

```
In [1]: import torch
import matplotlib.pyplot as plt
import numpy as np
from torch.optim import SGD
import torch.nn as nn
import torchvision
from torchvision.transforms import transforms
device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
device
```

Out[1]: device(type='cpu')

- Download dữ liệu CIFAR10 sau đó chia thành 2 tập dữ liệu train và validation.
- Chuẩn hóa dữ liệu với mean = 0.5 và std = 0.5

```
In [2]: import torch.utils
import torch.utils.data

transform = transforms.Compose([transforms.ToTensor(), transforms.Normalize(
trainset = torchvision.datasets.CIFAR10(root='CIFAR10', train=True, downl
trainloader = torch.utils.data.DataLoader(trainset, batch_size=1024, num_
testset = torchvision.datasets.CIFAR10(root='CIFAR10', train=True, downlo
testloader = torch.utils.data.DataLoader(testset, batch_size=1024, num_wo
```

Downloading <https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz> to CIFAR10/cifar-10-python.tar.gz

100%|██████████| 170498071/170498071 [00:03<00:00, 52184934.75it/s]

Extracting CIFAR10/cifar-10-python.tar.gz to CIFAR10

/opt/conda/lib/python3.10/site-packages/torch/utils/data/dataloader.py:557: UserWarning: This DataLoader will create 100 worker processes in total. Our suggested max number of worker in current system is 4, which is smaller than what this DataLoader is going to create. Please be aware that excessive worker creation might get DataLoader running slow or even freeze, lower the worker number to avoid potential slowness/freeze if necessary.

warnings.warn(\_create\_warning\_msg(
Files already downloaded and verified

- Hiển thị 5 ảnh đầu tiên trong tập dữ liệu testing

```
In [3]: def imshow(img):
img = img * 0.5 + 0.5
np_img = img.numpy()
plt.imshow(np.transpose(np_img, (1, 2, 0)))
plt.show()

for i, (images, labels) in enumerate(testloader, 0):
imshow(torchvision.utils.make_grid(images[:5]))
break
```



- Xây dựng model MLP cơ bản để train tập dữ liệu CIFAR10

```
In [8]: def getModel(n_features):
        model = nn.Sequential(
            nn.Flatten(),
            nn.Linear(n_features, 256),
            nn.ReLU(),
            nn.Linear(256, 10)
        ).to(device)
        return model
```

- Khởi tạo hàm loss function và phương thức optimizer

```
In [9]: n_features = 32*32*3
        model = getModel(n_features)
        lr = 0.01
        optim = SGD(params = model.parameters(), lr = lr)
        loss_fn = nn.CrossEntropyLoss()
        model
```

```
Out[9]: Sequential(
  (0): Flatten(start_dim=1, end_dim=-1)
  (1): Linear(in_features=3072, out_features=256, bias=True)
  (2): ReLU()
  (3): Linear(in_features=256, out_features=10, bias=True)
)
```

- Xây dựng hàm đánh giá model

```
In [10]: def evaluate(model, testloader, criterion):
        model.eval()
        test_loss = 0.0
        correct = 0
        total = 0
        for images, labels in testloader:
            images, labels = images.to(device), labels.to(device)

            outputs = model(images)
            loss = criterion(outputs, labels)
            test_loss += loss.item()

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

```

accuracy = 100 * correct / total
test_loss = test_loss / len(testloader)
return test_loss, accuracy

```

- Bắt đầu training và đánh giá model.

```

In [15]: n_epochs = 10
         train_losses = []
         train_accuracies = []
         test_losses = []
         test_accuracies = [0]

         epoch = 0
         while (epoch <= n_epochs):
             running_loss = 0.0
             running_correct = 0
             total = 0
             for i, (inputs, labels) in enumerate(trainloader, 0):

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

                 optim.zero_grad() # khởi tạo giá trị đạo hàm = 0

                 outputs = model(inputs)
                 loss = loss_fn(outputs, labels)
                 running_loss += loss.item()

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

                 # 2 dòng dưới đây là lan truyền ngược và optimizer tham số w và b
                 loss.backward()
                 optim.step()

             epoch_accuracy = 100 * running_correct / total
             epoch_loss = running_loss / (i + 1)
             test_loss, test_accuracy = evaluate(model, testloader, loss_fn)
             print(f"Epoch [{epoch + 1}/{n_epochs}], Loss: {epoch_loss:.4f}, Accur

             train_losses.append(epoch_loss)
             train_accuracies.append(epoch_accuracy)
             test_losses.append(test_loss)
             test_accuracies.append(test_accuracy)
             epoch += 1

```

```

Epoch [1/10], Loss: 1.6051, Accuracy: 44.40%, Test Loss: 1.6009, Test Accuracy: 44.52%
Epoch [2/10], Loss: 1.5996, Accuracy: 44.58%, Test Loss: 1.5958, Test Accuracy: 44.74%
Epoch [3/10], Loss: 1.5944, Accuracy: 44.80%, Test Loss: 1.5908, Test Accuracy: 44.94%

```

```
Traceback (most recent call last):
  File "/opt/conda/lib/python3.10/multiprocessing/queues.py", line 239, in
_feed
    reader_close()
  File "/opt/conda/lib/python3.10/multiprocessing/connection.py", line 177
, in close
    self._close()
  File "/opt/conda/lib/python3.10/multiprocessing/connection.py", line 361
, in _close
    _close(self._handle)
OSError: [Errno 9] Bad file descriptor
Traceback (most recent call last):
  File "/opt/conda/lib/python3.10/multiprocessing/queues.py", line 239, in
_feed
    reader_close()
  File "/opt/conda/lib/python3.10/multiprocessing/connection.py", line 177
, in close
    self._close()
  File "/opt/conda/lib/python3.10/multiprocessing/connection.py", line 361
, in _close
    _close(self._handle)
OSError: [Errno 9] Bad file descriptor
Exception ignored in: <function _ConnectionBase.__del__ at 0x7a9f1fa82710>
Traceback (most recent call last):
  File "/opt/conda/lib/python3.10/multiprocessing/connection.py", line 132
, in __del__
Traceback (most recent call last):
  File "/opt/conda/lib/python3.10/multiprocessing/queues.py", line 239, in
_feed
    reader_close()
  File "/opt/conda/lib/python3.10/multiprocessing/connection.py", line 177
, in close
    self._close()
  File "/opt/conda/lib/python3.10/multiprocessing/connection.py", line 361
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  File "/opt/conda/lib/python3.10/multiprocessing/connection.py", line 361
, in _close
    _close(self._handle)
OSError: [Errno 9] Bad file descriptor
self._close()
```

```
File "/opt/conda/lib/python3.10/multiprocessing/connection.py", line 361
, in _close
Traceback (most recent call last):
  File "/opt/conda/lib/python3.10/multiprocessing/queues.py", line 239, in
_feed
    reader_close()
  File "/opt/conda/lib/python3.10/multiprocessing/connection.py", line 177
, in close
    self._close()
  File "/opt/conda/lib/python3.10/multiprocessing/connection.py", line 361
, in _close
    _close(self._handle)
OSError: [Errno 9] Bad file descriptor
    _close(self._handle)
OSError: [Errno 9] Bad file descriptor
```

Epoch [4/10], Loss: 1.5895, Accuracy: 44.96%, Test Loss: 1.5860, Test Accuracy: 45.07%

Epoch [5/10], Loss: 1.5848, Accuracy: 45.12%, Test Loss: 1.5811, Test Accuracy: 45.25%

Epoch [6/10], Loss: 1.5801, Accuracy: 45.31%, Test Loss: 1.5766, Test Accuracy: 45.44%

Epoch [7/10], Loss: 1.5755, Accuracy: 45.44%, Test Loss: 1.5722, Test Accuracy: 45.66%

Epoch [8/10], Loss: 1.5711, Accuracy: 45.62%, Test Loss: 1.5676, Test Accuracy: 45.71%

Epoch [9/10], Loss: 1.5666, Accuracy: 45.77%, Test Loss: 1.5634, Test Accuracy: 45.88%

Epoch [10/10], Loss: 1.5626, Accuracy: 45.91%, Test Loss: 1.5592, Test Accuracy: 46.02%

Epoch [11/10], Loss: 1.5583, Accuracy: 46.02%, Test Loss: 1.5550, Test Accuracy: 46.13%

Epoch [12/10], Loss: 1.5545, Accuracy: 46.22%, Test Loss: 1.5509, Test Accuracy: 46.30%

Epoch [13/10], Loss: 1.5504, Accuracy: 46.31%, Test Loss: 1.5471, Test Accuracy: 46.50%

Epoch [14/10], Loss: 1.5465, Accuracy: 46.40%, Test Loss: 1.5432, Test Accuracy: 46.60%

Epoch [15/10], Loss: 1.5426, Accuracy: 46.51%, Test Loss: 1.5395, Test Accuracy: 46.70%

Epoch [16/10], Loss: 1.5390, Accuracy: 46.69%, Test Loss: 1.5357, Test Accuracy: 46.86%

Epoch [17/10], Loss: 1.5354, Accuracy: 46.83%, Test Loss: 1.5321, Test Accuracy: 46.99%

Epoch [18/10], Loss: 1.5317, Accuracy: 47.06%, Test Loss: 1.5284, Test Accuracy: 47.04%

Epoch [19/10], Loss: 1.5280, Accuracy: 47.12%, Test Loss: 1.5250, Test Accuracy: 47.20%

Epoch [20/10], Loss: 1.5248, Accuracy: 47.26%, Test Loss: 1.5215, Test Accuracy: 47.35%

Epoch [21/10], Loss: 1.5212, Accuracy: 47.37%, Test Loss: 1.5180, Test Accuracy: 47.53%

Epoch [22/10], Loss: 1.5176, Accuracy: 47.58%, Test Loss: 1.5147, Test Accuracy: 47.68%

Epoch [23/10], Loss: 1.5145, Accuracy: 47.65%, Test Loss: 1.5112, Test Accuracy: 47.79%

Epoch [24/10], Loss: 1.5111, Accuracy: 47.74%, Test Loss: 1.5081, Test Accuracy: 47.88%

Epoch [25/10], Loss: 1.5080, Accuracy: 47.87%, Test Loss: 1.5048, Test Accuracy: 47.95%

Epoch [26/10], Loss: 1.5047, Accuracy: 48.02%, Test Loss: 1.5015, Test Accuracy: 48.15%

Epoch [27/10], Loss: 1.5013, Accuracy: 48.14%, Test Loss: 1.4983, Test Accuracy: 48.22%

Epoch [28/10], Loss: 1.4984, Accuracy: 48.24%, Test Loss: 1.4953, Test Accuracy: 48.39%

Epoch [29/10], Loss: 1.4954, Accuracy: 48.40%, Test Loss: 1.4921, Test Accuracy: 48.54%

Epoch [30/10], Loss: 1.4920, Accuracy: 48.54%, Test Loss: 1.4891, Test Accuracy: 48.60%

Epoch [31/10], Loss: 1.4891, Accuracy: 48.61%, Test Loss: 1.4860, Test Accuracy: 48.76%

Epoch [32/10], Loss: 1.4860, Accuracy: 48.77%, Test Loss: 1.4830, Test Accuracy: 48.87%

Epoch [33/10], Loss: 1.4831, Accuracy: 48.81%, Test Loss: 1.4802, Test Accuracy: 48.89%

Epoch [34/10], Loss: 1.4802, Accuracy: 48.92%, Test Loss: 1.4772, Test Accuracy: 49.01%  
Epoch [35/10], Loss: 1.4773, Accuracy: 48.98%, Test Loss: 1.4743, Test Accuracy: 49.11%  
Epoch [36/10], Loss: 1.4746, Accuracy: 49.09%, Test Loss: 1.4714, Test Accuracy: 49.17%  
Epoch [37/10], Loss: 1.4716, Accuracy: 49.11%, Test Loss: 1.4686, Test Accuracy: 49.33%  
Epoch [38/10], Loss: 1.4686, Accuracy: 49.26%, Test Loss: 1.4657, Test Accuracy: 49.38%  
Epoch [39/10], Loss: 1.4660, Accuracy: 49.43%, Test Loss: 1.4631, Test Accuracy: 49.55%  
Epoch [40/10], Loss: 1.4631, Accuracy: 49.55%, Test Loss: 1.4600, Test Accuracy: 49.65%  
Epoch [41/10], Loss: 1.4604, Accuracy: 49.56%, Test Loss: 1.4575, Test Accuracy: 49.75%  
Epoch [42/10], Loss: 1.4574, Accuracy: 49.74%, Test Loss: 1.4545, Test Accuracy: 49.88%  
Epoch [43/10], Loss: 1.4550, Accuracy: 49.81%, Test Loss: 1.4520, Test Accuracy: 49.92%  
Epoch [44/10], Loss: 1.4525, Accuracy: 49.96%, Test Loss: 1.4492, Test Accuracy: 50.06%  
Epoch [45/10], Loss: 1.4494, Accuracy: 50.04%, Test Loss: 1.4467, Test Accuracy: 50.18%  
Epoch [46/10], Loss: 1.4468, Accuracy: 50.15%, Test Loss: 1.4439, Test Accuracy: 50.33%  
Epoch [47/10], Loss: 1.4442, Accuracy: 50.23%, Test Loss: 1.4412, Test Accuracy: 50.48%  
Epoch [48/10], Loss: 1.4415, Accuracy: 50.41%, Test Loss: 1.4387, Test Accuracy: 50.50%  
Epoch [49/10], Loss: 1.4388, Accuracy: 50.48%, Test Loss: 1.4359, Test Accuracy: 50.61%  
Epoch [50/10], Loss: 1.4364, Accuracy: 50.60%, Test Loss: 1.4333, Test Accuracy: 50.74%  
Epoch [51/10], Loss: 1.4338, Accuracy: 50.61%, Test Loss: 1.4308, Test Accuracy: 50.81%  
Epoch [52/10], Loss: 1.4310, Accuracy: 50.79%, Test Loss: 1.4282, Test Accuracy: 50.89%  
Epoch [53/10], Loss: 1.4288, Accuracy: 50.89%, Test Loss: 1.4257, Test Accuracy: 51.02%  
Epoch [54/10], Loss: 1.4263, Accuracy: 50.95%, Test Loss: 1.4230, Test Accuracy: 51.07%  
Epoch [55/10], Loss: 1.4237, Accuracy: 51.08%, Test Loss: 1.4206, Test Accuracy: 51.12%  
Epoch [56/10], Loss: 1.4212, Accuracy: 51.22%, Test Loss: 1.4180, Test Accuracy: 51.24%  
Epoch [57/10], Loss: 1.4187, Accuracy: 51.20%, Test Loss: 1.4156, Test Accuracy: 51.34%  
Epoch [58/10], Loss: 1.4159, Accuracy: 51.38%, Test Loss: 1.4131, Test Accuracy: 51.45%  
Epoch [59/10], Loss: 1.4138, Accuracy: 51.45%, Test Loss: 1.4107, Test Accuracy: 51.53%  
Epoch [60/10], Loss: 1.4114, Accuracy: 51.51%, Test Loss: 1.4081, Test Accuracy: 51.73%  
Epoch [61/10], Loss: 1.4089, Accuracy: 51.62%, Test Loss: 1.4059, Test Accuracy: 51.80%  
Epoch [62/10], Loss: 1.4064, Accuracy: 51.72%, Test Loss: 1.4033, Test Accuracy: 51.88%  
Epoch [63/10], Loss: 1.4039, Accuracy: 51.90%, Test Loss: 1.4009, Test Accuracy: 51.98%

Epoch [64/10], Loss: 1.4015, Accuracy: 51.99%, Test Loss: 1.3984, Test Accuracy: 52.05%  
Epoch [65/10], Loss: 1.3991, Accuracy: 52.02%, Test Loss: 1.3961, Test Accuracy: 52.11%  
Epoch [66/10], Loss: 1.3969, Accuracy: 52.11%, Test Loss: 1.3936, Test Accuracy: 52.18%  
Epoch [67/10], Loss: 1.3942, Accuracy: 52.15%, Test Loss: 1.3912, Test Accuracy: 52.36%  
Epoch [68/10], Loss: 1.3922, Accuracy: 52.26%, Test Loss: 1.3888, Test Accuracy: 52.39%  
Epoch [69/10], Loss: 1.3895, Accuracy: 52.35%, Test Loss: 1.3867, Test Accuracy: 52.51%  
Epoch [70/10], Loss: 1.3876, Accuracy: 52.50%, Test Loss: 1.3844, Test Accuracy: 52.61%  
Epoch [71/10], Loss: 1.3850, Accuracy: 52.58%, Test Loss: 1.3822, Test Accuracy: 52.59%  
Epoch [72/10], Loss: 1.3827, Accuracy: 52.59%, Test Loss: 1.3796, Test Accuracy: 52.73%  
Epoch [73/10], Loss: 1.3804, Accuracy: 52.75%, Test Loss: 1.3773, Test Accuracy: 52.83%  
Epoch [74/10], Loss: 1.3779, Accuracy: 52.81%, Test Loss: 1.3750, Test Accuracy: 52.88%  
Epoch [75/10], Loss: 1.3761, Accuracy: 52.85%, Test Loss: 1.3728, Test Accuracy: 53.01%  
Epoch [76/10], Loss: 1.3735, Accuracy: 52.96%, Test Loss: 1.3706, Test Accuracy: 53.03%  
Epoch [77/10], Loss: 1.3713, Accuracy: 53.00%, Test Loss: 1.3685, Test Accuracy: 53.14%  
Epoch [78/10], Loss: 1.3694, Accuracy: 53.11%, Test Loss: 1.3660, Test Accuracy: 53.29%  
Epoch [79/10], Loss: 1.3669, Accuracy: 53.22%, Test Loss: 1.3638, Test Accuracy: 53.44%  
Epoch [80/10], Loss: 1.3645, Accuracy: 53.34%, Test Loss: 1.3618, Test Accuracy: 53.43%  
Epoch [81/10], Loss: 1.3624, Accuracy: 53.34%, Test Loss: 1.3594, Test Accuracy: 53.55%  
Epoch [82/10], Loss: 1.3601, Accuracy: 53.43%, Test Loss: 1.3571, Test Accuracy: 53.63%  
Epoch [83/10], Loss: 1.3580, Accuracy: 53.62%, Test Loss: 1.3551, Test Accuracy: 53.65%  
Epoch [84/10], Loss: 1.3560, Accuracy: 53.64%, Test Loss: 1.3529, Test Accuracy: 53.81%  
Epoch [85/10], Loss: 1.3537, Accuracy: 53.65%, Test Loss: 1.3507, Test Accuracy: 53.81%  
Epoch [86/10], Loss: 1.3517, Accuracy: 53.77%, Test Loss: 1.3486, Test Accuracy: 53.97%  
Epoch [87/10], Loss: 1.3494, Accuracy: 53.87%, Test Loss: 1.3464, Test Accuracy: 54.04%  
Epoch [88/10], Loss: 1.3474, Accuracy: 53.98%, Test Loss: 1.3445, Test Accuracy: 54.00%  
Epoch [89/10], Loss: 1.3454, Accuracy: 54.01%, Test Loss: 1.3425, Test Accuracy: 54.17%  
Epoch [90/10], Loss: 1.3432, Accuracy: 54.10%, Test Loss: 1.3403, Test Accuracy: 54.12%  
Epoch [91/10], Loss: 1.3413, Accuracy: 54.17%, Test Loss: 1.3379, Test Accuracy: 54.30%  
Epoch [92/10], Loss: 1.3391, Accuracy: 54.27%, Test Loss: 1.3358, Test Accuracy: 54.35%  
Epoch [93/10], Loss: 1.3369, Accuracy: 54.38%, Test Loss: 1.3339, Test Accuracy: 54.42%



Epoch [94/10], Loss: 1.3348, Accuracy: 54.44%, Test Loss: 1.3320, Test Accuracy: 54.43%

Epoch [95/10], Loss: 1.3329, Accuracy: 54.44%, Test Loss: 1.3297, Test Accuracy: 54.59%

Epoch [96/10], Loss: 1.3307, Accuracy: 54.58%, Test Loss: 1.3277, Test Accuracy: 54.73%

Epoch [97/10], Loss: 1.3289, Accuracy: 54.61%, Test Loss: 1.3256, Test Accuracy: 54.71%

Epoch [98/10], Loss: 1.3268, Accuracy: 54.69%, Test Loss: 1.3237, Test Accuracy: 54.82%

Epoch [99/10], Loss: 1.3246, Accuracy: 54.78%, Test Loss: 1.3216, Test Accuracy: 54.88%

Epoch [100/10], Loss: 1.3227, Accuracy: 54.87%, Test Loss: 1.3194, Test Accuracy: 54.96%

Epoch [101/10], Loss: 1.3209, Accuracy: 54.90%, Test Loss: 1.3176, Test Accuracy: 54.98%

Epoch [102/10], Loss: 1.3188, Accuracy: 55.01%, Test Loss: 1.3155, Test Accuracy: 55.13%

Epoch [103/10], Loss: 1.3167, Accuracy: 55.03%, Test Loss: 1.3135, Test Accuracy: 55.09%

Epoch [104/10], Loss: 1.3149, Accuracy: 55.03%, Test Loss: 1.3116, Test Accuracy: 55.22%

Epoch [105/10], Loss: 1.3128, Accuracy: 55.15%, Test Loss: 1.3096, Test Accuracy: 55.30%

Epoch [106/10], Loss: 1.3106, Accuracy: 55.23%, Test Loss: 1.3076, Test Accuracy: 55.37%

Epoch [107/10], Loss: 1.3087, Accuracy: 55.36%, Test Loss: 1.3058, Test Accuracy: 55.36%

Epoch [108/10], Loss: 1.3067, Accuracy: 55.40%, Test Loss: 1.3037, Test Accuracy: 55.55%

Epoch [109/10], Loss: 1.3050, Accuracy: 55.44%, Test Loss: 1.3019, Test Accuracy: 55.64%

Epoch [110/10], Loss: 1.3031, Accuracy: 55.59%, Test Loss: 1.2999, Test Accuracy: 55.62%

Epoch [111/10], Loss: 1.3010, Accuracy: 55.62%, Test Loss: 1.2979, Test Accuracy: 55.70%

Epoch [112/10], Loss: 1.2993, Accuracy: 55.66%, Test Loss: 1.2960, Test Accuracy: 55.79%

Epoch [113/10], Loss: 1.2975, Accuracy: 55.70%, Test Loss: 1.2940, Test Accuracy: 55.85%

Epoch [114/10], Loss: 1.2956, Accuracy: 55.74%, Test Loss: 1.2923, Test Accuracy: 55.97%

Epoch [115/10], Loss: 1.2937, Accuracy: 55.91%, Test Loss: 1.2904, Test Accuracy: 55.99%

Epoch [116/10], Loss: 1.2917, Accuracy: 55.93%, Test Loss: 1.2884, Test Accuracy: 56.07%

Epoch [117/10], Loss: 1.2899, Accuracy: 55.97%, Test Loss: 1.2867, Test Accuracy: 56.17%

Epoch [118/10], Loss: 1.2879, Accuracy: 56.01%, Test Loss: 1.2850, Test Accuracy: 56.26%

Epoch [119/10], Loss: 1.2862, Accuracy: 56.13%, Test Loss: 1.2830, Test Accuracy: 56.26%

Epoch [120/10], Loss: 1.2843, Accuracy: 56.21%, Test Loss: 1.2810, Test Accuracy: 56.28%

Epoch [121/10], Loss: 1.2826, Accuracy: 56.20%, Test Loss: 1.2792, Test Accuracy: 56.39%

Epoch [122/10], Loss: 1.2808, Accuracy: 56.23%, Test Loss: 1.2776, Test Accuracy: 56.57%

Epoch [123/10], Loss: 1.2788, Accuracy: 56.39%, Test Loss: 1.2758, Test Accuracy: 56.51%

Epoch [124/10], Loss: 1.2770, Accuracy: 56.44%, Test Loss: 1.2740, Test Accuracy: 56.54%

Epoch [125/10], Loss: 1.2753, Accuracy: 56.52%, Test Loss: 1.2721, Test Accuracy: 56.64%

Epoch [126/10], Loss: 1.2735, Accuracy: 56.65%, Test Loss: 1.2702, Test Accuracy: 56.73%

Epoch [127/10], Loss: 1.2718, Accuracy: 56.64%, Test Loss: 1.2685, Test Accuracy: 56.74%

Epoch [128/10], Loss: 1.2699, Accuracy: 56.71%, Test Loss: 1.2666, Test Accuracy: 56.80%

Epoch [129/10], Loss: 1.2683, Accuracy: 56.70%, Test Loss: 1.2651, Test Accuracy: 56.88%

Epoch [130/10], Loss: 1.2666, Accuracy: 56.80%, Test Loss: 1.2633, Test Accuracy: 56.93%

Epoch [131/10], Loss: 1.2645, Accuracy: 56.91%, Test Loss: 1.2614, Test Accuracy: 57.04%

Epoch [132/10], Loss: 1.2628, Accuracy: 56.94%, Test Loss: 1.2595, Test Accuracy: 57.03%

Epoch [133/10], Loss: 1.2610, Accuracy: 56.95%, Test Loss: 1.2582, Test Accuracy: 57.19%

Epoch [134/10], Loss: 1.2594, Accuracy: 57.12%, Test Loss: 1.2560, Test Accuracy: 57.24%

Epoch [135/10], Loss: 1.2576, Accuracy: 57.14%, Test Loss: 1.2541, Test Accuracy: 57.29%

Epoch [136/10], Loss: 1.2559, Accuracy: 57.26%, Test Loss: 1.2525, Test Accuracy: 57.31%

Epoch [137/10], Loss: 1.2544, Accuracy: 57.25%, Test Loss: 1.2510, Test Accuracy: 57.43%

Epoch [138/10], Loss: 1.2524, Accuracy: 57.32%, Test Loss: 1.2492, Test Accuracy: 57.44%

Epoch [139/10], Loss: 1.2506, Accuracy: 57.42%, Test Loss: 1.2473, Test Accuracy: 57.50%

Epoch [140/10], Loss: 1.2492, Accuracy: 57.46%, Test Loss: 1.2459, Test Accuracy: 57.57%

Epoch [141/10], Loss: 1.2476, Accuracy: 57.52%, Test Loss: 1.2441, Test Accuracy: 57.62%

Epoch [142/10], Loss: 1.2452, Accuracy: 57.56%, Test Loss: 1.2424, Test Accuracy: 57.67%

Epoch [143/10], Loss: 1.2441, Accuracy: 57.63%, Test Loss: 1.2403, Test Accuracy: 57.79%

Epoch [144/10], Loss: 1.2424, Accuracy: 57.71%, Test Loss: 1.2386, Test Accuracy: 57.84%

Epoch [145/10], Loss: 1.2407, Accuracy: 57.72%, Test Loss: 1.2374, Test Accuracy: 57.93%

Epoch [146/10], Loss: 1.2388, Accuracy: 57.91%, Test Loss: 1.2354, Test Accuracy: 57.93%

Epoch [147/10], Loss: 1.2370, Accuracy: 58.01%, Test Loss: 1.2341, Test Accuracy: 58.05%

Epoch [148/10], Loss: 1.2355, Accuracy: 58.01%, Test Loss: 1.2323, Test Accuracy: 58.14%

Epoch [149/10], Loss: 1.2339, Accuracy: 58.03%, Test Loss: 1.2305, Test Accuracy: 58.22%

Epoch [150/10], Loss: 1.2320, Accuracy: 58.16%, Test Loss: 1.2288, Test Accuracy: 58.21%

Epoch [151/10], Loss: 1.2304, Accuracy: 58.08%, Test Loss: 1.2270, Test Accuracy: 58.30%

Epoch [152/10], Loss: 1.2289, Accuracy: 58.21%, Test Loss: 1.2254, Test Accuracy: 58.42%

Epoch [153/10], Loss: 1.2270, Accuracy: 58.26%, Test Loss: 1.2238, Test Accuracy: 58.40%

Epoch [154/10], Loss: 1.2255, Accuracy: 58.32%, Test Loss: 1.2221, Test Accuracy: 58.50%

Epoch [155/10], Loss: 1.2241, Accuracy: 58.37%, Test Loss: 1.2205, Test Accuracy: 58.47%

Epoch [156/10], Loss: 1.2221, Accuracy: 58.52%, Test Loss: 1.2188, Test Accuracy: 58.62%

Epoch [157/10], Loss: 1.2204, Accuracy: 58.45%, Test Loss: 1.2171, Test Accuracy: 58.70%

Epoch [158/10], Loss: 1.2190, Accuracy: 58.59%, Test Loss: 1.2156, Test Accuracy: 58.75%

Epoch [159/10], Loss: 1.2175, Accuracy: 58.68%, Test Loss: 1.2139, Test Accuracy: 58.81%

Epoch [160/10], Loss: 1.2157, Accuracy: 58.72%, Test Loss: 1.2124, Test Accuracy: 58.91%

Epoch [161/10], Loss: 1.2143, Accuracy: 58.82%, Test Loss: 1.2107, Test Accuracy: 58.84%

Epoch [162/10], Loss: 1.2126, Accuracy: 58.75%, Test Loss: 1.2093, Test Accuracy: 58.92%

Epoch [163/10], Loss: 1.2111, Accuracy: 58.94%, Test Loss: 1.2076, Test Accuracy: 59.02%

Epoch [164/10], Loss: 1.2094, Accuracy: 59.07%, Test Loss: 1.2061, Test Accuracy: 59.10%

Epoch [165/10], Loss: 1.2079, Accuracy: 59.06%, Test Loss: 1.2043, Test Accuracy: 59.14%

Epoch [166/10], Loss: 1.2060, Accuracy: 59.09%, Test Loss: 1.2030, Test Accuracy: 59.21%

Epoch [167/10], Loss: 1.2045, Accuracy: 59.12%, Test Loss: 1.2015, Test Accuracy: 59.24%

Epoch [168/10], Loss: 1.2031, Accuracy: 59.20%, Test Loss: 1.1994, Test Accuracy: 59.25%

Epoch [169/10], Loss: 1.2012, Accuracy: 59.28%, Test Loss: 1.1982, Test Accuracy: 59.28%

Epoch [170/10], Loss: 1.1997, Accuracy: 59.36%, Test Loss: 1.1965, Test Accuracy: 59.45%

Epoch [171/10], Loss: 1.1982, Accuracy: 59.35%, Test Loss: 1.1947, Test Accuracy: 59.62%

Epoch [172/10], Loss: 1.1966, Accuracy: 59.50%, Test Loss: 1.1935, Test Accuracy: 59.58%

Epoch [173/10], Loss: 1.1953, Accuracy: 59.48%, Test Loss: 1.1916, Test Accuracy: 59.72%

Epoch [174/10], Loss: 1.1936, Accuracy: 59.62%, Test Loss: 1.1902, Test Accuracy: 59.65%

Epoch [175/10], Loss: 1.1921, Accuracy: 59.68%, Test Loss: 1.1886, Test Accuracy: 59.78%

Epoch [176/10], Loss: 1.1906, Accuracy: 59.82%, Test Loss: 1.1869, Test Accuracy: 59.85%

Epoch [177/10], Loss: 1.1890, Accuracy: 59.68%, Test Loss: 1.1853, Test Accuracy: 59.84%

Epoch [178/10], Loss: 1.1875, Accuracy: 59.84%, Test Loss: 1.1839, Test Accuracy: 59.94%

Epoch [179/10], Loss: 1.1860, Accuracy: 59.83%, Test Loss: 1.1822, Test Accuracy: 59.93%

Epoch [180/10], Loss: 1.1844, Accuracy: 59.94%, Test Loss: 1.1807, Test Accuracy: 60.04%

Epoch [181/10], Loss: 1.1827, Accuracy: 59.97%, Test Loss: 1.1790, Test Accuracy: 60.06%

Epoch [182/10], Loss: 1.1813, Accuracy: 60.07%, Test Loss: 1.1778, Test Accuracy: 60.18%

Epoch [183/10], Loss: 1.1796, Accuracy: 60.11%, Test Loss: 1.1763, Test Accuracy: 60.26%

Epoch [184/10], Loss: 1.1784, Accuracy: 60.16%, Test Loss: 1.1745, Test Accuracy: 60.25%  
Epoch [185/10], Loss: 1.1770, Accuracy: 60.20%, Test Loss: 1.1729, Test Accuracy: 60.27%  
Epoch [186/10], Loss: 1.1752, Accuracy: 60.34%, Test Loss: 1.1714, Test Accuracy: 60.37%  
Epoch [187/10], Loss: 1.1737, Accuracy: 60.39%, Test Loss: 1.1699, Test Accuracy: 60.47%  
Epoch [188/10], Loss: 1.1719, Accuracy: 60.28%, Test Loss: 1.1686, Test Accuracy: 60.55%  
Epoch [189/10], Loss: 1.1707, Accuracy: 60.43%, Test Loss: 1.1669, Test Accuracy: 60.61%  
Epoch [190/10], Loss: 1.1690, Accuracy: 60.53%, Test Loss: 1.1657, Test Accuracy: 60.60%  
Epoch [191/10], Loss: 1.1674, Accuracy: 60.57%, Test Loss: 1.1639, Test Accuracy: 60.75%  
Epoch [192/10], Loss: 1.1662, Accuracy: 60.62%, Test Loss: 1.1625, Test Accuracy: 60.84%  
Epoch [193/10], Loss: 1.1648, Accuracy: 60.76%, Test Loss: 1.1607, Test Accuracy: 60.84%  
Epoch [194/10], Loss: 1.1631, Accuracy: 60.74%, Test Loss: 1.1596, Test Accuracy: 60.81%  
Epoch [195/10], Loss: 1.1616, Accuracy: 60.84%, Test Loss: 1.1578, Test Accuracy: 60.93%  
Epoch [196/10], Loss: 1.1603, Accuracy: 60.89%, Test Loss: 1.1566, Test Accuracy: 60.99%  
Epoch [197/10], Loss: 1.1587, Accuracy: 60.92%, Test Loss: 1.1551, Test Accuracy: 61.18%  
Epoch [198/10], Loss: 1.1571, Accuracy: 61.05%, Test Loss: 1.1534, Test Accuracy: 61.13%  
Epoch [199/10], Loss: 1.1556, Accuracy: 60.95%, Test Loss: 1.1522, Test Accuracy: 61.27%  
Epoch [200/10], Loss: 1.1539, Accuracy: 61.11%, Test Loss: 1.1505, Test Accuracy: 61.24%  
Epoch [201/10], Loss: 1.1526, Accuracy: 61.16%, Test Loss: 1.1498, Test Accuracy: 61.23%  
Epoch [202/10], Loss: 1.1514, Accuracy: 61.16%, Test Loss: 1.1475, Test Accuracy: 61.37%  
Epoch [203/10], Loss: 1.1496, Accuracy: 61.20%, Test Loss: 1.1463, Test Accuracy: 61.44%  
Epoch [204/10], Loss: 1.1485, Accuracy: 61.37%, Test Loss: 1.1447, Test Accuracy: 61.44%  
Epoch [205/10], Loss: 1.1470, Accuracy: 61.42%, Test Loss: 1.1430, Test Accuracy: 61.57%  
Epoch [206/10], Loss: 1.1456, Accuracy: 61.44%, Test Loss: 1.1417, Test Accuracy: 61.66%  
Epoch [207/10], Loss: 1.1440, Accuracy: 61.57%, Test Loss: 1.1401, Test Accuracy: 61.66%  
Epoch [208/10], Loss: 1.1427, Accuracy: 61.55%, Test Loss: 1.1389, Test Accuracy: 61.76%  
Epoch [209/10], Loss: 1.1412, Accuracy: 61.60%, Test Loss: 1.1373, Test Accuracy: 61.79%  
Epoch [210/10], Loss: 1.1397, Accuracy: 61.63%, Test Loss: 1.1357, Test Accuracy: 61.84%  
Epoch [211/10], Loss: 1.1381, Accuracy: 61.77%, Test Loss: 1.1340, Test Accuracy: 61.86%  
Epoch [212/10], Loss: 1.1368, Accuracy: 61.78%, Test Loss: 1.1330, Test Accuracy: 61.92%  
Epoch [213/10], Loss: 1.1352, Accuracy: 61.90%, Test Loss: 1.1318, Test Accuracy: 61.99%

Epoch [214/10], Loss: 1.1337, Accuracy: 61.95%, Test Loss: 1.1298, Test Accuracy: 62.04%

Epoch [215/10], Loss: 1.1324, Accuracy: 61.92%, Test Loss: 1.1285, Test Accuracy: 62.05%

Epoch [216/10], Loss: 1.1311, Accuracy: 61.94%, Test Loss: 1.1271, Test Accuracy: 62.16%

Epoch [217/10], Loss: 1.1297, Accuracy: 62.10%, Test Loss: 1.1259, Test Accuracy: 62.18%

Epoch [218/10], Loss: 1.1281, Accuracy: 62.11%, Test Loss: 1.1242, Test Accuracy: 62.31%

Epoch [219/10], Loss: 1.1266, Accuracy: 62.18%, Test Loss: 1.1229, Test Accuracy: 62.39%

Epoch [220/10], Loss: 1.1250, Accuracy: 62.31%, Test Loss: 1.1213, Test Accuracy: 62.47%

Epoch [221/10], Loss: 1.1238, Accuracy: 62.23%, Test Loss: 1.1197, Test Accuracy: 62.39%

Epoch [222/10], Loss: 1.1223, Accuracy: 62.32%, Test Loss: 1.1184, Test Accuracy: 62.50%

Epoch [223/10], Loss: 1.1209, Accuracy: 62.37%, Test Loss: 1.1170, Test Accuracy: 62.51%

Epoch [224/10], Loss: 1.1195, Accuracy: 62.33%, Test Loss: 1.1154, Test Accuracy: 62.58%

Epoch [225/10], Loss: 1.1181, Accuracy: 62.50%, Test Loss: 1.1145, Test Accuracy: 62.66%

Epoch [226/10], Loss: 1.1167, Accuracy: 62.58%, Test Loss: 1.1126, Test Accuracy: 62.75%

Epoch [227/10], Loss: 1.1153, Accuracy: 62.62%, Test Loss: 1.1117, Test Accuracy: 62.66%

Epoch [228/10], Loss: 1.1140, Accuracy: 62.60%, Test Loss: 1.1100, Test Accuracy: 62.85%

Epoch [229/10], Loss: 1.1124, Accuracy: 62.74%, Test Loss: 1.1090, Test Accuracy: 62.85%

Epoch [230/10], Loss: 1.1113, Accuracy: 62.77%, Test Loss: 1.1073, Test Accuracy: 62.96%

Epoch [231/10], Loss: 1.1098, Accuracy: 62.74%, Test Loss: 1.1059, Test Accuracy: 63.05%

Epoch [232/10], Loss: 1.1084, Accuracy: 62.88%, Test Loss: 1.1044, Test Accuracy: 62.98%

Epoch [233/10], Loss: 1.1069, Accuracy: 62.95%, Test Loss: 1.1029, Test Accuracy: 63.07%

Epoch [234/10], Loss: 1.1055, Accuracy: 62.93%, Test Loss: 1.1020, Test Accuracy: 63.08%

Epoch [235/10], Loss: 1.1041, Accuracy: 63.07%, Test Loss: 1.1001, Test Accuracy: 63.14%

Epoch [236/10], Loss: 1.1027, Accuracy: 63.04%, Test Loss: 1.0989, Test Accuracy: 63.27%

Epoch [237/10], Loss: 1.1015, Accuracy: 63.15%, Test Loss: 1.0974, Test Accuracy: 63.25%

Epoch [238/10], Loss: 1.1000, Accuracy: 63.15%, Test Loss: 1.0960, Test Accuracy: 63.31%

Epoch [239/10], Loss: 1.0987, Accuracy: 63.18%, Test Loss: 1.0947, Test Accuracy: 63.37%

Epoch [240/10], Loss: 1.0970, Accuracy: 63.29%, Test Loss: 1.0943, Test Accuracy: 63.46%

Epoch [241/10], Loss: 1.0957, Accuracy: 63.33%, Test Loss: 1.0920, Test Accuracy: 63.46%

Epoch [242/10], Loss: 1.0946, Accuracy: 63.38%, Test Loss: 1.0906, Test Accuracy: 63.50%

Epoch [243/10], Loss: 1.0930, Accuracy: 63.38%, Test Loss: 1.0888, Test Accuracy: 63.59%

Epoch [244/10], Loss: 1.0917, Accuracy: 63.51%, Test Loss: 1.0878, Test Accuracy: 63.55%  
Epoch [245/10], Loss: 1.0900, Accuracy: 63.52%, Test Loss: 1.0862, Test Accuracy: 63.69%  
Epoch [246/10], Loss: 1.0890, Accuracy: 63.60%, Test Loss: 1.0849, Test Accuracy: 63.74%  
Epoch [247/10], Loss: 1.0874, Accuracy: 63.63%, Test Loss: 1.0835, Test Accuracy: 63.87%  
Epoch [248/10], Loss: 1.0863, Accuracy: 63.60%, Test Loss: 1.0820, Test Accuracy: 63.86%  
Epoch [249/10], Loss: 1.0849, Accuracy: 63.77%, Test Loss: 1.0809, Test Accuracy: 63.81%  
Epoch [250/10], Loss: 1.0835, Accuracy: 63.71%, Test Loss: 1.0796, Test Accuracy: 63.87%  
Epoch [251/10], Loss: 1.0821, Accuracy: 63.85%, Test Loss: 1.0786, Test Accuracy: 63.89%  
Epoch [252/10], Loss: 1.0808, Accuracy: 63.88%, Test Loss: 1.0770, Test Accuracy: 63.94%  
Epoch [253/10], Loss: 1.0797, Accuracy: 63.87%, Test Loss: 1.0750, Test Accuracy: 64.07%  
Epoch [254/10], Loss: 1.0781, Accuracy: 63.94%, Test Loss: 1.0740, Test Accuracy: 64.09%  
Epoch [255/10], Loss: 1.0768, Accuracy: 63.93%, Test Loss: 1.0723, Test Accuracy: 64.24%  
Epoch [256/10], Loss: 1.0751, Accuracy: 64.06%, Test Loss: 1.0713, Test Accuracy: 64.20%  
Epoch [257/10], Loss: 1.0742, Accuracy: 64.15%, Test Loss: 1.0698, Test Accuracy: 64.31%  
Epoch [258/10], Loss: 1.0728, Accuracy: 64.15%, Test Loss: 1.0683, Test Accuracy: 64.35%  
Epoch [259/10], Loss: 1.0712, Accuracy: 64.13%, Test Loss: 1.0677, Test Accuracy: 64.36%  
Epoch [260/10], Loss: 1.0698, Accuracy: 64.25%, Test Loss: 1.0666, Test Accuracy: 64.43%  
Epoch [261/10], Loss: 1.0685, Accuracy: 64.32%, Test Loss: 1.0645, Test Accuracy: 64.55%  
Epoch [262/10], Loss: 1.0673, Accuracy: 64.45%, Test Loss: 1.0633, Test Accuracy: 64.46%  
Epoch [263/10], Loss: 1.0658, Accuracy: 64.40%, Test Loss: 1.0617, Test Accuracy: 64.58%  
Epoch [264/10], Loss: 1.0644, Accuracy: 64.49%, Test Loss: 1.0607, Test Accuracy: 64.61%  
Epoch [265/10], Loss: 1.0634, Accuracy: 64.55%, Test Loss: 1.0593, Test Accuracy: 64.63%  
Epoch [266/10], Loss: 1.0618, Accuracy: 64.53%, Test Loss: 1.0579, Test Accuracy: 64.81%  
Epoch [267/10], Loss: 1.0607, Accuracy: 64.61%, Test Loss: 1.0566, Test Accuracy: 64.82%  
Epoch [268/10], Loss: 1.0597, Accuracy: 64.65%, Test Loss: 1.0553, Test Accuracy: 64.90%  
Epoch [269/10], Loss: 1.0579, Accuracy: 64.73%, Test Loss: 1.0541, Test Accuracy: 64.94%  
Epoch [270/10], Loss: 1.0566, Accuracy: 64.82%, Test Loss: 1.0523, Test Accuracy: 64.95%  
Epoch [271/10], Loss: 1.0552, Accuracy: 64.82%, Test Loss: 1.0509, Test Accuracy: 64.97%  
Epoch [272/10], Loss: 1.0540, Accuracy: 64.85%, Test Loss: 1.0495, Test Accuracy: 64.97%  
Epoch [273/10], Loss: 1.0526, Accuracy: 64.96%, Test Loss: 1.0485, Test Accuracy: 65.09%

Epoch [274/10], Loss: 1.0513, Accuracy: 64.91%, Test Loss: 1.0472, Test Accuracy: 65.22%  
Epoch [275/10], Loss: 1.0501, Accuracy: 65.03%, Test Loss: 1.0458, Test Accuracy: 65.25%  
Epoch [276/10], Loss: 1.0485, Accuracy: 65.11%, Test Loss: 1.0451, Test Accuracy: 65.21%  
Epoch [277/10], Loss: 1.0474, Accuracy: 65.16%, Test Loss: 1.0438, Test Accuracy: 65.20%  
Epoch [278/10], Loss: 1.0461, Accuracy: 65.20%, Test Loss: 1.0417, Test Accuracy: 65.32%  
Epoch [279/10], Loss: 1.0449, Accuracy: 65.26%, Test Loss: 1.0408, Test Accuracy: 65.33%  
Epoch [280/10], Loss: 1.0434, Accuracy: 65.33%, Test Loss: 1.0393, Test Accuracy: 65.42%  
Epoch [281/10], Loss: 1.0424, Accuracy: 65.34%, Test Loss: 1.0381, Test Accuracy: 65.59%  
Epoch [282/10], Loss: 1.0409, Accuracy: 65.43%, Test Loss: 1.0369, Test Accuracy: 65.53%  
Epoch [283/10], Loss: 1.0396, Accuracy: 65.38%, Test Loss: 1.0351, Test Accuracy: 65.66%  
Epoch [284/10], Loss: 1.0381, Accuracy: 65.51%, Test Loss: 1.0344, Test Accuracy: 65.63%  
Epoch [285/10], Loss: 1.0370, Accuracy: 65.65%, Test Loss: 1.0329, Test Accuracy: 65.72%  
Epoch [286/10], Loss: 1.0356, Accuracy: 65.52%, Test Loss: 1.0324, Test Accuracy: 65.69%  
Epoch [287/10], Loss: 1.0344, Accuracy: 65.61%, Test Loss: 1.0300, Test Accuracy: 65.82%  
Epoch [288/10], Loss: 1.0330, Accuracy: 65.67%, Test Loss: 1.0290, Test Accuracy: 65.79%  
Epoch [289/10], Loss: 1.0318, Accuracy: 65.75%, Test Loss: 1.0276, Test Accuracy: 65.96%  
Epoch [290/10], Loss: 1.0307, Accuracy: 65.77%, Test Loss: 1.0261, Test Accuracy: 65.99%  
Epoch [291/10], Loss: 1.0292, Accuracy: 65.83%, Test Loss: 1.0248, Test Accuracy: 66.09%  
Epoch [292/10], Loss: 1.0279, Accuracy: 65.83%, Test Loss: 1.0235, Test Accuracy: 66.04%  
Epoch [293/10], Loss: 1.0264, Accuracy: 65.96%, Test Loss: 1.0221, Test Accuracy: 66.08%  
Epoch [294/10], Loss: 1.0256, Accuracy: 66.03%, Test Loss: 1.0214, Test Accuracy: 66.19%  
Epoch [295/10], Loss: 1.0241, Accuracy: 66.05%, Test Loss: 1.0193, Test Accuracy: 66.19%  
Epoch [296/10], Loss: 1.0227, Accuracy: 66.04%, Test Loss: 1.0185, Test Accuracy: 66.30%  
Epoch [297/10], Loss: 1.0214, Accuracy: 66.14%, Test Loss: 1.0171, Test Accuracy: 66.32%  
Epoch [298/10], Loss: 1.0202, Accuracy: 66.20%, Test Loss: 1.0159, Test Accuracy: 66.43%  
Epoch [299/10], Loss: 1.0190, Accuracy: 66.25%, Test Loss: 1.0142, Test Accuracy: 66.37%  
Epoch [300/10], Loss: 1.0175, Accuracy: 66.26%, Test Loss: 1.0133, Test Accuracy: 66.56%  
Epoch [301/10], Loss: 1.0168, Accuracy: 66.31%, Test Loss: 1.0117, Test Accuracy: 66.53%  
Epoch [302/10], Loss: 1.0152, Accuracy: 66.31%, Test Loss: 1.0108, Test Accuracy: 66.58%  
Epoch [303/10], Loss: 1.0139, Accuracy: 66.47%, Test Loss: 1.0094, Test Accuracy: 66.67%

Epoch [304/10], Loss: 1.0128, Accuracy: 66.56%, Test Loss: 1.0081, Test Accuracy: 66.64%

Epoch [305/10], Loss: 1.0111, Accuracy: 66.49%, Test Loss: 1.0069, Test Accuracy: 66.69%

Epoch [306/10], Loss: 1.0100, Accuracy: 66.62%, Test Loss: 1.0058, Test Accuracy: 66.69%

Epoch [307/10], Loss: 1.0085, Accuracy: 66.56%, Test Loss: 1.0046, Test Accuracy: 66.79%

Epoch [308/10], Loss: 1.0074, Accuracy: 66.59%, Test Loss: 1.0031, Test Accuracy: 66.87%

Epoch [309/10], Loss: 1.0063, Accuracy: 66.74%, Test Loss: 1.0015, Test Accuracy: 66.85%

Epoch [310/10], Loss: 1.0049, Accuracy: 66.72%, Test Loss: 1.0006, Test Accuracy: 66.94%

Epoch [311/10], Loss: 1.0037, Accuracy: 66.85%, Test Loss: 0.9995, Test Accuracy: 67.02%

Epoch [312/10], Loss: 1.0024, Accuracy: 66.88%, Test Loss: 0.9981, Test Accuracy: 67.09%

Epoch [313/10], Loss: 1.0014, Accuracy: 66.83%, Test Loss: 0.9969, Test Accuracy: 67.08%

Epoch [314/10], Loss: 1.0000, Accuracy: 66.95%, Test Loss: 0.9959, Test Accuracy: 67.06%

Epoch [315/10], Loss: 0.9987, Accuracy: 66.98%, Test Loss: 0.9940, Test Accuracy: 67.15%

Epoch [316/10], Loss: 0.9975, Accuracy: 67.01%, Test Loss: 0.9927, Test Accuracy: 67.26%

Epoch [317/10], Loss: 0.9963, Accuracy: 67.11%, Test Loss: 0.9918, Test Accuracy: 67.24%

Epoch [318/10], Loss: 0.9949, Accuracy: 67.10%, Test Loss: 0.9902, Test Accuracy: 67.33%

Epoch [319/10], Loss: 0.9937, Accuracy: 67.18%, Test Loss: 0.9887, Test Accuracy: 67.33%

Epoch [320/10], Loss: 0.9926, Accuracy: 67.26%, Test Loss: 0.9880, Test Accuracy: 67.45%

Epoch [321/10], Loss: 0.9910, Accuracy: 67.30%, Test Loss: 0.9872, Test Accuracy: 67.41%

Epoch [322/10], Loss: 0.9902, Accuracy: 67.24%, Test Loss: 0.9852, Test Accuracy: 67.54%

Epoch [323/10], Loss: 0.9885, Accuracy: 67.42%, Test Loss: 0.9848, Test Accuracy: 67.55%

Epoch [324/10], Loss: 0.9875, Accuracy: 67.46%, Test Loss: 0.9827, Test Accuracy: 67.56%

Epoch [325/10], Loss: 0.9862, Accuracy: 67.45%, Test Loss: 0.9821, Test Accuracy: 67.63%

Epoch [326/10], Loss: 0.9848, Accuracy: 67.56%, Test Loss: 0.9801, Test Accuracy: 67.74%

Epoch [327/10], Loss: 0.9838, Accuracy: 67.53%, Test Loss: 0.9792, Test Accuracy: 67.79%

Epoch [328/10], Loss: 0.9825, Accuracy: 67.55%, Test Loss: 0.9784, Test Accuracy: 67.73%

Epoch [329/10], Loss: 0.9814, Accuracy: 67.55%, Test Loss: 0.9764, Test Accuracy: 67.93%

Epoch [330/10], Loss: 0.9802, Accuracy: 67.73%, Test Loss: 0.9752, Test Accuracy: 67.89%

Epoch [331/10], Loss: 0.9788, Accuracy: 67.79%, Test Loss: 0.9748, Test Accuracy: 67.94%

Epoch [332/10], Loss: 0.9776, Accuracy: 67.85%, Test Loss: 0.9732, Test Accuracy: 67.97%

Epoch [333/10], Loss: 0.9763, Accuracy: 67.85%, Test Loss: 0.9719, Test Accuracy: 68.05%

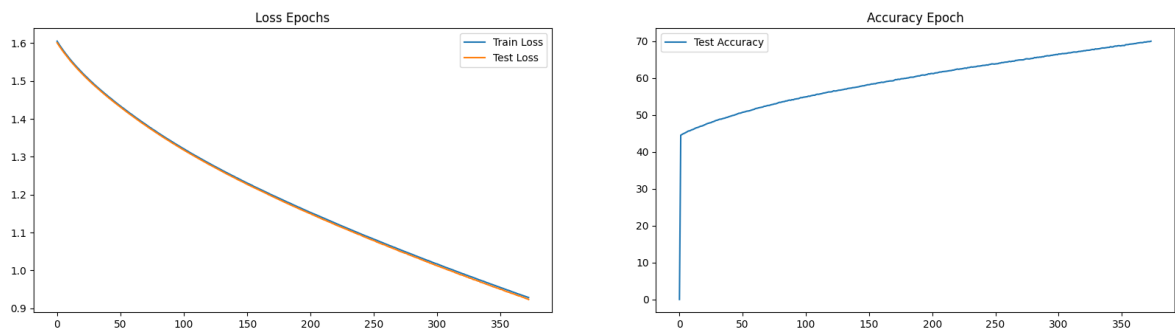


Epoch [334/10], Loss: 0.9748, Accuracy: 67.87%, Test Loss: 0.9712, Test Accuracy: 68.15%  
Epoch [335/10], Loss: 0.9739, Accuracy: 67.95%, Test Loss: 0.9687, Test Accuracy: 68.19%  
Epoch [336/10], Loss: 0.9724, Accuracy: 68.05%, Test Loss: 0.9682, Test Accuracy: 68.17%  
Epoch [337/10], Loss: 0.9717, Accuracy: 68.06%, Test Loss: 0.9668, Test Accuracy: 68.23%  
Epoch [338/10], Loss: 0.9704, Accuracy: 68.04%, Test Loss: 0.9658, Test Accuracy: 68.30%  
Epoch [339/10], Loss: 0.9691, Accuracy: 68.15%, Test Loss: 0.9643, Test Accuracy: 68.33%  
Epoch [340/10], Loss: 0.9675, Accuracy: 68.20%, Test Loss: 0.9631, Test Accuracy: 68.33%  
Epoch [341/10], Loss: 0.9667, Accuracy: 68.26%, Test Loss: 0.9619, Test Accuracy: 68.54%  
Epoch [342/10], Loss: 0.9651, Accuracy: 68.26%, Test Loss: 0.9609, Test Accuracy: 68.44%  
Epoch [343/10], Loss: 0.9640, Accuracy: 68.27%, Test Loss: 0.9594, Test Accuracy: 68.47%  
Epoch [344/10], Loss: 0.9630, Accuracy: 68.42%, Test Loss: 0.9583, Test Accuracy: 68.64%  
Epoch [345/10], Loss: 0.9618, Accuracy: 68.48%, Test Loss: 0.9566, Test Accuracy: 68.70%  
Epoch [346/10], Loss: 0.9604, Accuracy: 68.52%, Test Loss: 0.9560, Test Accuracy: 68.69%  
Epoch [347/10], Loss: 0.9594, Accuracy: 68.52%, Test Loss: 0.9546, Test Accuracy: 68.80%  
Epoch [348/10], Loss: 0.9579, Accuracy: 68.52%, Test Loss: 0.9533, Test Accuracy: 68.80%  
Epoch [349/10], Loss: 0.9568, Accuracy: 68.69%, Test Loss: 0.9528, Test Accuracy: 68.74%  
Epoch [350/10], Loss: 0.9557, Accuracy: 68.72%, Test Loss: 0.9509, Test Accuracy: 68.83%  
Epoch [351/10], Loss: 0.9542, Accuracy: 68.74%, Test Loss: 0.9497, Test Accuracy: 68.86%  
Epoch [352/10], Loss: 0.9532, Accuracy: 68.74%, Test Loss: 0.9494, Test Accuracy: 68.83%  
Epoch [353/10], Loss: 0.9521, Accuracy: 68.76%, Test Loss: 0.9473, Test Accuracy: 69.07%  
Epoch [354/10], Loss: 0.9507, Accuracy: 68.90%, Test Loss: 0.9461, Test Accuracy: 69.08%  
Epoch [355/10], Loss: 0.9494, Accuracy: 68.92%, Test Loss: 0.9448, Test Accuracy: 69.10%  
Epoch [356/10], Loss: 0.9482, Accuracy: 69.00%, Test Loss: 0.9435, Test Accuracy: 69.20%  
Epoch [357/10], Loss: 0.9473, Accuracy: 69.04%, Test Loss: 0.9428, Test Accuracy: 69.23%  
Epoch [358/10], Loss: 0.9462, Accuracy: 69.07%, Test Loss: 0.9413, Test Accuracy: 69.28%  
Epoch [359/10], Loss: 0.9448, Accuracy: 69.15%, Test Loss: 0.9399, Test Accuracy: 69.30%  
Epoch [360/10], Loss: 0.9433, Accuracy: 69.20%, Test Loss: 0.9390, Test Accuracy: 69.37%  
Epoch [361/10], Loss: 0.9423, Accuracy: 69.26%, Test Loss: 0.9381, Test Accuracy: 69.38%  
Epoch [362/10], Loss: 0.9410, Accuracy: 69.24%, Test Loss: 0.9368, Test Accuracy: 69.50%  
Epoch [363/10], Loss: 0.9401, Accuracy: 69.34%, Test Loss: 0.9354, Test Accuracy: 69.55%

Epoch [364/10], Loss: 0.9385, Accuracy: 69.37%, Test Loss: 0.9342, Test Accuracy: 69.60%  
 Epoch [365/10], Loss: 0.9375, Accuracy: 69.45%, Test Loss: 0.9327, Test Accuracy: 69.64%  
 Epoch [366/10], Loss: 0.9364, Accuracy: 69.37%, Test Loss: 0.9322, Test Accuracy: 69.61%  
 Epoch [367/10], Loss: 0.9351, Accuracy: 69.46%, Test Loss: 0.9311, Test Accuracy: 69.69%  
 Epoch [368/10], Loss: 0.9341, Accuracy: 69.53%, Test Loss: 0.9294, Test Accuracy: 69.80%  
 Epoch [369/10], Loss: 0.9328, Accuracy: 69.56%, Test Loss: 0.9285, Test Accuracy: 69.76%  
 Epoch [370/10], Loss: 0.9318, Accuracy: 69.64%, Test Loss: 0.9270, Test Accuracy: 69.87%  
 Epoch [371/10], Loss: 0.9305, Accuracy: 69.73%, Test Loss: 0.9255, Test Accuracy: 69.90%  
 Epoch [372/10], Loss: 0.9292, Accuracy: 69.71%, Test Loss: 0.9247, Test Accuracy: 69.90%  
 Epoch [373/10], Loss: 0.9280, Accuracy: 69.82%, Test Loss: 0.9231, Test Accuracy: 70.01%

```
In [16]: plt.figure(figsize = (20, 5))
plt.subplot(121)
plt.title('Loss Epochs')
plt.plot(train_losses, label = 'Train Loss')
plt.plot(test_losses, label = 'Test Loss')
plt.legend()
plt.subplot(122)
plt.title('Accuracy Epoch')
plt.plot(test_accuracies, label = 'Test Accuracy')
plt.legend()
```

Out[16]: <matplotlib.legend.Legend at 0x7a9f54abf040>



- Dưới đây là bài tập về code from scratch

```
In [21]: import tensorflow as tf
def zScoreScaling(tensor):
    mean, variance = tf.nn.moments(tensor, axes=[0])
    std_dev = tf.sqrt(variance)

    # Apply z-score scaling
    z_scores = (tensor - mean) / std_dev
    return z_scores
```

```
In [22]: def minMaxScaling(tensor):
    # Min and max values
    tensor_min = tf.reduce_min(tensor, axis=0)
```

```

tensor_max = tf.reduce_max(tensor, axis=0)

# Min-max scaling
scaled_tensor = (tensor - tensor_min) / (tensor_max - tensor_min)
return scaled_tensor

```

```

In [23]: class Linear:
        def __init__(self, input_dim, output_dim):
            self.weight = torch.randn(output_dim, input_dim)
            self.bias = torch.randn(output_dim)

        def forward(self, x):
            return torch.matmul(x, self.weight.T) + self.bias

```

```

In [25]: tensor = torch.tensor([
        [1.0, 2.0, 3.0],
        [4.0, 5.0, 6.0],
        [7.0, 8.0, 9.0]
    ])
zscore = zScoreScaling(tensor)
min_max = minMaxScaling(tensor)
print(zscore)
print(min_max)

tf.Tensor(
[[ -1.2247448  -1.2247448  -1.2247448]
 [  0.           0.           0.        ]
 [  1.2247448   1.2247448   1.2247448]], shape=(3, 3), dtype=float32)
tf.Tensor(
[[0.  0.  0. ]
 [0.5 0.5 0.5]
 [1.  1.  1. ]], shape=(3, 3), dtype=float32)

```

```

In [26]: tensor = torch.tensor([1.0, 2.0, 3.0])
        linear = Linear(3, 2)
        out = linear.forward(tensor)
        print(out)
        print(f"Weight = {linear.weight}")
        print(f"Bias = {linear.bias}")

tensor([ 6.7185, -3.1806])
Weight = tensor([[ -0.5124,  0.3793,  2.2742],
                 [ 0.3883,  0.0417, -0.9011]])
Bias = tensor([ -0.3503, -0.9488])

```

In [ ]: