

```

1 # Replace the average pooling with max-pooling.
2 # Replace the softmax layer with ReLU.
3 # Explore the learning rates.

```

```

1 import torch
2 !pip install d2l==1.0.0a0

```

```

Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.8/dist-packages (from requests->d2l==1.0.0a0) (2022.12.
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Collecting qtpy>=2.0.1

```

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Collecting jedi>=0.10

Downloading jedi-0.18.2-py2.py3-none-any.whl (1.6 MB)

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Successfully installed d2l-1.0.0a0 jedi-0.18.2 jupyter-1.0.0 qtconsole-5.4.0 qtpy-2.3.0

```

```

1 !pip install matplotlib
2 %matplotlib inline
3 !pip install matplotlib-inline
4 import sys
5 !{sys.executable} -m pip install matplotlib

```

Looking in indexes: <https://pypi.org/simple>, <https://us-python.pkg.dev/colab-wheels/public/simple/>

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Requirement already satisfied: matplotlib in /usr/local/lib/python3.8/dist-packages (3.2.2)
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```

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Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
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```

```

1 import time
2 import numpy as np
3 import torch
4 import torchvision
5 from torchvision import transforms
6 from torch import nn
7 from d2l import torch as d2l
8 from torch.optim import lr_scheduler

```

```

1 def LeNet(num_classes=10):
2     net = nn.Sequential(nn.LazyConv2d(6, kernel_size=5, padding=2),
3         nn.ReLU(),
4         nn.MaxPool2d(kernel_size=2, stride=2),
5         nn.LazyConv2d(16, kernel_size=5),
6         nn.ReLU(),
7         nn.MaxPool2d(kernel_size=2, stride=2),
8         nn.Flatten(),
9         nn.Linear(400, 120),
10        nn.ReLU(),
11        nn.Linear(120, 84),
12        nn.ReLU(),
13        nn.Linear(84, num_classes))
14     return net

```

```

1 def train(model, train_loader, test_loader, num_epochs, loss_fn, trainer):
2
3     animator = d2l.Animator(xlabel='epoch', xlim=[0, num_epochs], legend=['train loss', 'train accuracy', 'test accuracy'])
4     for epoch in range(num_epochs):
5         metric = d2l.Accumulator(3)
6         for i, (X, y) in enumerate(train_loader):
7             net.train()
8             trainer.zero_grad()
9             y_hat = net(X)
10            l = loss_fn(y_hat, y)
11            l.backward()
12            trainer.step()
13            with torch.no_grad():
14                metric.add(1 * X.shape[0], d2l.accuracy(y_hat, y), X.shape[0])
15            train_loss = metric[0] / metric[2]
16            train_acc = metric[1] / metric[2]
17            if (i + 1) % 50 == 0:
18                animator.add(epoch + i / len(train_loader),
19                    (train_loss, train_acc, None))
20
21            test_acc = d2l.evaluate_accuracy_gpu(model, test_loader)
22            animator.add(epoch+1, (None, None, test_acc))
23
24     print(f'train loss {train_loss:.3f}, train accuracy {train_acc:.3f}, 'f'test accuracy {test_acc:.3f}')

```

```

1 loss = nn.CrossEntropyLoss()
2 batch_size = 256
3 num_epochs = 10
4 lr=0.001

```

```

1 train_loader, test_loader = d2l.load_data_fashion_mnist(batch_size=batch_size)
2 net= LeNet(num_classes=10)
3 trainer = torch.optim.Adam(net.parameters(), lr=lr)

```

```

Downloading http://fashion-mnist.s3-website.eu-central-1.amazonaws.com/train-images-idx3-ubyte.gz
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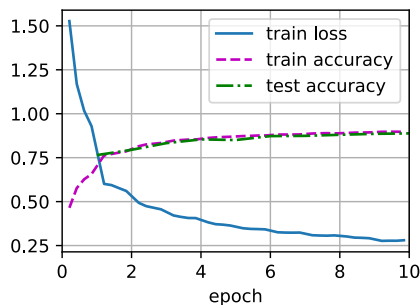
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/usr/local/lib/python3.8/dist-packages/torch/utils/data/dataloader.py:554: UserWarning: This DataLoader will create 4 worker processes i
warnings.warn(_create_warning_msg(
/usr/local/lib/python3.8/dist-packages/torch/nn/modules/lazy.py:180: UserWarning: Lazy modules are a new feature under heavy development
warnings.warn('Lazy modules are a new feature under heavy development '

```

```
1 train(net, train_loader, test_loader, num_epochs, loss, trainer)
```

train loss 0.280, train accuracy 0.897, test accuracy 0.888



```
1 # Measuring and comparing theoretical computation complexity (number of operations and parameters size)
```

```
1 pip install torchinfo
```

```

Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Collecting torchinfo
  Downloading torchinfo-1.7.2-py3-none-any.whl (22 kB)
Installing collected packages: torchinfo
Successfully installed torchinfo-1.7.2

```

```

1 from torchinfo import summary
2
3 model = LeNet()
4 batch_size = 256
5 summary(model, input_size=(batch_size, 1, 28, 28))

```

```

=====
Layer (type:depth-idx)                   Output Shape              Param #
=====
Sequential                                [256, 10]                 --
├─Conv2d: 1-1                             [256, 6, 28, 28]          156
├─ReLU: 1-2                              [256, 6, 28, 28]          --
├─MaxPool2d: 1-3                         [256, 6, 14, 14]          --
├─Conv2d: 1-4                             [256, 16, 10, 10]         2,416
├─ReLU: 1-5                              [256, 16, 10, 10]         --
├─MaxPool2d: 1-6                         [256, 16, 5, 5]          --
├─Flatten: 1-7                           [256, 400]                --
├─Linear: 1-8                             [256, 120]                48,120
├─ReLU: 1-9                              [256, 120]                --
├─Linear: 1-10                            [256, 84]                 10,164
├─ReLU: 1-11                             [256, 84]                 --
└─Linear: 1-12                            [256, 10]                 850
=====

```

```
Total params: 61,706
Trainable params: 61,706
Non-trainable params: 0
Total mult-adds (M): 108.30
=====
Input size (MB): 0.80
Forward/backward pass size (MB): 13.35
Params size (MB): 0.25
Estimated Total Size (MB): 14.40
=====
```

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