

```
In [1]: !pip install d2l
```

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Collecting d2l
  Downloading d2l-1.0.3-py3-none-any.whl.metadata (556 bytes)
Collecting jupyter==1.0.0 (from d2l)
  Downloading jupyter-1.0.0-py2.py3-none-any.whl.metadata (995 bytes)
Collecting numpy==1.23.5 (from d2l)
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Collecting requests==2.31.0 (from d2l)
  Downloading requests-2.31.0-py3-none-any.whl.metadata (4.6 kB)
Collecting pandas==2.0.3 (from d2l)
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Collecting scipy==1.10.1 (from d2l)
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Requirement already satisfied: notebook in /usr/local/lib/python3.10/dist-packages (from jupyter==1.0.0->d2l) (6.5.5)
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Requirement already satisfied: notebook-shim>=0.2.3 in /usr/local/lib/python3.10/dist-packages (from nbclassic>=0.4.7->notebook->jupyter==1.0.0->d2l) (0.2.4)
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Requirement already satisfied: jsonschema-specifications>=2023.03.6 in /usr/local/lib/python3.10/dist-packages (from jsonschema>=2.6->nbformat>=5.1->nbconvert->jupyter==1.0.0->d2l) (2023.12.1)
Requirement already satisfied: referencing>=0.28.4 in /usr/local/lib/python3.10/dist-packages (from jsonschema>=2.6->nbformat>=5.1->nbconvert->jupyter==1.0.0->d2l) (0.35.1)
Requirement already satisfied: rpds-py>=0.7.1 in /usr/local/lib/python3.10/dist-packages (from jsonschema>=2.6->nbformat>=5.1->nbconvert->jupyter==1.0.0->d2l) (0.20.0)
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Installing collected packages: requests, qtpy, pyparsing, numpy, matplotlib-inline, jedi, scipy, pandas, matplot
lib, qtconsole, jupyter, d2l
  Attempting uninstall: requests
    Found existing installation: requests 2.32.3
    Uninstalling requests-2.32.3:
      Successfully uninstalled requests-2.32.3
  Attempting uninstall: pyparsing
    Found existing installation: pyparsing 3.1.4
    Uninstalling pyparsing-3.1.4:
      Successfully uninstalled pyparsing-3.1.4
  Attempting uninstall: numpy
    Found existing installation: numpy 1.26.4
    Uninstalling numpy-1.26.4:
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  Attempting uninstall: matplotlib-inline
    Found existing installation: matplotlib-inline 0.1.7
    Uninstalling matplotlib-inline-0.1.7:
      Successfully uninstalled matplotlib-inline-0.1.7
  Attempting uninstall: scipy
    Found existing installation: scipy 1.13.1
    Uninstalling scipy-1.13.1:
      Successfully uninstalled scipy-1.13.1
  Attempting uninstall: pandas
    Found existing installation: pandas 2.2.2
    Uninstalling pandas-2.2.2:
      Successfully uninstalled pandas-2.2.2
  Attempting uninstall: matplotlib
    Found existing installation: matplotlib 3.7.1
    Uninstalling matplotlib-3.7.1:
      Successfully uninstalled matplotlib-3.7.1
ERROR: pip's dependency resolver does not currently take into account all the packages that are installed. This
behaviour is the source of the following dependency conflicts.
albcure 0.0.16 requires numpy>=1.24, but you have numpy 1.23.5 which is incompatible.
alumentations 1.4.15 requires numpy>=1.24.4, but you have numpy 1.23.5 which is incompatible.
bigframes 1.19.0 requires numpy>=1.24.0, but you have numpy 1.23.5 which is incompatible.
chex 0.1.87 requires numpy>=1.24.1, but you have numpy 1.23.5 which is incompatible.
google-colab 1.0.0 requires pandas==2.2.2, but you have pandas 2.0.3 which is incompatible.
google-colab 1.0.0 requires requests==2.32.3, but you have requests 2.31.0 which is incompatible.
jax 0.4.33 requires numpy>=1.24, but you have numpy 1.23.5 which is incompatible.
jaxlib 0.4.33 requires numpy>=1.24, but you have numpy 1.23.5 which is incompatible.
mizani 0.11.4 requires pandas>=2.1.0, but you have pandas 2.0.3 which is incompatible.
plotnine 0.13.6 requires pandas<3.0.0,>=2.1.0, but you have pandas 2.0.3 which is incompatible.
xarray 2024.9.0 requires numpy>=1.24, but you have numpy 1.23.5 which is incompatible.
xarray 2024.9.0 requires pandas>=2.1, but you have pandas 2.0.3 which is incompatible.
Successfully installed d2l-1.0.3 jedi-0.19.1 jupyter-1.0.0 matplotlib-3.7.2 matplotlib-inline-0.1.6 numpy-1.23.5
pandas-2.0.3 pyparsing-3.0.9 qtconsole-5.6.0 qtpy-2.4.1 requests-2.31.0 scipy-1.10.1

```

```

In [1]: import torch
        from torch import nn
        from d2l import torch as d2l

```

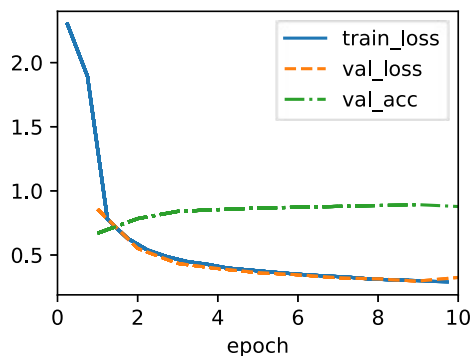
```
In [2]: def vgg_block(num_convs, out_channels):
        layers = []
        for _ in range(num_convs):
            layers.append(nn.LazyConv2d(out_channels, kernel_size=3, padding=1))
            layers.append(nn.ReLU())
        layers.append(nn.MaxPool2d(kernel_size=2, stride=2))
        return nn.Sequential(*layers)
```

```
In [3]: class VGG(d2l.Classifier):
        def __init__(self, arch, lr=0.1, num_classes=10):
            super().__init__()
            self.save_hyperparameters()
            conv_blks = []
            for (num_convs, out_channels) in arch:
                conv_blks.append(vgg_block(num_convs, out_channels))
            self.net = nn.Sequential(
                *conv_blks, nn.Flatten(),
                nn.LazyLinear(4096), nn.ReLU(), nn.Dropout(0.5),
                nn.LazyLinear(4096), nn.ReLU(), nn.Dropout(0.5),
                nn.LazyLinear(num_classes))
            self.net.apply(d2l.init_cnn)
```

```
In [4]: VGG(arch=((1, 64), (1, 128), (2, 256), (2, 512), (2, 512))).layer_summary(
        (1, 1, 224, 224))
```

```
Sequential output shape:      torch.Size([1, 64, 112, 112])
Sequential output shape:      torch.Size([1, 128, 56, 56])
Sequential output shape:      torch.Size([1, 256, 28, 28])
Sequential output shape:      torch.Size([1, 512, 14, 14])
Sequential output shape:      torch.Size([1, 512, 7, 7])
Flatten output shape:         torch.Size([1, 25088])
Linear output shape:          torch.Size([1, 4096])
ReLU output shape:            torch.Size([1, 4096])
Dropout output shape:         torch.Size([1, 4096])
Linear output shape:          torch.Size([1, 4096])
ReLU output shape:            torch.Size([1, 4096])
Dropout output shape:         torch.Size([1, 4096])
Linear output shape:          torch.Size([1, 10])
```

```
In [5]: model = VGG(arch=((1, 16), (1, 32), (2, 64), (2, 128), (2, 128)), lr=0.01)
        trainer = d2l.Trainer(max_epochs=10, num_gpus=1)
        data = d2l.FashionMNIST(batch_size=128, resize=(224, 224))
        model.apply_init([next(iter(data.get_dataloader(True)))[0]], d2l.init_cnn)
        trainer.fit(model, data)
```



Discussion: 일단 지금까지의 단원들에 비해 시간이 압도적으로 많이 걸렸다. 이번 단원은 VGG Network에 대해서 설명하는데, 이는 CNN의 여러 구조중 하나로, block구조를 사용한다는 특징을 가지고 있다. 각각의 block은 합성곱층, ReLU, Max Pooling의 순서로 이루어진다고 한다. 이러한 block들이 구성된 network는 크게 2가지 부분으로 나뉘는데, 합성곱 및 풀링 층으로 구성된 부분에서는 이미지에서 특징을 추출하고 입력 공간의 크기를 점차 줄여나가는 역할을 하고, 완전 연결 층으로 구성된 부분에서는 마지막에 추출된 특징을 사용하여 이미지를 분리하는 역할을 하였다. 이 예시에서는 5개의 block으로 구성되어 있으며, 위의 코드의 VGG구조에서 각 block의 채널 수나 계산 비용이 매우 크다는 것을 알 수 있다. 실제 훈련 및 실험에서는 채널 수를 줄여 더 간단한 버전을 훈련하였다. (그러나, 아무래도 데스크탑도 아니고 노트북으로 진행하고 있다 보니 시간이 여전히 너무 오래 걸렸다. 그래서 처음으로 colab으로 변경해서 진행하였다.)