```
import torch
import os
import torch.nn as nn
import torch.optim as optim
from torchvision import datasets, transforms
from torch.utils.data import DataLoader, Subset
import random
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import classification_report, confusion_matrix
import seaborn as sns
from tqdm import tqdm


# Step 1: Load and Normalize Dataset
def load_mnist_data():
    """Load MNIST dataset with normalization."""
    transform = transforms.Compose([
        transforms.ToTensor(),
        transforms.Normalize((0.5,), (0.5,))  # Normalize dataset
    ])
    train_dataset = datasets.MNIST(root='data', train=True, transform=transform, download=True)
    test_dataset = datasets.MNIST(root='data', train=False, transform=transform, download=True)
    return train_dataset, test_dataset


def extract_and_save_samples(dataset, specified_classes=[3, 5, 6], samples_per_class=1000):
    """
    Extract a specified number of samples from specific classes and save them.

    Args:
        dataset: The dataset to extract samples from.
        specified_classes (list): List of class labels to extract samples for.
        samples_per_class (int): Number of samples to extract per class.

    Returns:
        extracted_data: Subset of the dataset containing extracted samples.
        remaining_data: Subset of the dataset containing remaining samples.
        classes: List of classes for which samples were extracted.
    """
    # Ensure only the specified classes are used
    print(f"Extracting samples for classes: {specified_classes}")

    extracted_indices = []
    for cls in specified_classes:
        # Find indices of the specified class
        cls_indices = [i for i, (_, label) in enumerate(dataset) if label == cls]
        if len(cls_indices) < samples_per_class:
            print(f"Warning: Only {len(cls_indices)} samples available for class {cls}, fewer than {samples_per_class}.")
        extracted_indices.extend(cls_indices[:samples_per_class])

    # Determine remaining data indices
    remaining_indices = list(set(range(len(dataset))) - set(extracted_indices))

    # Create a directory to save the extracted samples
    os.makedirs('extracted_samples', exist_ok=True)
    for cls in specified_classes:
        cls_indices = [i for i in extracted_indices if dataset[i][1] == cls]
        cls_samples = [dataset[i] for i in cls_indices]
        torch.save(cls_samples, f'extracted_samples/class_{cls}.pt')
        print(f"Saved {len(cls_samples)} samples for class {cls}.")

    # Create subsets for extracted and remaining data
    extracted_data = Subset(dataset, extracted_indices)
    remaining_data = Subset(dataset, remaining_indices)

    return extracted_data, remaining_data, specified_classes


# Step 2: Define Model Using Class
class SimpleNN(nn.Module):
    """Define a simple neural network as a class."""
    def __init__(self):
        super(SimpleNN, self).__init__()
        self.flatten = nn.Flatten()
        self.fc1 = nn.Linear(28 * 28, 128)
        self.relu1 = nn.ReLU()
        self.fc2 = nn.Linear(128, 64)
        self.relu2 = nn.ReLU()
        self.fc3 = nn.Linear(64, 10)

    def forward(self, x):
        x = self.flatten(x)
        x = self.relu1(self.fc1(x))
        x = self.relu2(self.fc2(x))
        x = self.fc3(x)
        return x


# Step 3: Train Model with tqdm
def train_model(model, train_loader, test_loader, epochs=5, lr=0.001):
    """Train the model and plot accuracy/loss."""
    criterion = nn.CrossEntropyLoss()
    optimizer = optim.Adam(model.parameters(), lr=lr)

    train_loss, test_loss = [], []
    train_acc, test_acc = [], []

    for epoch in range(epochs):
        # Training phase with tqdm
        model.train()
        running_loss, correct = 0.0, 0
        # Wrap the train_loader with tqdm for progress bar
        for images, labels in tqdm(train_loader, desc=f"Epoch {epoch + 1}/{epochs} - Training", ncols=100):
            optimizer.zero_grad()
            outputs = model(images)
            loss = criterion(outputs, labels)
            loss.backward()
            optimizer.step()
            running_loss += loss.item()
            _, predicted = torch.max(outputs, 1)
            correct += (predicted == labels).sum().item()

        train_loss.append(running_loss / len(train_loader))
        train_acc.append(correct / len(train_loader.dataset))

        # Validation phase with tqdm
        model.eval()
        running_loss, correct = 0.0, 0
        # Wrap the test_loader with tqdm for progress bar
        with torch.no_grad():
            for images, labels in tqdm(test_loader, desc=f"Epoch {epoch + 1}/{epochs} - Validation", ncols=100):
                outputs = model(images)
                loss = criterion(outputs, labels)
                running_loss += loss.item()
                _, predicted = torch.max(outputs, 1)
                correct += (predicted == labels).sum().item()

        test_loss.append(running_loss / len(test_loader))
        test_acc.append(correct / len(test_loader.dataset))

        # Print the epoch results
        print(f"Epoch {epoch + 1}/{epochs} -> Train Loss: {train_loss[-1]:.4f}, Test Loss: {test_loss[-1]:.4f}, Train Acc: {

    # Plot results
    plot_metrics(train_loss, test_loss, train_acc, test_acc)

    return model


def plot_metrics(train_loss, test_loss, train_acc, test_acc):
    """Plot training and validation loss/accuracy."""
    epochs = range(1, len(train_loss) + 1)
    plt.figure(figsize=(12, 5))

    # Plot loss
    plt.subplot(1, 2, 1)
    plt.plot(epochs, train_loss, label="Train Loss")
    plt.plot(epochs, test_loss, label="Test Loss")
    plt.xlabel("Epochs")
    plt.ylabel("Loss")
    plt.title("Loss Curve")
    plt.legend()

    # Plot accuracy
    plt.subplot(1, 2, 2)
    plt.plot(epochs, train_acc, label="Train Accuracy")
    plt.plot(epochs, test_acc, label="Test Accuracy")
    plt.xlabel("Epochs")
    plt.ylabel("Accuracy")
    plt.title("Accuracy Curve")
    plt.legend()

    plt.show()
```

```
# Step 4: Model Evaluation
def evaluate_model(model, data_loader, class_names):
    """Evaluate model performance."""
    model.eval()
    all_labels, all_preds = [], []

    with torch.no_grad():
        for images, labels in data_loader:
            outputs = model(images)
            _, predicted = torch.max(outputs, 1)
            all_labels.extend(labels.cpu().numpy())
            all_preds.extend(predicted.cpu().numpy())

    # Classification report
    print("Classification Report:")
    print(classification_report(all_labels, all_preds, target_names=class_names))

    # Confusion matrix
    cm = confusion_matrix(all_labels, all_preds)
    plt.figure(figsize=(8, 6))
    sns.heatmap(cm, annot=True, fmt="d", cmap="Blues", xticklabels=class_names, yticklabels=class_names)
    plt.xlabel("Predicted")
    plt.ylabel("True")
    plt.title("Confusion Matrix")
    plt.show()
```

```
# Main Execution
train_dataset, test_dataset = load_mnist_data()
```

```
Downloading http://yann.lecun.com/exdb/mnist/train-images-idx3-ubyte.gz
Failed to download (trying next):
HTTP Error 403: Forbidden

Downloading https://ossci-datasets.s3.amazonaws.com/mnist/train-images-idx3-ubyte.gz
Downloading https://ossci-datasets.s3.amazonaws.com/mnist/train-images-idx3-ubyte.gz to data/MNIST/raw/train-images-idx3
100%|██████████| 9.91M/9.91M [00:01<00:00, 5.10MB/s]
Extracting data/MNIST/raw/train-images-idx3-ubyte.gz to data/MNIST/raw

Downloading http://yann.lecun.com/exdb/mnist/train-labels-idx1-ubyte.gz
Failed to download (trying next):
HTTP Error 403: Forbidden

Downloading https://ossci-datasets.s3.amazonaws.com/mnist/train-labels-idx1-ubyte.gz
Downloading https://ossci-datasets.s3.amazonaws.com/mnist/train-labels-idx1-ubyte.gz to data/MNIST/raw/train-labels-idx1
100%|██████████| 28.9k/28.9k [00:00<00:00, 133kB/s]
Extracting data/MNIST/raw/train-labels-idx1-ubyte.gz to data/MNIST/raw

Downloading http://yann.lecun.com/exdb/mnist/t10k-images-idx3-ubyte.gz
Failed to download (trying next):
HTTP Error 403: Forbidden

Downloading https://ossci-datasets.s3.amazonaws.com/mnist/t10k-images-idx3-ubyte.gz
Downloading https://ossci-datasets.s3.amazonaws.com/mnist/t10k-images-idx3-ubyte.gz to data/MNIST/raw/t10k-images-idx3-u
100%|██████████| 1.65M/1.65M [00:01<00:00, 1.08MB/s]
Extracting data/MNIST/raw/t10k-images-idx3-ubyte.gz to data/MNIST/raw

Downloading http://yann.lecun.com/exdb/mnist/t10k-labels-idx1-ubyte.gz
Failed to download (trying next):
HTTP Error 403: Forbidden

Downloading https://ossci-datasets.s3.amazonaws.com/mnist/t10k-labels-idx1-ubyte.gz
Downloading https://ossci-datasets.s3.amazonaws.com/mnist/t10k-labels-idx1-ubyte.gz to data/MNIST/raw/t10k-labels-idx1-u
100%|██████████| 4.54k/4.54k [00:00<00:00, 2.56MB/s]Extracting data/MNIST/raw/t10k-labels-idx1-ubyte.gz to data/MNIST/ra
```

```
extracted_data, remaining_data, selected_classes = extract_and_save_samples(train_dataset)
print(f"Extracted {len(extracted_data)} samples, Remaining {len(remaining_data)} samples.")
```

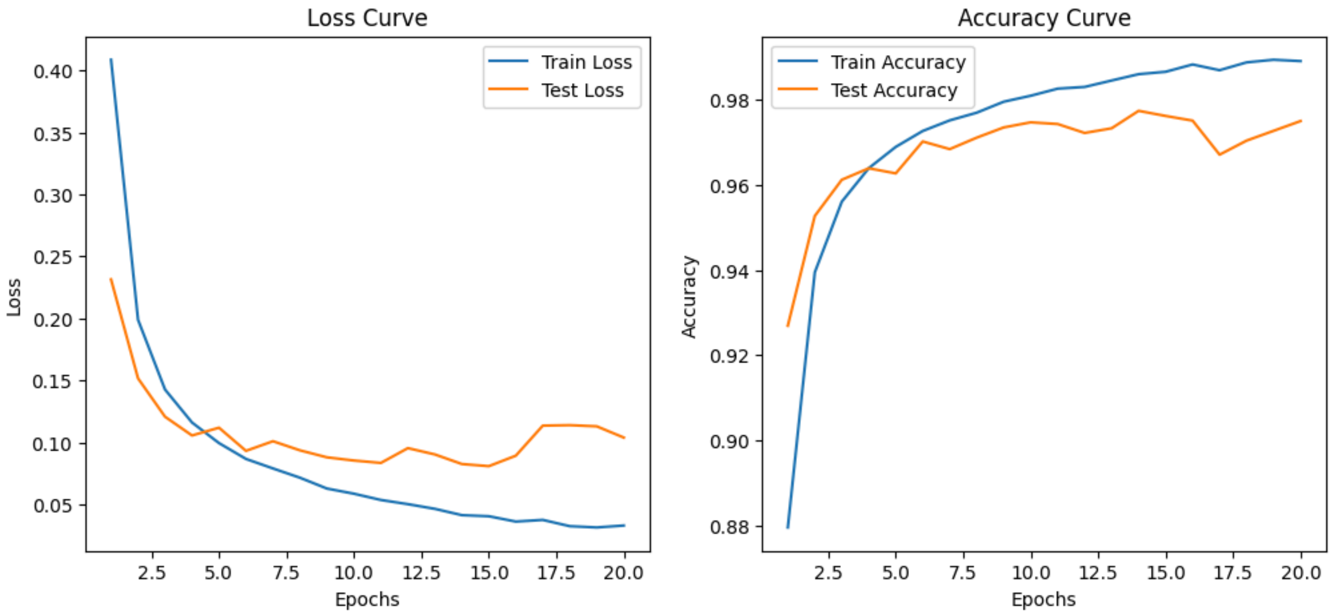
```
Extracting samples for classes: [3, 5, 6]
Saved 1000 samples for class 3.
Saved 1000 samples for class 5.
Saved 1000 samples for class 6.
Extracted 3000 samples, Remaining 57000 samples.
```

```
# DataLoader
train_loader = DataLoader(remaining_data, batch_size=64, shuffle=True)
test_loader = DataLoader(test_dataset, batch_size=64, shuffle=False)
```

```
# Initialize model
model = SimpleNN()
```

```
# Train model
pretrained_model = train_model(model, train_loader, test_loader, epochs=20)
```

```
Epoch 1/20 - Training: 100%|██████████████████████████████████████| 891/891 [00:18<00:00, 49.14it/s]
Epoch 1/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 54.44it/s]
Epoch 1/20 -> Train Loss: 0.4086, Test Loss: 0.2314, Train Acc: 0.8795, Test Acc: 0.9269
Epoch 2/20 - Training: 100%|██████████████████████████████████████| 891/891 [00:18<00:00, 46.94it/s]
Epoch 2/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 62.48it/s]
Epoch 2/20 -> Train Loss: 0.1989, Test Loss: 0.1516, Train Acc: 0.9395, Test Acc: 0.9527
Epoch 3/20 - Training: 100%|██████████████████████████████████████| 891/891 [00:18<00:00, 48.63it/s]
Epoch 3/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:03<00:00, 46.33it/s]
Epoch 3/20 -> Train Loss: 0.1426, Test Loss: 0.1207, Train Acc: 0.9561, Test Acc: 0.9612
Epoch 4/20 - Training: 100%|██████████████████████████████████████| 891/891 [00:18<00:00, 49.11it/s]
Epoch 4/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 62.38it/s]
Epoch 4/20 -> Train Loss: 0.1160, Test Loss: 0.1056, Train Acc: 0.9639, Test Acc: 0.9639
Epoch 5/20 - Training: 100%|██████████████████████████████████████| 891/891 [00:20<00:00, 44.01it/s]
Epoch 5/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 61.56it/s]
Epoch 5/20 -> Train Loss: 0.0994, Test Loss: 0.1118, Train Acc: 0.9689, Test Acc: 0.9627
Epoch 6/20 - Training: 100%|██████████████████████████████████████| 891/891 [00:18<00:00, 49.00it/s]
Epoch 6/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:03<00:00, 49.24it/s]
Epoch 6/20 -> Train Loss: 0.0866, Test Loss: 0.0931, Train Acc: 0.9727, Test Acc: 0.9702
Epoch 7/20 - Training: 100%|██████████████████████████████████████| 891/891 [00:18<00:00, 47.74it/s]
Epoch 7/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 61.36it/s]
Epoch 7/20 -> Train Loss: 0.0790, Test Loss: 0.1009, Train Acc: 0.9752, Test Acc: 0.9684
Epoch 8/20 - Training: 100%|██████████████████████████████████████| 891/891 [00:18<00:00, 46.91it/s]
Epoch 8/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:03<00:00, 52.31it/s]
Epoch 8/20 -> Train Loss: 0.0715, Test Loss: 0.0936, Train Acc: 0.9770, Test Acc: 0.9711
Epoch 9/20 - Training: 100%|██████████████████████████████████████| 891/891 [00:18<00:00, 48.76it/s]
Epoch 9/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 61.23it/s]
Epoch 9/20 -> Train Loss: 0.0628, Test Loss: 0.0879, Train Acc: 0.9795, Test Acc: 0.9735
Epoch 10/20 - Training: 100%|█████████████████████████████████████| 891/891 [00:20<00:00, 43.91it/s]
Epoch 10/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:02<00:00, 62.63it/s]
Epoch 10/20 -> Train Loss: 0.0586, Test Loss: 0.0853, Train Acc: 0.9809, Test Acc: 0.9747
Epoch 11/20 - Training: 100%|█████████████████████████████████████| 891/891 [00:19<00:00, 45.38it/s]
Epoch 11/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:03<00:00, 49.36it/s]
Epoch 11/20 -> Train Loss: 0.0535, Test Loss: 0.0834, Train Acc: 0.9826, Test Acc: 0.9743
Epoch 12/20 - Training: 100%|█████████████████████████████████████| 891/891 [00:18<00:00, 49.11it/s]
Epoch 12/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:02<00:00, 61.09it/s]
Epoch 12/20 -> Train Loss: 0.0502, Test Loss: 0.0953, Train Acc: 0.9830, Test Acc: 0.9722
Epoch 13/20 - Training: 100%|█████████████████████████████████████| 891/891 [00:19<00:00, 46.10it/s]
Epoch 13/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:02<00:00, 61.66it/s]
Epoch 13/20 -> Train Loss: 0.0464, Test Loss: 0.0903, Train Acc: 0.9845, Test Acc: 0.9733
Epoch 14/20 - Training: 100%|█████████████████████████████████████| 891/891 [00:18<00:00, 48.75it/s]
Epoch 14/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:03<00:00, 52.20it/s]
Epoch 14/20 -> Train Loss: 0.0413, Test Loss: 0.0825, Train Acc: 0.9860, Test Acc: 0.9774
Epoch 15/20 - Training: 100%|█████████████████████████████████████| 891/891 [00:18<00:00, 47.58it/s]
Epoch 15/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:02<00:00, 61.35it/s]
Epoch 15/20 -> Train Loss: 0.0404, Test Loss: 0.0808, Train Acc: 0.9866, Test Acc: 0.9762
Epoch 16/20 - Training: 100%|█████████████████████████████████████| 891/891 [00:18<00:00, 48.43it/s]
Epoch 16/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:03<00:00, 49.58it/s]
Epoch 16/20 -> Train Loss: 0.0361, Test Loss: 0.0893, Train Acc: 0.9883, Test Acc: 0.9751
Epoch 17/20 - Training: 100%|█████████████████████████████████████| 891/891 [00:18<00:00, 49.16it/s]
Epoch 17/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:02<00:00, 63.64it/s]
Epoch 17/20 -> Train Loss: 0.0375, Test Loss: 0.1135, Train Acc: 0.9869, Test Acc: 0.9671
Epoch 18/20 - Training: 100%|█████████████████████████████████████| 891/891 [00:19<00:00, 46.40it/s]
Epoch 18/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:02<00:00, 62.83it/s]
Epoch 18/20 -> Train Loss: 0.0324, Test Loss: 0.1139, Train Acc: 0.9888, Test Acc: 0.9704
Epoch 19/20 - Training: 100%|█████████████████████████████████████| 891/891 [00:18<00:00, 49.23it/s]
Epoch 19/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:02<00:00, 56.33it/s]
Epoch 19/20 -> Train Loss: 0.0314, Test Loss: 0.1129, Train Acc: 0.9894, Test Acc: 0.9727
Epoch 20/20 - Training: 100%|█████████████████████████████████████| 891/891 [00:18<00:00, 47.17it/s]
Epoch 20/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:02<00:00, 62.51it/s]
Epoch 20/20 -> Train Loss: 0.0329, Test Loss: 0.1039, Train Acc: 0.9891, Test Acc: 0.9750
```



```
# Save model
torch.save(pretrained_model.state_dict(), 'pretrained_model.pth')
print("Pre-trained model saved as 'pretrained_model.pth'")
```

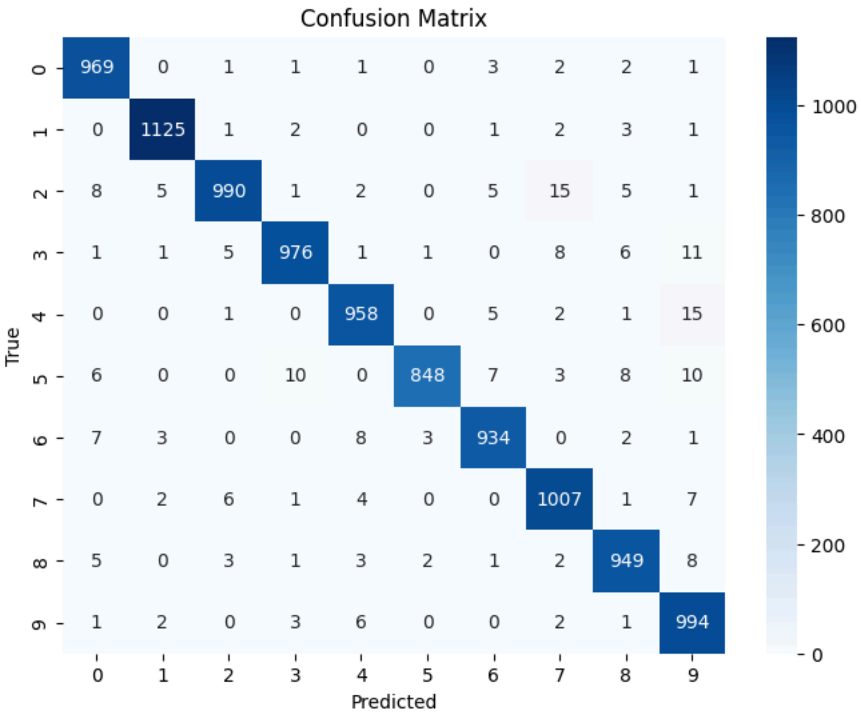
```
Pre-trained model saved as 'pretrained_model.pth'
```

```
# Evaluate model
evaluate_model(pretrained_model, test_loader, class_names=[str(i) for i in range(10)])
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.97      0.99      0.98       980
           1       0.99      0.99      0.99      1135
           2       0.98      0.96      0.97      1032
           3       0.98      0.97      0.97      1010
           4       0.97      0.98      0.98       982
           5       0.99      0.95      0.97       892
           6       0.98      0.97      0.98       958
           7       0.97      0.98      0.97      1028
           8       0.97      0.97      0.97       974
           9       0.95      0.99      0.97      1009

    accuracy                           0.97     10000
   macro avg       0.98      0.97      0.97     10000
weighted avg       0.98      0.97      0.98     10000
```



Fine tuning

```
from torch.utils.data import DataLoader, Dataset
```

```
class FineTunableNN(nn.Module):
    """Neural network model with flexibility for fine-tuning."""
    def __init__(self, num_classes=10, freeze_base=False):
        """
        Args:
            num_classes (int): Number of output classes. Defaults to 10.
            freeze_base (bool): Whether to freeze the base layers for fine-tuning.
        """
        super(FineTunableNN, self).__init__()

        # Base layers
        self.flatten = nn.Flatten()
        self.fc1 = nn.Linear(28 * 28, 128)
        self.relu1 = nn.ReLU()
        self.fc2 = nn.Linear(128, 64)
        self.relu2 = nn.ReLU()

        # Output layer (can be fine-tuned or replaced)
        self.fc3 = nn.Linear(64, num_classes)
        # Freeze base layers if specified
        if freeze_base:
            self._freeze_layers()

    def _freeze_layers(self):
        """Freeze parameters of the base layers."""
        for layer in [self.fc1, self.relu1, self.fc2, self.relu2]:
            for param in layer.parameters():
                param.requires_grad = False

    def forward(self, x):
        """Forward pass."""
        x = self.flatten(x)
        x = self.relu1(self.fc1(x))
        x = self.relu2(self.fc2(x))
        x = self.fc3(x)
        return x



# Data Loading and Preprocessing
def load_extracted_samples(selected_classes):
    """Load extracted samples for selected classes."""
    extracted_data = []
    extracted_labels = []

    for cls in selected_classes:
        samples_path = f'extracted_samples/class_{cls}.pt'
        if os.path.exists(samples_path):
            samples = torch.load(samples_path)
            for data, label in samples:
                extracted_data.append(data)
                extracted_labels.append(label)
        else:
            print(f"No samples found for class {cls} at {samples_path}.")

    extracted_dataset = CustomDataset(extracted_data, extracted_labels)
    return extracted_dataset



class CustomDataset(Dataset):
    """Custom dataset to handle extracted data."""
    def __init__(self, data, labels):
        self.data = data
        self.labels = labels

    def __len__(self):
        return len(self.data)

    def __getitem__(self, idx):
        return self.data[idx], self.labels[idx]


# Fine-tune the pre-trained model
def fine_tune_model(pretrained_model_path, finetune_loader, test_loader, epochs, lr):
    """Fine-tune the pre-trained model using new samples."""
    model = SimpleNN()
    model.load_state_dict(torch.load(pretrained_model_path))

    criterion = nn.CrossEntropyLoss()
    optimizer = optim.Adam(model.parameters(), lr=lr)

    train_losses, train_accuracies = [], []
    test_losses, test_accuracies = [], []

    for epoch in range(epochs):
        model.train()
        running_loss, correct = 0.0, 0
        for images, labels in finetune_loader:
            optimizer.zero_grad()
            outputs = model(images)
            loss = criterion(outputs, labels)
            loss.backward()
            optimizer.step()

            running_loss += loss.item()
            _, predicted = torch.max(outputs, 1)
            correct += (predicted == labels).sum().item()

        train_loss = running_loss / len(finetune_loader)
        train_accuracy = correct / len(finetune_loader.dataset)
        train_losses.append(train_loss)
        train_accuracies.append(train_accuracy)

        # Evaluate on test set
        model.eval()
        test_loss, correct = 0.0, 0
        with torch.no_grad():
            for images, labels in test_loader:
                outputs = model(images)
                loss = criterion(outputs, labels)
                test_loss += loss.item()
                _, predicted = torch.max(outputs, 1)
                correct += (predicted == labels).sum().item()

        test_loss /= len(test_loader)
        test_accuracy = correct / len(test_loader.dataset)
        test_losses.append(test_loss)
        test_accuracies.append(test_accuracy)

        print(f"Epoch {epoch + 1}/{epochs} -> Train Loss: {train_loss:.4f}, Train Acc: {train_accuracy:.4f}, Test Loss: {tes

    # Plot training/testing accuracy and loss
    plt.figure(figsize=(12, 5))
    plt.subplot(1, 2, 1)
    plt.plot(range(1, epochs + 1), train_losses, label='Fine-tune Train Loss')
    plt.plot(range(1, epochs + 1), test_losses, label='Fine-tune Test Loss')
    plt.xlabel('Epochs')
    plt.ylabel('Loss')
    plt.title('Fine-tune Loss over Epochs')
    plt.legend()

    plt.subplot(1, 2, 2)
    plt.plot(range(1, epochs + 1), train_accuracies, label='Fine-tune Train Accuracy')
    plt.plot(range(1, epochs + 1), test_accuracies, label='Fine-tune Test Accuracy')
    plt.xlabel('Epochs')
    plt.ylabel('Accuracy')
    plt.title('Fine-tune Accuracy over Epochs')
    plt.legend()
    plt.show()

    return model



def evaluate_finetuned_model(model, data_loader, class_names):
    """Evaluate fine-tuned model and display metrics."""
    model.eval()
    all_labels, all_preds = [], []

    with torch.no_grad():
        for images, labels in data_loader:
            outputs = model(images)
            _, predicted = torch.max(outputs, 1)
            all_labels.extend(labels.cpu().numpy())
            all_preds.extend(predicted.cpu().numpy())

    # Ensure class names match the number of unique labels
    unique_labels = sorted(set(all_labels))

    # Fix: Create a mapping between original labels and class names
    label_to_classname = {label: str(label) for label in unique_labels}
    adjusted_class_names = [label_to_classname[label] for label in unique_labels]

    # Classification report
    print("Classification Report:")
    print(classification_report(all_labels, all_preds, target_names=adjusted_class_names))

    # Confusion matrix
    cm = confusion_matrix(all_labels, all_preds, labels=unique_labels)
    plt.figure(figsize=(8, 6))
    sns.heatmap(cm, annot=True, fmt="d", xticklabels=adjusted_class_names, yticklabels=adjusted_class_names, cmap="Blues")
    plt.xlabel('Predicted')
    plt.ylabel('True')
    plt.title('Confusion Matrix')
    plt.show()


# Define selected classes for fine-tuning
selected_classes = [3, 5, 6]  # Replace with the classes you extracted earlier


# Load extracted samples
finetune_dataset = load_extracted_samples(selected_classes)
```

```
finetune_loader = DataLoader(finetune_dataset, batch_size=64, shuffle=True)
```

```
<ipython-input-23-0c0ae1a23050>:10: FutureWarning: You are using `torch.load` with `weights_only=False` (the current def
  samples = torch.load(samples_path)
```

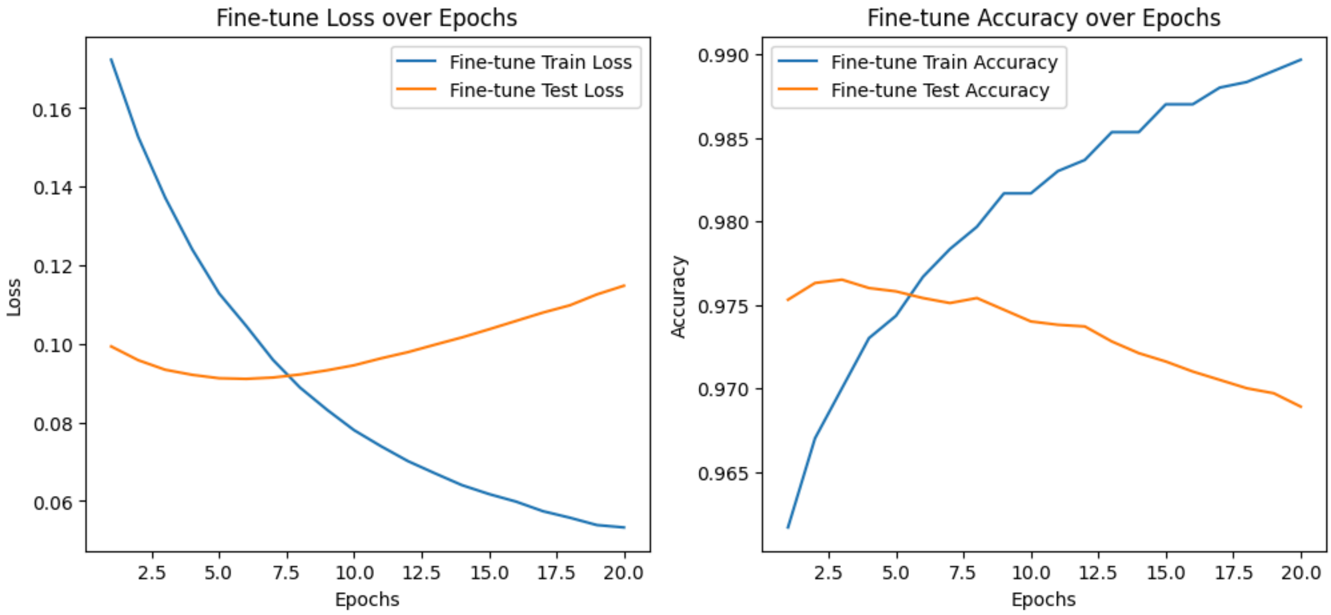
```
def adjust_state_dict(state_dict):
    adjusted_dict = {}
    for key, value in state_dict.items():
        new_key = key.replace("fc1", "fc.1").replace("fc2", "fc.3").replace("fc3", "fc.5")
        adjusted_dict[new_key] = value
    return adjusted_dict
```

```
import io

# Load the pretrained model safely
pretrained_model_path = 'pretrained_model.pth'
try:
    with open(pretrained_model_path, 'rb') as f:
        buffer = io.BytesIO(f.read())  # Load the model file into a buffer
        model = SimpleNN()
        state_dict = torch.load(buffer, weights_only=True)  # Use weights_only=True for security
        model.load_state_dict(state_dict)
except FileNotFoundError:
    print(f"Error: The file {pretrained_model_path} was not found.")
except Exception as e:
    print(f"An error occurred: {e}")
```

```
finetuned_model = fine_tune_model(
    pretrained_model_path=pretrained_model_path,
    finetune_loader=finetune_loader,
    test_loader=test_loader,
    epochs=20,  # Adjust the number of epochs as needed
    lr=0.00001  # Adjust the learning rate for fine-tuning
)
```

```
<ipython-input-25-874195b1a058>:5: FutureWarning: You are using `torch.load` with `weights_only=False` (the current defa
  model.load_state_dict(torch.load(pretrained_model_path))
Epoch 1/20 -> Train Loss: 0.1723, Train Acc: 0.9617, Test Loss: 0.0993, Test Acc: 0.9753
Epoch 2/20 -> Train Loss: 0.1527, Train Acc: 0.9670, Test Loss: 0.0958, Test Acc: 0.9763
Epoch 3/20 -> Train Loss: 0.1372, Train Acc: 0.9700, Test Loss: 0.0934, Test Acc: 0.9765
Epoch 4/20 -> Train Loss: 0.1241, Train Acc: 0.9730, Test Loss: 0.0921, Test Acc: 0.9760
Epoch 5/20 -> Train Loss: 0.1128, Train Acc: 0.9743, Test Loss: 0.0912, Test Acc: 0.9758
Epoch 6/20 -> Train Loss: 0.1046, Train Acc: 0.9767, Test Loss: 0.0911, Test Acc: 0.9754
Epoch 7/20 -> Train Loss: 0.0959, Train Acc: 0.9783, Test Loss: 0.0914, Test Acc: 0.9751
Epoch 8/20 -> Train Loss: 0.0889, Train Acc: 0.9797, Test Loss: 0.0922, Test Acc: 0.9754
Epoch 9/20 -> Train Loss: 0.0832, Train Acc: 0.9817, Test Loss: 0.0933, Test Acc: 0.9747
Epoch 10/20 -> Train Loss: 0.0780, Train Acc: 0.9817, Test Loss: 0.0945, Test Acc: 0.9740
Epoch 11/20 -> Train Loss: 0.0739, Train Acc: 0.9830, Test Loss: 0.0963, Test Acc: 0.9738
Epoch 12/20 -> Train Loss: 0.0701, Train Acc: 0.9837, Test Loss: 0.0979, Test Acc: 0.9737
Epoch 13/20 -> Train Loss: 0.0670, Train Acc: 0.9853, Test Loss: 0.0998, Test Acc: 0.9728
Epoch 14/20 -> Train Loss: 0.0640, Train Acc: 0.9853, Test Loss: 0.1016, Test Acc: 0.9721
Epoch 15/20 -> Train Loss: 0.0618, Train Acc: 0.9870, Test Loss: 0.1037, Test Acc: 0.9716
Epoch 16/20 -> Train Loss: 0.0598, Train Acc: 0.9870, Test Loss: 0.1058, Test Acc: 0.9710
Epoch 17/20 -> Train Loss: 0.0574, Train Acc: 0.9880, Test Loss: 0.1080, Test Acc: 0.9705
Epoch 18/20 -> Train Loss: 0.0557, Train Acc: 0.9883, Test Loss: 0.1098, Test Acc: 0.9700
Epoch 19/20 -> Train Loss: 0.0539, Train Acc: 0.9890, Test Loss: 0.1126, Test Acc: 0.9697
Epoch 20/20 -> Train Loss: 0.0533, Train Acc: 0.9897, Test Loss: 0.1148, Test Acc: 0.9689
```

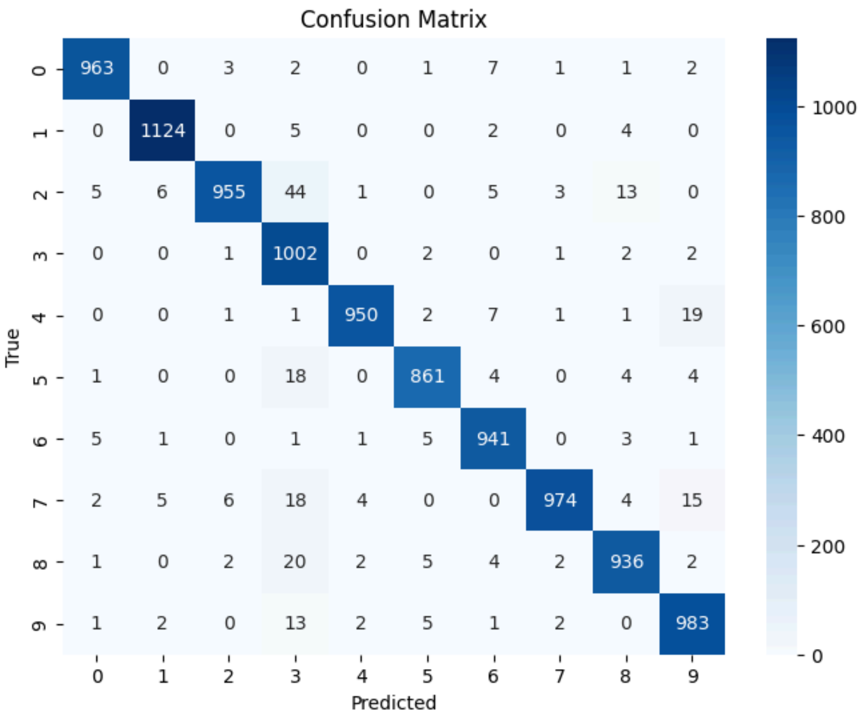


```
# Evaluate the fine-tuned model
class_names = [str(cls) for cls in selected_classes]
evaluate_finetuned_model(finetuned_model, test_loader, class_names)
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.98      0.98      0.98       980
           1       0.99      0.99      0.99      1135
           2       0.99      0.93      0.95      1032
           3       0.89      0.99      0.94      1010
           4       0.99      0.97      0.98       982
           5       0.98      0.97      0.97       892
           6       0.97      0.98      0.98       958
           7       0.99      0.95      0.97      1028
           8       0.97      0.96      0.96       974
           9       0.96      0.97      0.97      1009

    accuracy                           0.97     10000
   macro avg       0.97      0.97      0.97     10000
weighted avg       0.97      0.97      0.97     10000
```



	0	1	2	3	4	5	6	7	8	9
0	963	0	3	2	0	1	7	1	1	2
1	0	1124	0	5	0	0	2	0	4	0
2	5	6	955	44	1	0	5	3	13	0
3	0	0	1	1002	0	2	0	1	2	2
4	0	0	1	1	950	2	7	1	1	19
5	1	0	0	18	0	861	4	0	4	4
6	5	1	0	1	1	5	941	0	3	1
7	2	5	6	18	4	0	0	974	4	15
8	1	0	2	20	2	5	4	2	936	2
9	1	2	0	13	2	5	1	2	0	983

```
# Save the fine-tuned model
finetuned_model_path = 'finetuned_model.pth'  # Choose a path for your fine-tuned model
torch.save(finetuned_model.state_dict(), finetuned_model_path)
print(f"Fine-tuned model saved as '{finetuned_model_path}'")
```

```
Fine-tuned model saved as 'finetuned_model.pth'
```

```
# Function to compute task vector
def compute_task_vector(pretrained_model_path, finetuned_model_path):
    """Computes the task vector by subtracting pre-trained weights from fine-tuned weights."""
    # Load pre-trained model weights
    pretrained_state_dict = torch.load(pretrained_model_path)
    # Load fine-tuned model weights
    finetuned_state_dict = torch.load(finetuned_model_path)

    task_vector = {}
    for key in pretrained_state_dict.keys():
        task_vector[key] = finetuned_state_dict[key] - pretrained_state_dict[key]

    return task_vector


# Compute and print the task vector
task_vector = compute_task_vector(pretrained_model_path, finetuned_model_path)
print("Task Vector:")
for key, value in task_vector.items():
    print(f"{key}: {value.shape}")
```

```
Task Vector:
fc1.weight: torch.Size([128, 784])
fc1.bias: torch.Size([128])
fc2.weight: torch.Size([64, 128])
fc2.bias: torch.Size([64])
fc3.weight: torch.Size([10, 64])
fc3.bias: torch.Size([10])
```

```
<ipython-input-34-620f51f2661d>:5: FutureWarning: You are using `torch.load` with `weights_only=False` (the current defa
  pretrained_state_dict = torch.load(pretrained_model_path)
<ipython-input-34-620f51f2661d>:7: FutureWarning: You are using `torch.load` with `weights_only=False` (the current defa
  finetuned_state_dict = torch.load(finetuned_model_path)
```

```
# Save the task vector
task_vector_path = 'task_vector.pth'  # Choose a path to save the task vector
torch.save(task_vector, task_vector_path)
print(f"Task vector saved as '{task_vector_path}'")
```

```
Task vector saved as 'task_vector.pth'
```

Another model for training

```
# Load FashionMNIST dataset
def load_fashionmnist_data():
    """Load FashionMNIST dataset with normalization."""
    transform = transforms.Compose([
        transforms.ToTensor(),
        transforms.Normalize((0.5,), (0.5,))  # Normalize dataset
    ])
    train_dataset = datasets.FashionMNIST(root='data_fashion', train=True, transform=transform, download=True)
    test_dataset = datasets.FashionMNIST(root='data_fashion', train=False, transform=transform, download=True)
    return train_dataset, test_dataset
```

```
fashion_train_dataset, fashion_test_dataset = load_fashionmnist_data()
```

```
Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/train-images-idx3-ubyte.gz
Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/train-images-idx3-ubyte.gz to data_fashion/Fashio
100%|██████████| 26.4M/26.4M [00:02<00:00, 11.1MB/s]
Extracting data_fashion/FashionMNIST/raw/train-images-idx3-ubyte.gz to data_fashion/FashionMNIST/raw

Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/train-labels-idx1-ubyte.gz
Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/train-labels-idx1-ubyte.gz to data_fashion/Fashio
100%|██████████| 29.5k/29.5k [00:00<00:00, 171kB/s]
Extracting data_fashion/FashionMNIST/raw/train-labels-idx1-ubyte.gz to data_fashion/FashionMNIST/raw

Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/t10k-images-idx3-ubyte.gz
Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/t10k-images-idx3-ubyte.gz to data_fashion/Fashion
100%|██████████| 4.42M/4.42M [00:01<00:00, 3.10MB/s]
Extracting data_fashion/FashionMNIST/raw/t10k-images-idx3-ubyte.gz to data_fashion/FashionMNIST/raw

Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/t10k-labels-idx1-ubyte.gz
Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/t10k-labels-idx1-ubyte.gz to data_fashion/Fashion
100%|██████████| 5.15k/5.15k [00:00<00:00, 18.2MB/s]Extracting data_fashion/FashionMNIST/raw/t10k-labels-idx1-ubyte.gz t
```

```
# Create data loaders
fashion_train_loader = DataLoader(fashion_train_dataset, batch_size=64, shuffle=True)
fashion_test_loader = DataLoader(fashion_test_dataset, batch_size=64, shuffle=False)
```

```
# Initialize a new model (or load a pre-trained one if needed)
fashion_model = SimpleNN()
```

```
# Train the model on FashionMNIST
trained_fashion_model = train_model(fashion_model, fashion_train_loader, fashion_test_loader, epochs=20)
```

```
Epoch 1/20 - Training: 100%|██████████████████████████████████████| 938/938 [00:18<00:00, 50.89it/s]
Epoch 1/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:03<00:00, 46.10it/s]
Epoch 1/20 -> Train Loss: 0.5123, Test Loss: 0.4432, Train Acc: 0.8139, Test Acc: 0.8368
Epoch 2/20 - Training: 100%|██████████████████████████████████████| 938/938 [00:18<00:00, 50.01it/s]
Epoch 2/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 61.81it/s]
Epoch 2/20 -> Train Loss: 0.3768, Test Loss: 0.4054, Train Acc: 0.8620, Test Acc: 0.8545
Epoch 3/20 - Training: 100%|██████████████████████████████████████| 938/938 [00:19<00:00, 48.19it/s]
Epoch 3/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 61.42it/s]
Epoch 3/20 -> Train Loss: 0.3380, Test Loss: 0.3820, Train Acc: 0.8745, Test Acc: 0.8608
Epoch 4/20 - Training: 100%|██████████████████████████████████████| 938/938 [00:18<00:00, 49.93it/s]
Epoch 4/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 53.19it/s]
Epoch 4/20 -> Train Loss: 0.3138, Test Loss: 0.3821, Train Acc: 0.8834, Test Acc: 0.8611
Epoch 5/20 - Training: 100%|██████████████████████████████████████| 938/938 [00:19<00:00, 48.84it/s]
Epoch 5/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 62.30it/s]
Epoch 5/20 -> Train Loss: 0.2981, Test Loss: 0.3599, Train Acc: 0.8898, Test Acc: 0.8717
Epoch 6/20 - Training: 100%|██████████████████████████████████████| 938/938 [00:19<00:00, 48.65it/s]
Epoch 6/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 57.58it/s]
Epoch 6/20 -> Train Loss: 0.2829, Test Loss: 0.3417, Train Acc: 0.8955, Test Acc: 0.8784
Epoch 7/20 - Training: 100%|██████████████████████████████████████| 938/938 [00:18<00:00, 50.55it/s]
Epoch 7/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 60.45it/s]
Epoch 7/20 -> Train Loss: 0.2674, Test Loss: 0.3394, Train Acc: 0.9006, Test Acc: 0.8804
Epoch 8/20 - Training: 100%|██████████████████████████████████████| 938/938 [00:19<00:00, 48.49it/s]
Epoch 8/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 61.13it/s]
Epoch 8/20 -> Train Loss: 0.2600, Test Loss: 0.3396, Train Acc: 0.9024, Test Acc: 0.8813
Epoch 9/20 - Training: 100%|██████████████████████████████████████| 938/938 [00:20<00:00, 45.51it/s]
Epoch 9/20 - Validation: 100%|████████████████████████████████████| 157/157 [00:02<00:00, 56.93it/s]
Epoch 9/20 -> Train Loss: 0.2450, Test Loss: 0.3415, Train Acc: 0.9081, Test Acc: 0.8828
Epoch 10/20 - Training: 100%|█████████████████████████████████████| 938/938 [00:18<00:00, 50.95it/s]
Epoch 10/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:02<00:00, 61.71it/s]
Epoch 10/20 -> Train Loss: 0.2381, Test Loss: 0.3464, Train Acc: 0.9104, Test Acc: 0.8786
Epoch 11/20 - Training: 100%|█████████████████████████████████████| 938/938 [00:19<00:00, 48.64it/s]
Epoch 11/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:02<00:00, 61.47it/s]
Epoch 11/20 -> Train Loss: 0.2286, Test Loss: 0.3561, Train Acc: 0.9133, Test Acc: 0.8819
Epoch 12/20 - Training: 100%|█████████████████████████████████████| 938/938 [00:18<00:00, 50.11it/s]
Epoch 12/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:03<00:00, 45.87it/s]
Epoch 12/20 -> Train Loss: 0.2191, Test Loss: 0.3532, Train Acc: 0.9172, Test Acc: 0.8820
Epoch 13/20 - Training: 100%|█████████████████████████████████████| 938/938 [00:18<00:00, 49.79it/s]
Epoch 13/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:02<00:00, 61.43it/s]
Epoch 13/20 -> Train Loss: 0.2100, Test Loss: 0.3359, Train Acc: 0.9204, Test Acc: 0.8864
Epoch 14/20 - Training: 100%|█████████████████████████████████████| 938/938 [00:19<00:00, 47.75it/s]
Epoch 14/20 - Validation: 100%|███████████████████████████████████| 157/157 [00:02<00:00, 61.25it/s]
```