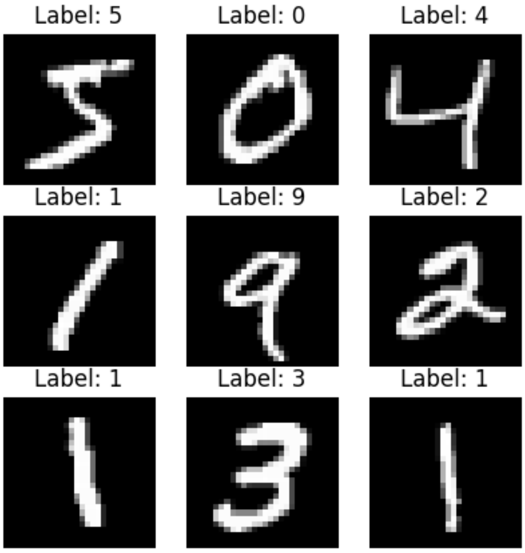
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remoun
```

```
import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import fetch_openml
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.decomposition import PCA
import torch
import torch.nn as nn
import torch.optim as optim
from torch.utils.data import DataLoader, TensorDataset, random_split
```

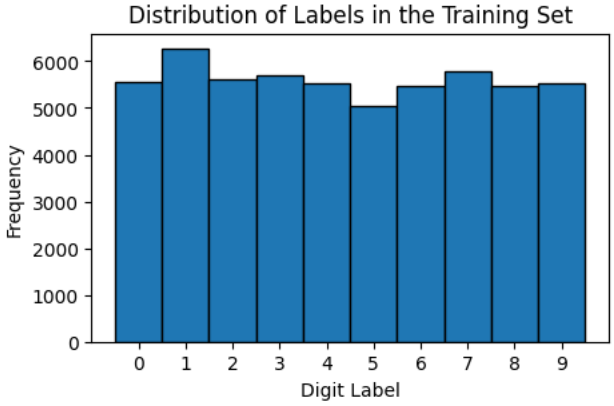
```
#load the MNIST data set
mnist = fetch_openml('mnist_784', version=1)
X, y = mnist.data.to_numpy(), mnist.target.astype(int)

print(f"Shape of y: {y.shape}")

plt.figure(figsize=(5, 5))
for i in range(9):
    plt.subplot(3, 3, i + 1)
    plt.imshow(X[i].reshape(28, 28), cmap='gray')
    plt.title(f"Label: {y[i]}")
    plt.axis('off')
plt.show()
```

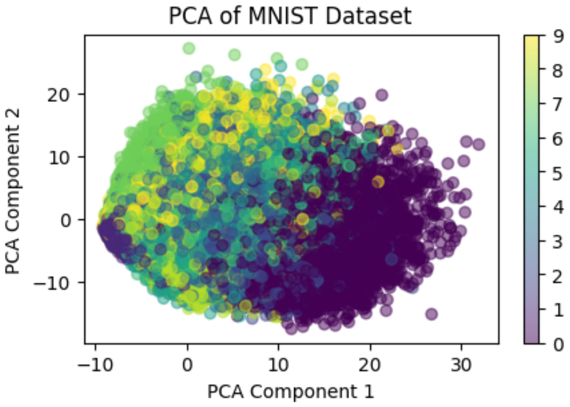
```
/usr/local/lib/python3.10/dist-packages/sklearn/datasets/_openml.py:1022: Fut
  warn(
Shape of y: (70000,)
```



```
#NApplying normalisation and standardization on the dataset
X = X / 255.0

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)
```

```
plt.figure(figsize=(5, 3))
plt.hist(y_train, bins=np.arange(11) - 0.5, edgecolor='black')
plt.xticks(np.arange(10))
plt.xlabel('Digit Label')
plt.ylabel('Frequency')
plt.title('Distribution of Labels in the Training Set')
plt.show()

pca = PCA(n_components=2)
X_train_pca = pca.fit_transform(X_train)

plt.figure(figsize=(5,3))
scatter = plt.scatter(X_train_pca[:, 0], X_train_pca[:, 1], c=y_train, cmap='viridis', alpha=0.5)
plt.colorbar(scatter, ticks=np.arange(10))
plt.xlabel('PCA Component 1')
plt.ylabel('PCA Component 2')
plt.title('PCA of MNIST Dataset')
plt.show()
```





```
#defining the MLP structure
class MLP(nn.Module):
    def __init__(self):
        super(MLP, self).__init__()
        self.fc1 = nn.Linear(784, 128)
        self.relu = nn.ReLU()
        self.fc2 = nn.Linear(128, 10)

    def forward(self, x):
        x = x.view(-1, 784)
        x = self.fc1(x)
        x = self.relu(x)
        x = self.fc2(x)
        return x

batch_size = 64
y_train_np = y_train.to_numpy()
train_dataset = TensorDataset(torch.tensor(X_train, dtype=torch.float32), torch.tensor(y_train_np, dtype=torch.long))
train_loader = DataLoader(train_dataset, batch_size=batch_size, shuffle=True)

mlp_model = MLP()
criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(mlp_model.parameters(), lr=0.001)
```

```
#trainging MLP model
num_epochs = 10
mlp_train_losses = []
for epoch in range(num_epochs):
    mlp_model.train()
    running_loss = 0.0
    for inputs, labels in train_loader:
        optimizer.zero_grad()
        outputs = mlp_model(inputs)
        loss = criterion(outputs, labels)
        loss.backward()
        optimizer.step()
        running_loss += loss.item()
    mlp_train_losses.append(running_loss / len(train_loader))
    print(f"Epoch [{epoch+1}/{num_epochs}], Loss: {running_loss/len(train_loader):.4f}")

def evaluate_model(model, loader):
    model.eval()
    correct = 0
    total = 0
    with torch.no_grad():
        for inputs, labels in loader:
            outputs = model(inputs)
            _, predicted = torch.max(outputs, 1)
            total += labels.size(0)
            correct += (predicted == labels).sum().item()
    return correct / total

train_accuracy = evaluate_model(mlp_model, train_loader)

print(f"training accuracy of the MLP model is: {train_accuracy:.4f}")
```

```
Epoch [1/10], Loss: 0.2380
Epoch [2/10], Loss: 0.1000
Epoch [3/10], Loss: 0.0644
Epoch [4/10], Loss: 0.0461
Epoch [5/10], Loss: 0.0319
Epoch [6/10], Loss: 0.0236
Epoch [7/10], Loss: 0.0178
Epoch [8/10], Loss: 0.0155
Epoch [9/10], Loss: 0.0152
Epoch [10/10], Loss: 0.0130
training accuracy of the MLP model is: 0.9964
```

```
#saving the MLP model
import os
drive_dir = '/content/drive/MyDrive/Colab Notebooks/harshith_neco'
model_filename = 'mlp_model.pth'
model_save_path = os.path.join(drive_dir, model_filename)

torch.save(mlp_model.state_dict(), model_save_path)
print(f"Model saved to {model_save_path}")
```

```
Model saved to /content/drive/MyDrive/Colab Notebooks/harshith_neco/mlp_model.pth
```

```
#defining the cnn model
class CNN(nn.Module):
    def __init__(self):
        super(CNN, self).__init__()
        self.conv1 = nn.Conv2d(1, 32, kernel_size=3, padding=1)
        self.conv2 = nn.Conv2d(32, 64, kernel_size=3, padding=1)
        self.pool = nn.MaxPool2d(kernel_size=2, stride=2)
        self.fc1 = nn.Linear(64 * 7 * 7, 128)
        self.fc2 = nn.Linear(128, 10)
        self.relu = nn.ReLU()

    def forward(self, x):
        x = self.conv1(x)
        x = self.relu(x)
        x = self.pool(x)
        x = self.conv2(x)
        x = self.relu(x)
        x = self.pool(x)
        x = x.view(-1, 64 * 7 * 7)
        x = self.fc1(x)
        x = self.relu(x)
        x = self.fc2(x)
        return x
```

```
#dataloaders for CNN
train_dataset = TensorDataset(torch.tensor(X_train.reshape(-1, 1, 28, 28), dtype=torch.float32), torch.tensor(y_train_np, dt
train_loader = DataLoader(train_dataset, batch_size=batch_size, shuffle=True)

cnn_model = CNN()
criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(cnn_model.parameters(), lr=0.001)


#training the cnn model
cnn_train_losses = []
for epoch in range(num_epochs):
    cnn_model.train()
    running_loss = 0.0
    for inputs, labels in train_loader:
        optimizer.zero_grad()
        outputs = cnn_model(inputs)
        loss = criterion(outputs, labels)
        loss.backward()
        optimizer.step()
        running_loss += loss.item()
    cnn_train_losses.append(running_loss / len(train_loader))
    print(f"Epoch [{epoch+1}/{num_epochs}], Loss: {running_loss/len(train_loader):.4f}")

train_accuracy = evaluate_model(cnn_model, train_loader)
print(f"CNN Training Accuracy: {train_accuracy:.4f}")
```

```
Epoch [1/10], Loss: 0.1513
Epoch [2/10], Loss: 0.0450
Epoch [3/10], Loss: 0.0306
Epoch [4/10], Loss: 0.0221
Epoch [5/10], Loss: 0.0200
Epoch [6/10], Loss: 0.0168
Epoch [7/10], Loss: 0.0126
Epoch [8/10], Loss: 0.0101
Epoch [9/10], Loss: 0.0077
Epoch [10/10], Loss: 0.0083
CNN Training Accuracy: 0.9990
```

```
#saving the cnn model
cnn_model_filename = 'cnn_model.pth'
cnn_model_save_path = os.path.join(drive_dir, cnn_model_filename)
torch.save(cnn_model.state_dict(), cnn_model_save_path)
print(f"CNN Model saved to {cnn_model_save_path}")
```

```
CNN Model saved to /content/drive/MyDrive/Colab Notebooks/harshith_neco/cnn_model.pth
```

```
#calculating and storing the accuracy and loss parameters of the trained models
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay


# Prepare MLP data loader (input is flat, 1D)
mlp_train_loader = DataLoader(train_dataset, batch_size=batch_size, shuffle=True)

# Prepare CNN data loader (input is 2D, with shape [batch_size, 1, 28, 28])
cnn_train_dataset = TensorDataset(torch.tensor(X_train.reshape(-1, 1, 28, 28), dtype=torch.float32), torch.tensor(y_train_np
cnn_train_loader = DataLoader(cnn_train_dataset, batch_size=batch_size, shuffle=True)

# Instantiate the CNN model, define the loss function and the optimizer
cnn_model = CNN()
criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(cnn_model.parameters(), lr=0.001)

# Modified CNN training loop to store accuracy and loss
cnn_train_losses = []
cnn_train_accuracies = []

def evaluate_model(model, loader):
    model.eval()
    correct = 0
    total = 0
    with torch.no_grad():
        for inputs, labels in loader:
            outputs = model(inputs)
            _, predicted = torch.max(outputs, 1)
            total += labels.size(0)
            correct += (predicted == labels).sum().item()
    return correct / total

mlp_train_losses = []
mlp_train_accuracies = []

num_epochs = 10
for epoch in range(num_epochs):
    mlp_model.train()
    running_loss = 0.0
    for inputs, labels in train_loader:
        optimizer.zero_grad()
        outputs = mlp_model(inputs)
        loss = criterion(outputs, labels)
        loss.backward()
        optimizer.step()
        running_loss += loss.item()
    mlp_train_losses.append(running_loss / len(train_loader))
    mlp_train_accuracies.append(evaluate_model(mlp_model, train_loader))


cnn_train_losses = []
cnn_train_accuracies = []

for epoch in range(num_epochs):
    cnn_model.train()
    running_loss = 0.0
    for inputs, labels in cnn_train_loader:  # Use cnn_train_loader here
        optimizer.zero_grad()
        outputs = cnn_model(inputs)
        loss = criterion(outputs, labels)
        loss.backward()
        optimizer.step()
        running_loss += loss.item()
    cnn_train_losses.append(running_loss / len(cnn_train_loader))
    cnn_train_accuracies.append(evaluate_model(cnn_model, cnn_train_loader))
```

```
mlp_losses_path = os.path.join(drive_dir, 'mlp_train_losses.npy')
mlp_accuracies_path = os.path.join(drive_dir, 'mlp_train_accuracies.npy')
cnn_losses_path = os.path.join(drive_dir, 'cnn_train_losses.npy')
cnn_accuracies_path = os.path.join(drive_dir, 'cnn_train_accuracies.npy')

np.save(mlp_losses_path, np.array(mlp_train_losses))
np.save(mlp_accuracies_path, np.array(mlp_train_accuracies))
np.save(cnn_losses_path, np.array(cnn_train_losses))
np.save(cnn_accuracies_path, np.array(cnn_train_accuracies))

print(f"MLP losses saved to {mlp_losses_path}")
print(f"MLP accuracies saved to {mlp_accuracies_path}")
print(f"CNN losses saved to {cnn_losses_path}")
print(f"CNN accuracies saved to {cnn_accuracies_path}")
```

```
MLP losses saved to /content/drive/MyDrive/Colab Notebooks/harshith_neco/mlp_train_losses.npy
MLP accuracies saved to /content/drive/MyDrive/Colab Notebooks/harshith_neco/mlp_train_accuracies.npy
CNN losses saved to /content/drive/MyDrive/Colab Notebooks/harshith_neco/cnn_train_losses.npy
CNN accuracies saved to /content/drive/MyDrive/Colab Notebooks/harshith_neco/cnn_train_accuracies.npy
```

```
#Training simple mlp and cnn with augmented data
```

```
import torch
import torch.nn as nn
import torch.optim as optim
from torch.utils.data import DataLoader, TensorDataset
import numpy as np

#this will add random noise to the dataset
def add_noise(images, noise_factor):
    noisy_images = images + noise_factor * np.random.randn(*images.shape)
    noisy_images = np.clip(noisy_images, 0., 1.)
    return noisy_images


mnist = fetch_openml('mnist_784', version=1)
X, y = mnist.data.to_numpy(), mnist.target.astype(int)
X = X / 255.0
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)
y_train_np = y_train.to_numpy()
y_test_np = y_test.to_numpy()

noise_factor = 0.2
X_train_noisy = add_noise(X_train, noise_factor)

X_train_augmented = np.concatenate((X_train, X_train_noisy), axis=0)
y_train_augmented = np.concatenate((y_train_np, y_train_np), axis=0)

batch_size = 64
train_dataset_augmented = TensorDataset(torch.tensor(X_train_augmented, dtype=torch.float32), torch.tensor(y_train_augmentec
train_loader_augmented = DataLoader(train_dataset_augmented, batch_size=batch_size, shuffle=True)

#Redefining the MLP and CNN models
class MLP(nn.Module):
    def __init__(self):
        super(MLP, self).__init__()
        self.fc1 = nn.Linear(784, 128)
        self.relu = nn.ReLU()
        self.fc2 = nn.Linear(128, 10)

    def forward(self, x):
        x = x.view(-1, 784)
        x = self.fc1(x)
        x = self.relu(x)
        x = self.fc2(x)
        return x

class CNN(nn.Module):
    def __init__(self):
        super(CNN, self).__init__()
        self.conv1 = nn.Conv2d(1, 32, kernel_size=3, padding=1)
        self.conv2 = nn.Conv2d(32, 64, kernel_size=3, padding=1)
        self.pool = nn.MaxPool2d(kernel_size=2, stride=2)
        self.fc1 = nn.Linear(64 * 7 * 7, 128)
        self.fc2 = nn.Linear(128, 10)
        self.relu = nn.ReLU()

    def forward(self, x):
        x = self.conv1(x)
        x = self.relu(x)
        x = self.pool(x)
        x = self.conv2(x)
        x = self.relu(x)
        x = self.pool(x)
        x = x.view(-1, 64 * 7 * 7)
        x = self.fc1(x)
        x = self.relu(x)
        x = self.fc2(x)
        return x

mlp_model_augmented = MLP()
cnn_model_augmented = CNN()

criterion = nn.CrossEntropyLoss()
mlp_optimizer = optim.Adam(mlp_model_augmented.parameters(), lr=0.001)
cnn_optimizer = optim.Adam(cnn_model_augmented.parameters(), lr=0.001)

#training the mlp model
def train_model_mlp(model, optimizer, train_loader, num_epochs):
    for epoch in range(num_epochs):
        model.train()
        running_loss = 0.0
        for inputs, labels in train_loader:
            optimizer.zero_grad()
            outputs = model(inputs)
            loss = criterion(outputs, labels)
            loss.backward()
            optimizer.step()
            running_loss += loss.item()
        print(f"Epoch [{epoch+1}/{num_epochs}], Loss: {running_loss/len(train_loader):.4f}")

#training the cnn model
def train_model_cnn(model, optimizer, train_loader, num_epochs):
    for epoch in range(num_epochs):
        model.train()
        running_loss = 0.0
        for inputs, labels in train_loader:
            optimizer.zero_grad()
            inputs = inputs.view(-1, 1, 28, 28)  # Reshape inputs for CNN
            outputs = model(inputs)
            loss = criterion(outputs, labels)
            loss.backward()
            optimizer.step()
            running_loss += loss.item()
        print(f"Epoch [{epoch+1}/{num_epochs}], Loss: {running_loss/len(train_loader):.4f}")

#mlp model training with augmented data
print("mlp model training with augmented data...")
train_model_mlp(mlp_model_augmented, mlp_optimizer, train_loader_augmented, num_epochs=10)

#CNN model training with augmented data
print("CNN model training with augmented data...")
train_model_cnn(cnn_model_augmented, cnn_optimizer, train_loader_augmented, num_epochs=10)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/datasets/_openml.py:1022: FutureWarning: The default value of `parser` w
  warn(
mlp model training with augmented data...
Epoch [1/10], Loss: 0.2910
Epoch [2/10], Loss: 0.1165
Epoch [3/10], Loss: 0.0715
Epoch [4/10], Loss: 0.0476
Epoch [5/10], Loss: 0.0335
Epoch [6/10], Loss: 0.0242
Epoch [7/10], Loss: 0.0177
Epoch [8/10], Loss: 0.0141
Epoch [9/10], Loss: 0.0111
Epoch [10/10], Loss: 0.0089
CNN model training with augmented data...
Epoch [1/10], Loss: 0.1284
Epoch [2/10], Loss: 0.0343
Epoch [3/10], Loss: 0.0210
Epoch [4/10], Loss: 0.0147
Epoch [5/10], Loss: 0.0097
Epoch [6/10], Loss: 0.0076
Epoch [7/10], Loss: 0.0059
Epoch [8/10], Loss: 0.0053
Epoch [9/10], Loss: 0.0049
Epoch [10/10], Loss: 0.0034
```

```
mlp_augmented_save_path = os.path.join(drive_dir, 'mlp_model_augmented.pth')
cnn_augmented_save_path = os.path.join(drive_dir, 'cnn_model_augmented.pth')

torch.save(mlp_model_augmented.state_dict(), mlp_augmented_save_path)
torch.save(cnn_model_augmented.state_dict(), cnn_augmented_save_path)

print(f"MLP Augmented Model saved to {mlp_augmented_save_path}")
print(f"CNN Augmented Model saved to {cnn_augmented_save_path}")
```

```
MLP Augmented Model saved to /content/drive/MyDrive/Colab Notebooks/harshith_neco/mlp_model_augmented.pth
CNN Augmented Model saved to /content/drive/MyDrive/Colab Notebooks/harshith_neco/cnn_model_augmented.pth
```

Start coding or generate with AI.

```
#Training hyperparameter mlp and cnn without augmented data


import torch
import torch.nn as nn
import torch.optim as optim
from torch.utils.data import DataLoader, TensorDataset, random_split
import numpy as np
from sklearn.model_selection import ParameterGrid
import json

#this will add random noise to images with a specified noise factor
```

```
def add_noise(images, noise_factor):
    noisy_images = images + noise_factor * np.random.randn(*images.shape)
    noisy_images = np.clip(noisy_images, 0., 1.)
    return noisy_images

#the noise factor
noise_factor = 0.2
X_train_noisy = add_noise(X_train, noise_factor)

X_train_augmented = np.concatenate((X_train, X_train_noisy), axis=0)
y_train_augmented = np.concatenate((y_train_np, y_train_np), axis=0)

batch_size = 64
train_dataset_augmented = TensorDataset(torch.tensor(X_train_augmented, dtype=torch.float32), torch.tensor(y_train_augmented,

train_size = int(0.8 * len(train_dataset_augmented))
val_size = len(train_dataset_augmented) - train_size
train_dataset, val_dataset = random_split(train_dataset_augmented, [train_size, val_size])
train_loader = DataLoader(train_dataset, batch_size=batch_size, shuffle=True)
val_loader = DataLoader(val_dataset, batch_size=batch_size, shuffle=False)
train_loader_augmented = DataLoader(train_dataset_augmented, batch_size=batch_size, shuffle=True)

#redefining the ml and cnn with ReLU activation
class MLPHyperparam(nn.Module):
    def __init__(self, input_size=784, hidden_size=128, output_size=10):
        super(MLPHyperparam, self).__init__()
        self.fc1 = nn.Linear(input_size, hidden_size)
        self.activation = nn.ReLU()
        self.fc2 = nn.Linear(hidden_size, output_size)

    def forward(self, x):
        x = x.view(-1, 784)
        x = self.fc1(x)
        x = self.activation(x)
        x = self.fc2(x)
        return x

class CNNHyperparam(nn.Module):
    def __init__(self):
        super(CNNHyperparam, self).__init__()
        self.conv1 = nn.Conv2d(1, 32, kernel_size=3, padding=1)
        self.conv2 = nn.Conv2d(32, 64, kernel_size=3, padding=1)
        self.pool = nn.MaxPool2d(kernel_size=2, stride=2)
        self.fc1 = nn.Linear(64 * 7 * 7, 128)
        self.fc2 = nn.Linear(128, 10)
        self.activation = nn.ReLU()

    def forward(self, x):
        x = self.conv1(x)
        x = self.activation(x)
        x = self.pool(x)
        x = self.conv2(x)
        x = self.activation(x)
        x = self.pool(x)
        x = x.view(-1, 64 * 7 * 7)
        x = self.fc1(x)
        x = self.activation(x)
        x = self.fc2(x)
        return x

#hyperparameters
mlp_param_grid = {
    'hidden_size': [64, 128, 256]
}

cnn_param_grid = {}

learning_rates = [0.001, 0.01, 0.1]

#training the models
def train_model_mlp_hyperparam(model, optimizer, train_loader, num_epochs=10):
    model.train()
    criterion = nn.CrossEntropyLoss()
    for epoch in range(num_epochs):
        running_loss = 0.0
        for inputs, labels in train_loader:
            optimizer.zero_grad()
            outputs = model(inputs)
            loss = criterion(outputs, labels)
            loss.backward()
            optimizer.step()
            running_loss += loss.item()
    return model
    return model

def train_model_cnn_hyperparam(model, optimizer, train_loader, num_epochs=10):
    model.train()
    criterion = nn.CrossEntropyLoss()
    for epoch in range(num_epochs):
        running_loss = 0.0
        for inputs, labels in train_loader:
            optimizer.zero_grad()
            inputs = inputs.view(-1, 1, 28, 28)
            outputs = model(inputs)
            loss = criterion(outputs, labels)
            loss.backward()
            optimizer.step()
            running_loss += loss.item()
    return model

#evaluating the accuracies
def evaluate_model_hyperparam(model, data_loader, model_name):
    model.eval()
    correct = 0
    total = 0
    with torch.no_grad():
        for inputs, labels in data_loader:
            if model_name.startswith("CNN"):
                inputs = inputs.view(-1, 1, 28, 28)
            outputs = model(inputs)
            _, predicted = torch.max(outputs, 1)
            total += labels.size(0)
            correct += (predicted == labels).sum().item()
    accuracy = correct / total
    return accuracy

#this will perform hyperparameter tuning
def hyperparameter_tuning(model_class, param_grid, learning_rates, train_loader, val_loader, num_epochs=10):
    best_params = None
    best_score = 0
    for param_comb in ParameterGrid(param_grid):
        for lr in learning_rates:
            model = model_class(**param_comb)
            optimizer = optim.Adam(model.parameters(), lr=lr)

            if model_class == MLPHyperparam:
                model = train_model_mlp_hyperparam(model, optimizer, train_loader, num_epochs)
            else:
                model = train_model_cnn_hyperparam(model, optimizer, train_loader, num_epochs)

            val_accuracy = evaluate_model_hyperparam(model, val_loader, model_class.__name__)
            print(f"Parameters: {param_comb}, lr: {lr}, Validation Accuracy: {val_accuracy:.4f}")

            if val_accuracy > best_score:
                best_score = val_accuracy
                best_params = {**param_comb, 'lr': lr}

    return best_params, best_score

print("Tuning MLP...")
best_mlp_params, best_mlp_val_score = hyperparameter_tuning(MLPHyperparam, mlp_param_grid, learning_rates, train_loader, val_
print(f"Best MLP params: {best_mlp_params}, Validation Accuracy: {best_mlp_val_score:.4f}")

print("Tuning CNN...")
best_cnn_params, best_cnn_val_score = hyperparameter_tuning(CNNHyperparam, cnn_param_grid, learning_rates, train_loader, val_
print(f"Best CNN params: {best_cnn_params}, Validation Accuracy: {best_cnn_val_score:.4f}")

#saving the best hyperparameters
mlp_params_file = os.path.join(drive_dir, 'best_mlp_params.json')
cnn_params_file = os.path.join(drive_dir, 'best_cnn_params.json')

with open(mlp_params_file, 'w') as f:
    json.dump(best_mlp_params, f)
print(f"Best MLP hyperparameters saved to {mlp_params_file}")

with open(cnn_params_file, 'w') as f:
    json.dump(best_cnn_params, f)
print(f"Best CNN hyperparameters saved to {cnn_params_file}")

print("best cnn hyperparameters saved")


best_mlp_model = MLPHyperparam(**{k: v for k, v in best_mlp_params.items() if k != 'lr'})
best_mlp_optimizer = optim.Adam(best_mlp_model.parameters(), lr=best_mlp_params['lr'])
best_mlp_model = train_model_mlp_hyperparam(best_mlp_model, best_mlp_optimizer, train_loader_augmented)
torch.save(best_mlp_model.state_dict(), 'best_mlp_model.pth')
```

```
best_cnn_model = CNNHyperparam()
best_cnn_optimizer = optim.Adam(best_cnn_model.parameters(), lr=best_cnn_params['lr'])
best_cnn_model = train_model_cnn_hyperparam(best_cnn_model, best_cnn_optimizer, train_loader_augmented)
torch.save(best_cnn_model.state_dict(), 'best_cnn_model.pth')
```

```
Tuning MLP...
Parameters: {'hidden_size': 64}, lr: 0.001, Validation Accuracy: 0.9730
Parameters: {'hidden_size': 64}, lr: 0.01, Validation Accuracy: 0.9650
Parameters: {'hidden_size': 64}, lr: 0.1, Validation Accuracy: 0.4897
Parameters: {'hidden_size': 128}, lr: 0.001, Validation Accuracy: 0.9783
Parameters: {'hidden_size': 128}, lr: 0.01, Validation Accuracy: 0.9674
Parameters: {'hidden_size': 128}, lr: 0.1, Validation Accuracy: 0.5768
Parameters: {'hidden_size': 256}, lr: 0.001, Validation Accuracy: 0.9803
Parameters: {'hidden_size': 256}, lr: 0.01, Validation Accuracy: 0.9674
Parameters: {'hidden_size': 256}, lr: 0.1, Validation Accuracy: 0.5751
Best MLP params: {'hidden_size': 256, 'lr': 0.001}, Validation Accuracy: 0.9803
Tuning CNN...
Parameters: {}, lr: 0.001, Validation Accuracy: 0.9936
Parameters: {}, lr: 0.01, Validation Accuracy: 0.9826
Parameters: {}, lr: 0.1, Validation Accuracy: 0.1020
Best CNN params: {'lr': 0.001}, Validation Accuracy: 0.9936
Best MLP hyperparameters saved to /content/drive/MyDrive/Colab Notebooks/harshith_neco/best_mlp_params.json
Best CNN hyperparameters saved to /content/drive/MyDrive/Colab Notebooks/harshith_neco/best_cnn_params.json
best cnn hyperparameters saved
```

```
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_remoun
```

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