

```
In [2]: '''
Patrick Ballou
ID: 801130521
ECGR 4105
Homework 6
Problem 2
'''
```

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Out[2]: '\nPatrick Ballou\nID: 801130521\nECGR 4105\nHomework 6\nProblem 2\n'
```

```
In [3]: import torch
from torch import cuda
import torch.nn as nn
from torchvision import transforms
from torchvision import datasets
import datetime
```

```
In [4]: data_path = 'C:/Users/patri/Documents/School_Fall_2022/ECGR_4105/Homework/homework_6'
#normalized
cifar10 = datasets.CIFAR10(data_path, train=True, download=True, transform=transforms.
cifar10_val = datasets.CIFAR10(data_path, train=False, download=True, transform=transf

Files already downloaded and verified
Files already downloaded and verified
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In [5]: device = 'cuda'
cuda.get_device_name()
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Out[5]: 'Quadro T2000'
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```
In [6]: class Net(nn.Module):
def __init__(self):
super().__init__()
self.conv1 = nn.Conv2d(3, 16, kernel_size=3, padding=1)
self.act1 = nn.Tanh()
self.pool1 = nn.MaxPool2d(2)
self.conv2 = nn.Conv2d(16, 8, kernel_size=3, padding=1)
self.act2 = nn.Tanh()
self.pool2 = nn.MaxPool2d(2)
self.fc1 = nn.Linear(8 * 8 * 8, 32)
self.act3 = nn.Tanh()
self.fc2 = nn.Linear(32, 10)

def forward(self, x):
out = self.pool1(self.act1(self.conv1(x)))
out = self.pool2(self.act2(self.conv2(out)))
out = out.view(-1, 8 * 8 * 8)
out = self.act3(self.fc1(out))
out = self.fc2(out)
return out
```

```
In [97]: def training_loop(n_epochs, optimizer, model, loss_fn, train_loader):
for epoch in range(1, n_epochs + 1):
loss_train = 0.0
for imgs, labels in train_loader:
imgs, labels = imgs.to(device=device), labels.to(device=device)
outputs = model(imgs)
```

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    loss = loss_fn(outputs, labels)

    optimizer.zero_grad()
    loss.backward()
    optimizer.step()
    loss_train += loss.item()
    print("{} Epoch {}, Training loss {}".format(datetime.datetime.now(), epoch, loss_t
```

```
In [98]: l_r = .008
         num_epochs = 300
```

```
In [99]: train_loader = torch.utils.data.DataLoader(cifar10, batch_size=128, shuffle=True)
         model_a = Net().to(device=device)
         optimizer = torch.optim.SGD(model_a.parameters(), lr=l_r)
         loss_fn = nn.CrossEntropyLoss()

         training_loop(num_epochs, optimizer, model_a, loss_fn, train_loader)
```

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2022-12-10	23:02:09.229572	Epoch 221, Training	loss 0.6802652377606658
2022-12-10	23:02:23.046961	Epoch 222, Training	loss 0.6782492110338967
2022-12-10	23:02:37.687461	Epoch 223, Training	loss 0.6789777907721527
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2022-12-10	23:03:36.149000	Epoch 227, Training	loss 0.6756115162464054
2022-12-10	23:03:50.766816	Epoch 228, Training	loss 0.6737423574223238
2022-12-10	23:04:05.332438	Epoch 229, Training	loss 0.6730693526127759
2022-12-10	23:04:19.970572	Epoch 230, Training	loss 0.6726078962730935
2022-12-10	23:04:34.619791	Epoch 231, Training	loss 0.6716287450869675
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2022-12-10	23:06:02.457188	Epoch 237, Training	loss 0.6677093265763939
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2022-12-10	23:06:31.660827	Epoch 239, Training	loss 0.6660692339663006
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2022-12-10	23:07:44.709516	Epoch 244, Training loss	0.6635654195952598
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2022-12-10	23:14:47.009517	Epoch 273, Training loss	0.6425867019711858
2022-12-10	23:15:01.652478	Epoch 274, Training loss	0.643020971428098
2022-12-10	23:15:16.286480	Epoch 275, Training loss	0.6420470031783404
2022-12-10	23:15:30.823706	Epoch 276, Training loss	0.6421989650677538
2022-12-10	23:15:45.441937	Epoch 277, Training loss	0.6418880405633346
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2022-12-10	23:16:14.841733	Epoch 279, Training loss	0.6412767434821409
2022-12-10	23:16:29.558375	Epoch 280, Training loss	0.6393794025606512
2022-12-10	23:16:44.280250	Epoch 281, Training loss	0.639505406551044
2022-12-10	23:16:58.862458	Epoch 282, Training loss	0.6375005661374162
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2022-12-10	23:17:28.038559	Epoch 284, Training loss	0.6371633285451728
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2022-12-10	23:18:11.906822	Epoch 287, Training loss	0.636332292767132
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2022-12-10	23:18:41.023622	Epoch 289, Training loss	0.633772713525216
2022-12-10	23:18:55.615315	Epoch 290, Training loss	0.635432627423645
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2022-12-10	23:19:24.815966	Epoch 292, Training loss	0.6308439541655733
2022-12-10	23:19:39.379824	Epoch 293, Training loss	0.6309619110715968
2022-12-10	23:19:53.954660	Epoch 294, Training loss	0.6317406920978176
2022-12-10	23:20:08.775359	Epoch 295, Training loss	0.6310596101729157
2022-12-10	23:20:23.390961	Epoch 296, Training loss	0.6304930619266637
2022-12-10	23:20:38.010909	Epoch 297, Training loss	0.628794339306824
2022-12-10	23:20:52.622748	Epoch 298, Training loss	0.6278755280672742
2022-12-10	23:21:07.377463	Epoch 299, Training loss	0.6275831274211864
2022-12-10	23:21:19.686524	Epoch 300, Training loss	0.628146682858772

```
In [105... val_loader = torch.utils.data.DataLoader(cifar10_val, batch_size=128, shuffle=False)
correct = 0
total = 0
with torch.no_grad():
    for imgs, labels in val_loader:
        imgs, labels = imgs.to(device), labels.to(device)
        batch_size = imgs.shape[0]
        outputs = model_a(imgs)
        _, predicted = torch.max(outputs, dim=1)
        total += labels.shape[0]
        correct += int((predicted == labels).sum())
    print("Accuracy: {:.2f}".format(correct / total))
```

Accuracy: 0.66

```
In [106... class Net(nn.Module):
    def __init__(self):
        super().__init__()
        self.conv1 = nn.Conv2d(3, 16, kernel_size=3, padding=1)
        self.act1 = nn.LeakyReLU()
        self.pool1 = nn.MaxPool2d(2)
        self.conv2 = nn.Conv2d(16, 8, kernel_size=3, padding=1)
        self.act2 = nn.LeakyReLU()
        self.pool2 = nn.MaxPool2d(2)
        self.conv3 = nn.Conv2d(8, 3, kernel_size=3, padding=1)
        self.act3 = nn.LeakyReLU()
        self.pool3 = nn.MaxPool2d(2)
        self.fc1 = nn.Linear(8 * 8 * 8, 32)
        self.act3 = nn.Tanh()
        self.fc2 = nn.Linear(32, 10)

    def forward(self, x):
        out = self.pool1(self.act1(self.conv1(x)))
        out = self.pool2(self.act2(self.conv2(out)))
        out = out.view(-1, 8 * 8 * 8)
        out = self.act3(self.fc1(out))
        out = self.fc2(out)
        return out
```

```
In [107... lr = .02
num_epochs = 300
```

```
In [108... train_loader = torch.utils.data.DataLoader(cifar10, batch_size=256, shuffle=True)
model_b = Net().to(device=device)
optimizer = torch.optim.SGD(model_b.parameters(), lr=lr)
loss_fn = nn.CrossEntropyLoss()

training_loop(num_epochs, optimizer, model_b, loss_fn, train_loader)
```



```
2022-12-10 23:28:30.487254 Epoch 1, Training loss 2.205159378295042
2022-12-10 23:28:43.116394 Epoch 2, Training loss 1.94727153255015
2022-12-10 23:28:55.956614 Epoch 3, Training loss 1.7649597884440908
2022-12-10 23:29:07.961058 Epoch 4, Training loss 1.6282386335791375
2022-12-10 23:29:20.687763 Epoch 5, Training loss 1.5353622661561381
2022-12-10 23:29:33.986395 Epoch 6, Training loss 1.4670775411080341
2022-12-10 23:29:46.892074 Epoch 7, Training loss 1.418908684837575
2022-12-10 23:29:59.886462 Epoch 8, Training loss 1.372822064526227
2022-12-10 23:30:12.591734 Epoch 9, Training loss 1.341478488274983
2022-12-10 23:30:25.580109 Epoch 10, Training loss 1.3129363175557585
2022-12-10 23:30:38.837057 Epoch 11, Training loss 1.2900027955064968
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2022-12-10 23:41:50.077579 Epoch 60, Training loss 0.8543012841623656
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2022-12-10 23:55:37.376513 Epoch 119, Training loss 0.7258758058353346
2022-12-10 23:55:51.471555 Epoch 120, Training loss 0.7264798569435976
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2022-12-11 00:40:09.505616 Epoch 300, Training loss 0.5656508883955528
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In [114...

```
val_loader = torch.utils.data.DataLoader(cifar10_val, batch_size=256, shuffle=False)
correct = 0
total = 0
with torch.no_grad():
    for imgs, labels in val_loader:
        imgs, labels = imgs.to(device), labels.to(device)
        batch_size = imgs.shape[0]
        outputs = model_b(imgs)
        _, predicted = torch.max(outputs, dim=1)
        total += labels.shape[0]
        correct += int((predicted == labels).sum())
print("Accuracy: {:.2f}".format(correct / total))
```

Accuracy: 0.60