

Lab

Task :

1: Practice the implementation of optimization algorithms and compare the results of different optimization algorithms.

```
DeepNorn.py 2 ...
3
4 class DeepNorn(nn.Module):
5     Tabnine | Edit | Test | Explain | Document | Ask
6     def __init__(self, input_dim, hidden_dims, output_dim): # hidden_dim is a list, input_dim and output_dim are numbers
7         super(DeepNorn, self).__init__()
8         self.layers = nn.ModuleList()
9         self.norm_layers = nn.ModuleList()
10        self.residual_linear_layers = nn.ModuleList() # List to hold residual linear layers
11
12        # Build layers with residual connections and pre-normalization
13        for i, hidden_dim in enumerate(hidden_dims):
14            # Add normalization layer for each layer
15            self.norm_layers.append(nn.LayerNorm(input_dim))
16
17            # Add the linear transformation for the main layer
18            self.layers.append(nn.Linear(input_dim, hidden_dim))
19
20            # Add the linear transformation for the residual connection
21            self.residual_linear_layers.append(nn.Linear(input_dim, hidden_dim))
22
23            # Update input_dim for the next layer
24            input_dim = hidden_dim
25
26        # Final output layer
27        self.output_layer = nn.Linear(input_dim, output_dim)
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29        Tabnine | Edit | Test | Explain | Document | Ask
30        def forward(self, x):
31            relu = nn.ReLU()
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```

TransformerFFN.py ...

Feed-Forward Network (FFN).

"""

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```
def __init__(self, d_model, d_hidden):
```

"""

Args:

d_model: Dimension of input and output features (e.g., 512).

d_hidden: Dimension of the hidden layer in FFN (e.g., 2048).

"""

```
super(FeedForwardNetwork, self).__init__()
```

```
# Define two linear layers and GELU activation
```

```
self.fc1 = nn.Linear(d_model, d_hidden)
```

```
self.gelu = nn.GELU()
```

```
self.fc2 = nn.Linear(d_hidden, d_model)
```

Tabnine | Edit | Test | Explain | Document | Ask

```
def forward(self, x):
```

"""

Args:

x: Input tensor of shape (batch_size, seq_length, d_model).

Returns:

output: Output tensor of shape (batch_size, seq_length, d_model).

"""

```
x = self.fc1(x) # First linear transformation
```

```
x = self.gelu(x) # GELU activation
```

```
x = self.fc2(x) # Second linear transformation
```

```
return x
```

```
class TransformerEncoderLayer(nn.Module):
```

"""

Transformer Encoder Layer.

"""

Tabnine | Edit | Test | Explain | Document | Ask

```
def __init__(self, d_model, num_heads, d_hidden, dropout=0.1):
```

"""

Args:

d_model: Dimension of input features (e.g., 512).

num_heads: Number of attention heads (e.g., 8).

d_hidden: Dimension of the hidden layer in FFN (e.g., 2048).

dropout: Dropout probability (e.g., 0.1).

"""

```
super(TransformerEncoderLayer, self).__init__()
```

```
self.mha = MultiHeadAttention(d_model, num_heads) # Multi-head attention module
```

```
self.ffn = FeedForwardNetwork(d_model, d_hidden) # Feed-forward network
```

```
self.norm1 = nn.LayerNorm(d_model) # LayerNorm for MHA output
```

```
self.norm2 = nn.LayerNorm(d_model) # LayerNorm for FFN output
```

```
self.dropout = nn.Dropout(dropout) # Dropout for regularization
```

Tabnine | Edit | Test | Explain | Document | Ask

```
def forward(self, x):
```

"""

Args:

x: Input tensor of shape (batch_size, seq_length, d_model).

Returns:

output: Output tensor of shape (batch_size, seq_length, d_model).

"""

```
# Multi-Head Attention + Residual Connection + LayerNorm
```

```
attn_output = self.mha(x)
```

```
x = x + self.dropout(attn_output) # Residual connection
```

```
x = self.norm1(x) # Layer normalization
```

```
# Feed-Forward Network + Residual Connection + LayerNorm
```

```
ffn_output = self.ffn(x)
```

Task3

```
.import torch
import torch.nn as nn
import torch.optim as optim
import torchvision
import torchvision.transforms as transforms
from torch.utils.data import DataLoader
import time

# Define the CNN model
class CNN_Model(nn.Module):
    def __init__(self, num_classes=10):
        super(CNN_Model, self).__init__()

        # 4+ convolutional layers with ReLU activation
        self.conv1 = nn.Conv2d(3, 32, kernel_size=3, padding=1)
        self.conv2 = nn.Conv2d(32, 64, kernel_size=3, padding=1)
        self.conv3 = nn.Conv2d(64, 128, kernel_size=3, padding=1)
        self.conv4 = nn.Conv2d(128, 256, kernel_size=3, padding=1)

        self.pool = nn.MaxPool2d(2, 2)
        self.fc1 = nn.Linear(256 * 8 * 8, 512)
        self.fc2 = nn.Linear(512, num_classes)

    def forward(self, x):
        x = self.pool(torch.relu(self.conv1(x)))
        x = self.pool(torch.relu(self.conv2(x)))
        x = self.pool(torch.relu(self.conv3(x)))
        x = self.pool(torch.relu(self.conv4(x)))
```

```
# Flatten the output from convolutional layers
```

```
x = x.view(-1, 256 * 8 * 8)
```

```
x = torch.relu(self.fc1(x))
```

```
x = self.fc2(x)
```

```
return x
```

```
# Define function to load the dataset
```

```
def load_dataset(dataset_name):
```

```
    transform = transforms.Compose([transforms.ToTensor(),  
    transforms.Normalize((0.5, 0.5, 0.5), (0.5, 0.5, 0.5))])
```

```
    if dataset_name == 'CIFAR-10':
```

```
        trainset = torchvision.datasets.CIFAR10(root='./data', train=True,  
download=True, transform=transform)
```

```
        testset = torchvision.datasets.CIFAR10(root='./data', train=False,  
download=True, transform=transform)
```

```
        num_classes = 10
```

```
    elif dataset_name == 'FashionMNIST':
```

```
        trainset = torchvision.datasets.FashionMNIST(root='./data', train=True,  
download=True, transform=transform)
```

```
        testset = torchvision.datasets.FashionMNIST(root='./data', train=False,  
download=True, transform=transform)
```

```
        num_classes = 10
```

```
    else:
```

```
        trainset = torchvision.datasets.MNIST(root='./data', train=True,  
download=True, transform=transform)
```

```
        testset = torchvision.datasets.MNIST(root='./data', train=False,  
download=True, transform=transform)
```

```
num_classes = 10
```

```
trainloader = DataLoader(trainset, batch_size=64, shuffle=True)
```

```
testloader = DataLoader(testset, batch_size=64, shuffle=False)
```

```
return trainloader, testloader, num_classes
```

```
# Define function to train the model
```

```
def train_model(model, trainloader, testloader, device, epochs=5):
```

```
    criterion = nn.CrossEntropyLoss()
```

```
    optimizer = optim.Adam(model.parameters(), lr=0.001)
```

```
    start_time = time.time()
```

```
    for epoch in range(epochs):
```

```
        model.train()
```

```
        running_loss = 0.0
```

```
        correct = 0
```

```
        total = 0
```

```
        for inputs, labels in trainloader:
```

```
            inputs, labels = inputs.to(device), labels.to(device)
```

```
            optimizer.zero_grad()
```

```
            outputs = model(inputs)
```

```
            loss = criterion(outputs, labels)
```

```
            loss.backward()
```

```
            optimizer.step()
```

```
            running_loss += loss.item()
```

```

_, predicted = torch.max(outputs.data, 1)
total += labels.size(0)
correct += (predicted == labels).sum().item()

accuracy = 100 * correct / total
print(f'Epoch {epoch+1}/{epochs} - Loss:
{running_loss/len(trainloader)} - Accuracy: {accuracy}%')

end_time = time.time()
elapsed_time = end_time - start_time
return elapsed_time

# Define function to test the model
def test_model(model, testloader, device):
    model.eval()
    correct = 0
    total = 0

    with torch.no_grad():
        for inputs, labels in testloader:
            inputs, labels = inputs.to(device), labels.to(device)
            outputs = model(inputs)
            _, predicted = torch.max(outputs.data, 1)
            total += labels.size(0)
            correct += (predicted == labels).sum().item()

    accuracy = 100 * correct / total
    print(f'Test Accuracy: {accuracy}%')
    return accuracy

```

```

# Main function to run the training and testing
def run_experiment(dataset_name, epochs_list=[5, 10, 20], use_gpu=True):
    device = torch.device("cuda" if use_gpu and torch.cuda.is_available() else
"cpu")
    print(f"Training on device: {device}")

    # Load dataset
    trainloader, testloader, num_classes = load_dataset(dataset_name)

    # Initialize model
    model = CNN_Model(num_classes=num_classes).to(device)

    # Train and test for each epoch count
    for epochs in epochs_list:
        print(f"\nTraining for {epochs} epochs:")
        elapsed_time = train_model(model, trainloader, testloader, device,
epochs=epochs)
        print(f"Training time for {epochs} epochs: {elapsed_time:.2f} seconds")
        test_model(model, testloader, device)

# Run experiment for CIFAR-10 dataset (you can change the dataset to
'FashionMNIST' or 'MNIST')
run_experiment(dataset_name='CIFAR-10', epochs_list=[5, 10, 20],
use_gpu=True)

```