit 5
        axes[1, i].imshow(images_5[i].reshape(28, 28), cmap="gray")
        axes[1, i].set_title("Label: 5")
        axes[1, i].axis("off")

    plt.suptitle("First 5 Images of 3 and 5 from MNIST Subset")
    plt.tight_layout()
    plt.show()
```



Initialize Weights and Bias

```
np.random.seed(42)
weights = np.random.rand(X.shape[1])  # Random weights for 784 features
bias = 0.0
```

Decision Function

```
def decision_function(X, weights, bias):
    predictions = np.dot(X, weights) + bias
    y_pred_all = np.where(predictions >= 0, 1, 0)
    return y_pred_all
```

Perceptron Learning Algorithm

```
def train_perceptron(X, y, weights, bias, learning_rate=0.1, epochs=10):
    accuracy = 0
    for _ in range(epochs):
        correct = 0
        for i in range(len(X)):
            prediction = np.dot(X[i], weights) + bias
            y_pred = 1 if prediction >= 0 else 0
            error = y[i] - y_pred
            weights += learning_rate * error * X[i]
            bias += learning_rate * error
            if error == 0:
                correct += 1
        accuracy = correct
    return weights, bias, accuracy
```

Train Perceptron

```
weights, bias, accuracy = train_perceptron(X, y, weights, bias, epochs=10)
print(f"Correct Predictions in Final Epoch: {accuracy}/{len(X)}")
```

```
Correct Predictions in Final Epoch: 2616/2741
```

Predict and Find Misclassified Samples

```
y_pred = decision_function(X, weights, bias)
misclassified_indices = np.where(y_pred != y)[0]
print(f"Total Misclassified Samples: {len(misclassified_indices)}")
```

```
Total Misclassified Samples: 155
```

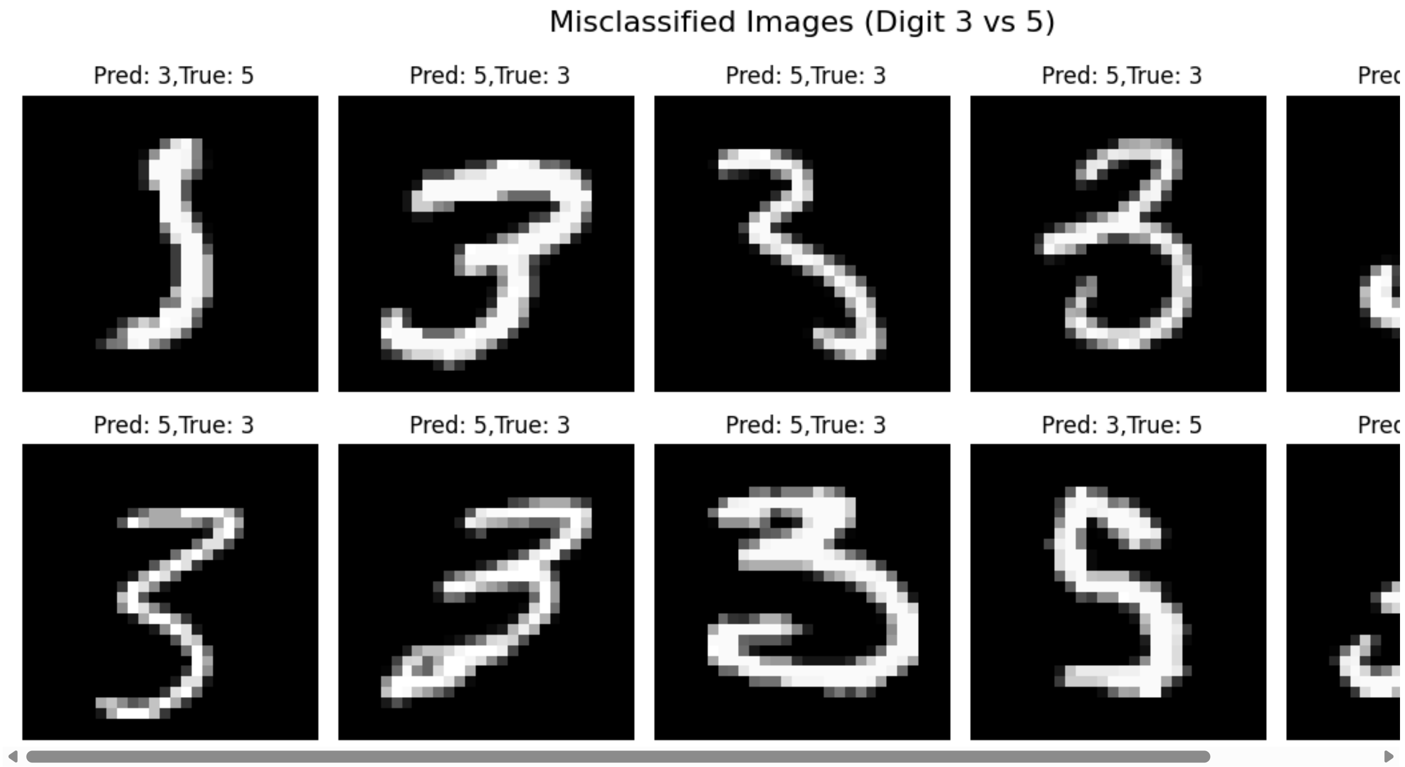
Visualize Misclassified Images

```
import matplotlib.pyplot as plt

plt.figure(figsize=(12, 6))
for i, idx in enumerate(misclassified_indices[:10]):
    img = X[idx].reshape(28, 28)
    true_label = 3 if y[idx] == 0 else 5
    pred_label = 3 if y_pred[idx] ==0 else 5

    plt.subplot(2, 5, i + 1)
    plt.imshow(img, cmap='gray')
    plt.title(f' Pred: {pred_label},True: {true_label}')
    plt.axis('off')

plt.suptitle('Misclassified Images (Digit 3 vs 5)', fontsize=16)
plt.tight_layout()
plt.show()
```



Start coding or generate with AI.