

강아지 vs 고양이 분류하기(3)-VGG16

학습 내용

- 강아지와 고양이 데이터를 캐글로 부터 데이터를 준비
- 학습/검증/테스트 폴더 생성 후, 일부 데이터를 준비
- 신경망을 구성 후, 학습을 수행합니다.
- 모델을 저장하는 것에 대해 알아봅니다.

```
In [ ]: import os, shutil
```

```
In [ ]: ### 드라이브 마운트
from google.colab import drive
drive.mount('/content/drive')
```

Mounted at /content/drive

```
In [ ]: !cp -r '/content/drive/My Drive/dataset/cats_dogs' '/content/'
!ls -ls '/content/cats_dogs'
```

```
total 833956
277664 -rw----- 1 root root 284321224 Nov 14 23:19 cats_and_dogs_test1.zip
556204 -rw----- 1 root root 569546721 Nov 14 23:19 cats_and_dogs_train.zip
88 -rw----- 1 root root 88903 Nov 14 23:19 sampleSubmission.csv
```

```
In [ ]: # 압축풀기
!rm -rf '/content/datasets/'
!unzip '/content/cats_dogs/cats_and_dogs_test1.zip' -d '/content/datasets/'
!unzip '/content/cats_dogs/cats_and_dogs_train.zip' -d '/content/datasets/'
```

스트리밍 출력 내용이 길어서 마지막 5000줄이 삭제되었습니다.

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```

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ch05_07_VGG_CatvsDogs(3)_wColab

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ch05_07_VGG_CatvsDogs(3)_wColab

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ch05 07 VGG CatvsDogs(3) wColab

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ch05 07 VGG CatvsDogs(3) wColab

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inflating: /content/datasets/train/dog.9775.jpg
inflating: /content/datasets/train/dog.9776.jpg
inflating: /content/datasets/train/dog.9777.jpg
inflating: /content/datasets/train/dog.9778.jpg
inflating: /content/datasets/train/dog.9779.jpg
inflating: /content/datasets/train/dog.978.jpg
inflating: /content/datasets/train/dog.9780.jpg
inflating: /content/datasets/train/dog.9781.jpg
inflating: /content/datasets/train/dog.9782.jpg
inflating: /content/datasets/train/dog.9783.jpg
inflating: /content/datasets/train/dog.9784.jpg
inflating: /content/datasets/train/dog.9785.jpg
inflating: /content/datasets/train/dog.9786.jpg
inflating: /content/datasets/train/dog.9787.jpg
inflating: /content/datasets/train/dog.9788.jpg
inflating: /content/datasets/train/dog.9789.jpg
inflating: /content/datasets/train/dog.979.jpg
inflating: /content/datasets/train/dog.9790.jpg
inflating: /content/datasets/train/dog.9791.jpg
inflating: /content/datasets/train/dog.9792.jpg
inflating: /content/datasets/train/dog.9793.jpg
inflating: /content/datasets/train/dog.9794.jpg
inflating: /content/datasets/train/dog.9795.jpg
inflating: /content/datasets/train/dog.9796.jpg
inflating: /content/datasets/train/dog.9797.jpg
inflating: /content/datasets/train/dog.9798.jpg
inflating: /content/datasets/train/dog.9799.jpg
inflating: /content/datasets/train/dog.98.jpg
inflating: /content/datasets/train/dog.980.jpg
inflating: /content/datasets/train/dog.9800.jpg
inflating: /content/datasets/train/dog.9801.jpg
inflating: /content/datasets/train/dog.9802.jpg
inflating: /content/datasets/train/dog.9803.jpg
inflating: /content/datasets/train/dog.9804.jpg
inflating: /content/datasets/train/dog.9805.jpg
inflating: /content/datasets/train/dog.9806.jpg
inflating: /content/datasets/train/dog.9807.jpg
inflating: /content/datasets/train/dog.9808.jpg
inflating: /content/datasets/train/dog.9809.jpg
inflating: /content/datasets/train/dog.981.jpg
inflating: /content/datasets/train/dog.9810.jpg
inflating: /content/datasets/train/dog.9811.jpg

ch05_07_VGG_CatvsDogs(3)_wColab

ch05_07_VGG_CatvsDogs(3)_wColab

[illegible]

```
In [ ]: !ls -al '/content/datasets/train' | head -5
!ls -l '/content/datasets/train' | grep ^- | wc -l
!ls -al '/content/datasets/test1' | head -5
!ls -l '/content/datasets/test1' | grep ^- | wc -l

total 609260
drwxr-xr-x 2 root root 770048 Sep 20 2013 .
drwxr-xr-x 4 root root 4096 Nov 14 23:19 ..
-rw-r--r-- 1 root root 12414 Sep 20 2013 cat.0.jpg
-rw-r--r-- 1 root root 21944 Sep 20 2013 cat.10000.jpg
25000
total 304268
drwxr-xr-x 2 root root 278528 Sep 20 2013 .
drwxr-xr-x 4 root root 4096 Nov 14 23:19 ..
-rw-r--r-- 1 root root 54902 Sep 20 2013 10000.jpg
-rw-r--r-- 1 root root 21671 Sep 20 2013 10001.jpg
12500
```

데이터 준비

```
In [ ]: # 원본 데이터셋을 압축 해제한 디렉터리 경로
ori_dataset_dir = './datasets/train'

# 소규모 데이터셋을 저장할 디렉터리
base_dir = './datasets/cats_and_dogs_small'
```

```
In [ ]: # 반복실행을 위해 디렉터리 삭제
if os.path.exists(base_dir):
    shutil.rmtree(base_dir)
os.mkdir(base_dir)
```

```
In [ ]: # 훈련, 검증, 테스트 분할을 위한 디렉터리
train_dir = os.path.join(base_dir, 'train')
os.mkdir(train_dir)

val_dir = os.path.join(base_dir, 'validation')
os.mkdir(val_dir)

test_dir = os.path.join(base_dir, 'test')
os.mkdir(test_dir)
```

```
In [ ]: # 훈련용 고양이 사진 디렉터리
train_cats_dir = os.path.join(train_dir, 'cats')
os.mkdir(train_cats_dir)

# 훈련용 강아지 사진 디렉터리
train_dogs_dir = os.path.join(train_dir, 'dogs')
os.mkdir(train_dogs_dir)

# 검증용 고양이 사진 디렉터리
val_cats_dir = os.path.join(val_dir, 'cats')
os.mkdir(val_cats_dir)

# 검증용 강아지 사진 디렉터리
val_dogs_dir = os.path.join(val_dir, 'dogs')
os.mkdir(val_dogs_dir)

# 테스트용 고양이 사진 디렉터리
test_cats_dir = os.path.join(test_dir, 'cats')
os.mkdir(test_cats_dir)

# 테스트용 강아지 사진 디렉터리
test_dogs_dir = os.path.join(test_dir, 'dogs')
os.mkdir(test_dogs_dir)
```

```
In [ ]: # 처음 1,000개의 고양이 이미지를 train_cats_dir에 복사합니다
fnames = ['cat.{}.jpg'.format(i) for i in range(1000)]
for fname in fnames:
    src = os.path.join(ori_dataset_dir, fname)
    dst = os.path.join(train_cats_dir, fname)
    shutil.copyfile(src, dst)

# 다음 500개 고양이 이미지를 validation_cats_dir에 복사합니다
fnames = ['cat.{}.jpg'.format(i) for i in range(1000, 1500)]
for fname in fnames:
    src = os.path.join(ori_dataset_dir, fname)
    dst = os.path.join(val_cats_dir, fname)
    shutil.copyfile(src, dst)

# 다음 500개 고양이 이미지를 test_cats_dir에 복사합니다
fnames = ['cat.{}.jpg'.format(i) for i in range(1500, 2000)]
for fname in fnames:
    src = os.path.join(ori_dataset_dir, fname)
    dst = os.path.join(test_cats_dir, fname)
    shutil.copyfile(src, dst)

# 처음 1,000개의 강아지 이미지를 train_dogs_dir에 복사합니다
fnames = ['dog.{}.jpg'.format(i) for i in range(1000)]
for fname in fnames:
    src = os.path.join(ori_dataset_dir, fname)
    dst = os.path.join(train_dogs_dir, fname)
    shutil.copyfile(src, dst)

# 다음 500개 강아지 이미지를 validation_dogs_dir에 복사합니다
fnames = ['dog.{}.jpg'.format(i) for i in range(1000, 1500)]
for fname in fnames:
    src = os.path.join(ori_dataset_dir, fname)
    dst = os.path.join(val_dogs_dir, fname)
    shutil.copyfile(src, dst)

# 다음 500개 강아지 이미지를 test_dogs_dir에 복사합니다
fnames = ['dog.{}.jpg'.format(i) for i in range(1500, 2000)]
for fname in fnames:
    src = os.path.join(ori_dataset_dir, fname)
    dst = os.path.join(test_dogs_dir, fname)
    shutil.copyfile(src, dst)
```

```
In [ ]: print('훈련용 고양이 이미지 전체 개수:', len(os.listdir(train_cats_dir)))
print('훈련용 강아지 이미지 전체 개수:', len(os.listdir(train_dogs_dir)))

print('검증용 고양이 이미지 전체 개수:', len(os.listdir(val_cats_dir)))
print('검증용 강아지 이미지 전체 개수:', len(os.listdir(val_dogs_dir)))

print('테스트용 고양이 이미지 전체 개수:', len(os.listdir(test_cats_dir)))
print('테스트용 강아지 이미지 전체 개수:', len(os.listdir(test_dogs_dir)))
```

```
훈련용 고양이 이미지 전체 개수: 1000
훈련용 강아지 이미지 전체 개수: 1000
검증용 고양이 이미지 전체 개수: 500
검증용 강아지 이미지 전체 개수: 500
테스트용 고양이 이미지 전체 개수: 500
테스트용 강아지 이미지 전체 개수: 500
```

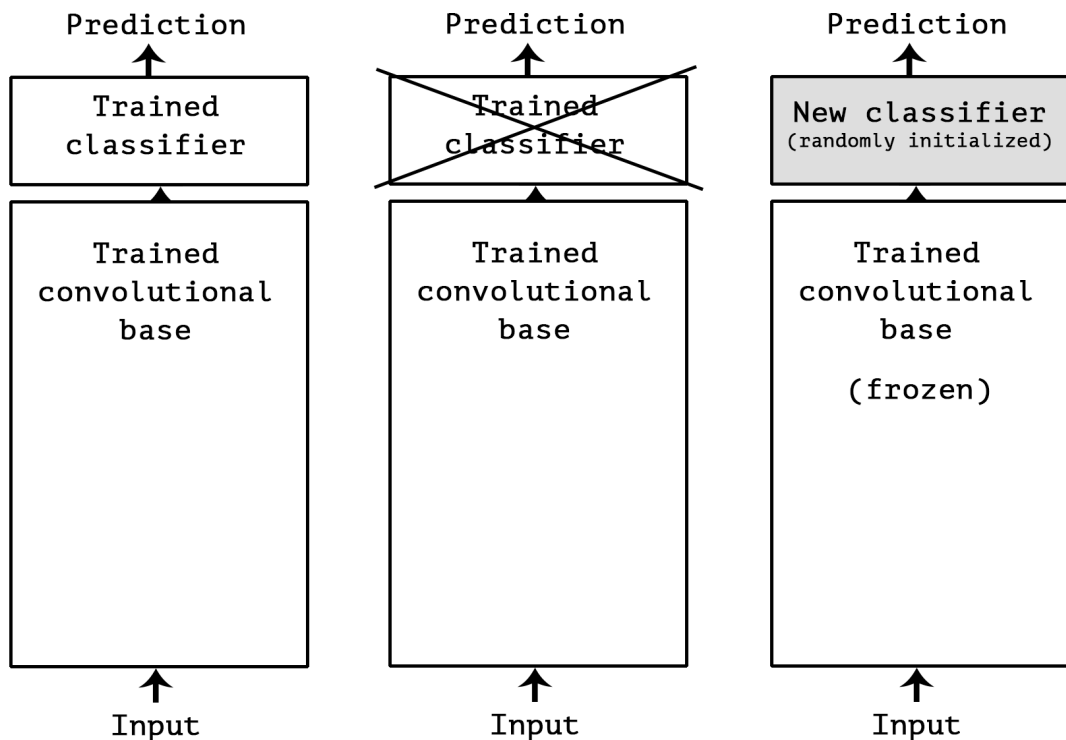
사전 훈련된 컨브넷 사용.

- 작은 이미지 데이터 셋에 딥러닝을 적용하는 일반적이고 매우 효과적인 방법은 **사전 훈련된 네트워크를 사용하는 것**.

- 사전 훈련된 네트워크(pretrained network)는 일반적으로 대규모 이미지 분류 문제를 위해 대량의 데이터셋에서 미리 훈련되어 저장된 네트워크
- ImageNet : 1400만개의 레이블된 이미지와 1000개의 클래스
- VGG16 : 캐런 시몬연(Keren Simonyan)과 앤드류 지서먼(Andrew Zisserman)이 2014년 개발
- 이외에도 VGG, ResNet, Inception, Inception-ResNet, Xception

특성 추출

앞서 보았듯이 컨브넷은 이미지 분류를 위해 두 부분으로 구성됩니다. 먼저 연속된 **합성곱과 풀링 층**으로 시작해서 **완전 연결 분류기**로 끝납니다. 첫 번째 부분을 모델의 합성곱 기반층(convolutional base)이라고 부르겠습니다. 컨브넷의 경우 특성 추출은 사전에 훈련된 네트워크의 합성곱 기반층을 선택해 새로운 데이터를 통과시키고 그 출력으로 새로운 분류기를 훈련합니다.



- 특정 합성곱 층에서 추출한 표현의 일반성(그리고 재사용성)의 수준은 모델에 있는 층의 깊이에 달려 있습니다. 모델의 하위 층은 (에지, 색깔, 질감 등과 같이) 지역적이고 매우 일반적인 특성 맵을 추출합니다. 반면 상위 층은 ('강아지 눈'이나 '고양이 귀'와 같이) 좀 더 추상적인 개념을 추출
- 만약 새로운 데이터셋이 원본 모델이 훈련한 데이터셋과 많이 다르다면 전체 합성곱 기반층을 사용하는 것보다는 모델의 하위 층 몇 개만 특성 추출에 사용하는 것이 좋음.
- VGG16 모델은 케라스에 패키지로 포함되어 있습니다. keras.applications 모듈에서 임포트 가능
- keras.applications 모듈에서 사용 가능한 이미지 분류 모델은 다음과 같습니다(모두 ImageNet 데이터셋에서 훈련)
- Xception

- InceptionV3
- ResNet50
- VGG16
- ResNet50
- VGG19
- MobileNet

```
In [ ]: from keras.applications import VGG16

conv_base = VGG16(weights='imagenet',
                      include_top=False,
                      input_shape=(150, 150, 3))
```

Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vgg16/vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5
58892288/58889256 [=====] - 0s 0us/step

- VGG16 함수에 세 개의 매개변수를 전달
 - weights는 모델을 초기화할 가중치 체크포인트를 지정
 - include_top은 네트워크의 최상위 완전 연결 분류기를 포함할지 안할지를 지정.
 - 기본값은 ImageNet의 1,000개의 클래스에 대응되는 완전 연결 분류기를 포함.
 - 별도의 (강아지와 고양이 두 개의 클래스를 구분하는) 완전 연결 층을 추가할 계획.
 - input_shape은 네트워크에 주입할 이미지 텐서의 크기입니다.
 - 이 매개변수는 선택사항입니다. 이 값을 지정하지 않으면 네트워크가 어떤 크기의 입력도 처리할 수 있습니다.

```
In [ ]: conv_base.summary()
```

Model: "vgg16"

Layer (type)	Output Shape	Param #
input_1 (InputLayer)	[(None, 150, 150, 3)]	0
block1_conv1 (Conv2D)	(None, 150, 150, 64)	1792
block1_conv2 (Conv2D)	(None, 150, 150, 64)	36928
block1_pool (MaxPooling2D)	(None, 75, 75, 64)	0
block2_conv1 (Conv2D)	(None, 75, 75, 128)	73856
block2_conv2 (Conv2D)	(None, 75, 75, 128)	147584
block2_pool (MaxPooling2D)	(None, 37, 37, 128)	0
block3_conv1 (Conv2D)	(None, 37, 37, 256)	295168
block3_conv2 (Conv2D)	(None, 37, 37, 256)	590080
block3_conv3 (Conv2D)	(None, 37, 37, 256)	590080
block3_pool (MaxPooling2D)	(None, 18, 18, 256)	0
block4_conv1 (Conv2D)	(None, 18, 18, 512)	1180160
block4_conv2 (Conv2D)	(None, 18, 18, 512)	2359808
block4_conv3 (Conv2D)	(None, 18, 18, 512)	2359808
block4_pool (MaxPooling2D)	(None, 9, 9, 512)	0

block5_conv1 (Conv2D)	(None, 9, 9, 512)	2359808
block5_conv2 (Conv2D)	(None, 9, 9, 512)	2359808
block5_conv3 (Conv2D)	(None, 9, 9, 512)	2359808
block5_pool (MaxPooling2D)	(None, 4, 4, 512)	0
=====		
Total params:	14,714,688	
Trainable params:	14,714,688	
Non-trainable params:	0	

- VGG19는 합성곱 층 16개, 완전 연결 층 3개로 이루어져 있음.
 - VGG16은 합성곱 13개, 완전 연결 층 3개.
 - include_top이 기본값이 True일 경우 input_shape이 원본 모델과 동일한 (224, 224, 3)이 되어야 한다.

방법 1: 데이터 증식을 사용하지 않는 빠른 특성 추출

```
In [ ]: import os
import numpy as np
from keras.preprocessing.image import ImageDataGenerator

# 소규모 데이터셋을 저장할 디렉토리
base_dir = './datasets/cats_and_dogs_small'

train_dir = os.path.join(base_dir, 'train')
validation_dir = os.path.join(base_dir, 'validation')
test_dir = os.path.join(base_dir, 'test')

datagen = ImageDataGenerator(rescale=1./255)
batch_size = 20

def extract_features(directory, sample_count):
    features = np.zeros(shape=(sample_count, 4, 4, 512))
    labels = np.zeros(shape=(sample_count))
    generator = datagen.flow_from_directory(
        directory,
        target_size=(150, 150),
        batch_size=batch_size,
        class_mode='binary')
    i = 0
    for inputs_batch, labels_batch in generator:
        features_batch = conv_base.predict(inputs_batch)
        features[i * batch_size : (i + 1) * batch_size] = features_batch
        labels[i * batch_size : (i + 1) * batch_size] = labels_batch
        i += 1
    if i * batch_size >= sample_count:
        # 제너레이터는 루프 안에서 무한하게 데이터를 만들어내므로 모든 이미지를 한
        break
    return features, labels

train_features, train_labels = extract_features(train_dir, 2000)
validation_features, validation_labels = extract_features(validation_dir, 1000)
test_features, test_labels = extract_features(test_dir, 1000)
```

Found 2000 images belonging to 2 classes.
 Found 1000 images belonging to 2 classes.
 Found 1000 images belonging to 2 classes.

- 추출된 특성의 크기는 (samples, 4, 4, 512). 완전 연결 분류기에 주입하기 위해 먼저 (samples, 8192)크기로 펼치기

```
In [ ]: train_features = np.reshape(train_features, (2000, 4 * 4 * 512))
        validation_features = np.reshape(validation_features, (1000, 4 * 4 * 512))
        test_features = np.reshape(test_features, (1000, 4 * 4 * 512))
```

완전 연결 분류기 정의(FCL)

- 완전 연결 분류기를 정의하고(규제를 위해 드롭아웃을 사용합니다)
- 저장된 데이터와 레이블을 사용해 훈련

```
In [ ]: from keras import models
        from keras import layers
        from keras import optimizers

        model = models.Sequential()
        model.add(layers.Dense(256, activation='relu', input_dim=4 * 4 * 512))
        model.add(layers.Dropout(0.5))
        model.add(layers.Dense(1, activation='sigmoid'))

        model.compile(optimizer=optimizers.RMSprop(lr=2e-5),
                      loss='binary_crossentropy',
                      metrics=['acc'])

        history = model.fit(train_features, train_labels,
                            epochs=30,
                            batch_size=20,
                            validation_data=(validation_features, validation_labels))
```

```
Epoch 1/30
100/100 [=====] - 1s 6ms/step - loss: 0.5766 - acc: 0.6915 -
val_loss: 0.4415 - val_acc: 0.8300
Epoch 2/30
100/100 [=====] - 0s 4ms/step - loss: 0.4183 - acc: 0.8170 -
val_loss: 0.3553 - val_acc: 0.8670
Epoch 3/30
100/100 [=====] - 0s 4ms/step - loss: 0.3514 - acc: 0.8480 -
val_loss: 0.3241 - val_acc: 0.8650
Epoch 4/30
100/100 [=====] - 0s 4ms/step - loss: 0.3090 - acc: 0.8800 -
val_loss: 0.2966 - val_acc: 0.8850
Epoch 5/30
100/100 [=====] - 0s 4ms/step - loss: 0.2865 - acc: 0.8850 -
val_loss: 0.2808 - val_acc: 0.8950
Epoch 6/30
100/100 [=====] - 0s 4ms/step - loss: 0.2649 - acc: 0.8980 -
val_loss: 0.2708 - val_acc: 0.8940
Epoch 7/30
100/100 [=====] - 0s 4ms/step - loss: 0.2388 - acc: 0.9090 -
val_loss: 0.2610 - val_acc: 0.8960
Epoch 8/30
100/100 [=====] - 0s 4ms/step - loss: 0.2336 - acc: 0.9085 -
val_loss: 0.2543 - val_acc: 0.9010
Epoch 9/30
100/100 [=====] - 0s 4ms/step - loss: 0.2146 - acc: 0.9240 -
val_loss: 0.2507 - val_acc: 0.9050
Epoch 10/30
100/100 [=====] - 0s 4ms/step - loss: 0.2011 - acc: 0.9265 -
val_loss: 0.2448 - val_acc: 0.9010
Epoch 11/30
100/100 [=====] - 0s 4ms/step - loss: 0.2020 - acc: 0.9240 -
val_loss: 0.2465 - val_acc: 0.8970
Epoch 12/30
100/100 [=====] - 0s 3ms/step - loss: 0.1834 - acc: 0.9300 -
val_loss: 0.2599 - val_acc: 0.8880
Epoch 13/30
100/100 [=====] - 0s 4ms/step - loss: 0.1763 - acc: 0.9330 -
```

```

val_loss: 0.2391 - val_acc: 0.9030
Epoch 14/30
100/100 [=====] - 0s 4ms/step - loss: 0.1693 - acc: 0.9345 -
val_loss: 0.2424 - val_acc: 0.9020
Epoch 15/30
100/100 [=====] - 0s 4ms/step - loss: 0.1626 - acc: 0.9375 -
val_loss: 0.2349 - val_acc: 0.9060
Epoch 16/30
100/100 [=====] - 0s 4ms/step - loss: 0.1525 - acc: 0.9465 -
val_loss: 0.2333 - val_acc: 0.9030
Epoch 17/30
100/100 [=====] - 0s 4ms/step - loss: 0.1490 - acc: 0.9495 -
val_loss: 0.2346 - val_acc: 0.8990
Epoch 18/30
100/100 [=====] - 0s 4ms/step - loss: 0.1388 - acc: 0.9545 -
val_loss: 0.2390 - val_acc: 0.9030
Epoch 19/30
100/100 [=====] - 0s 4ms/step - loss: 0.1356 - acc: 0.9525 -
val_loss: 0.2381 - val_acc: 0.9040
Epoch 20/30
100/100 [=====] - 0s 4ms/step - loss: 0.1327 - acc: 0.9560 -
val_loss: 0.2341 - val_acc: 0.8990
Epoch 21/30
100/100 [=====] - 0s 4ms/step - loss: 0.1229 - acc: 0.9565 -
val_loss: 0.2318 - val_acc: 0.9020
Epoch 22/30
100/100 [=====] - 0s 4ms/step - loss: 0.1176 - acc: 0.9635 -
val_loss: 0.2346 - val_acc: 0.9000
Epoch 23/30
100/100 [=====] - 0s 4ms/step - loss: 0.1126 - acc: 0.9635 -
val_loss: 0.2342 - val_acc: 0.9010
Epoch 24/30
100/100 [=====] - 0s 4ms/step - loss: 0.1076 - acc: 0.9670 -
val_loss: 0.2361 - val_acc: 0.9020
Epoch 25/30
100/100 [=====] - 0s 4ms/step - loss: 0.1062 - acc: 0.9625 -
val_loss: 0.2364 - val_acc: 0.9030
Epoch 26/30
100/100 [=====] - 0s 4ms/step - loss: 0.1024 - acc: 0.9670 -
val_loss: 0.2328 - val_acc: 0.9020
Epoch 27/30
100/100 [=====] - 0s 4ms/step - loss: 0.0963 - acc: 0.9685 -
val_loss: 0.2343 - val_acc: 0.9000
Epoch 28/30
100/100 [=====] - 0s 4ms/step - loss: 0.0964 - acc: 0.9665 -
val_loss: 0.2336 - val_acc: 0.9010
Epoch 29/30
100/100 [=====] - 0s 4ms/step - loss: 0.0922 - acc: 0.9695 -
val_loss: 0.2378 - val_acc: 0.9030
Epoch 30/30
100/100 [=====] - 0s 4ms/step - loss: 0.0896 - acc: 0.9730 -
val_loss: 0.2355 - val_acc: 0.9030

```

- 2개의 Dense 층만 처리하면 되기 때문에 훈련이 빠르다.

```
In [ ]: import matplotlib.pyplot as plt
```

훈련 손실과 정확도 곡선

```
In [ ]: acc = history.history['acc']
val_acc = history.history['val_acc']
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(len(acc))
```



```

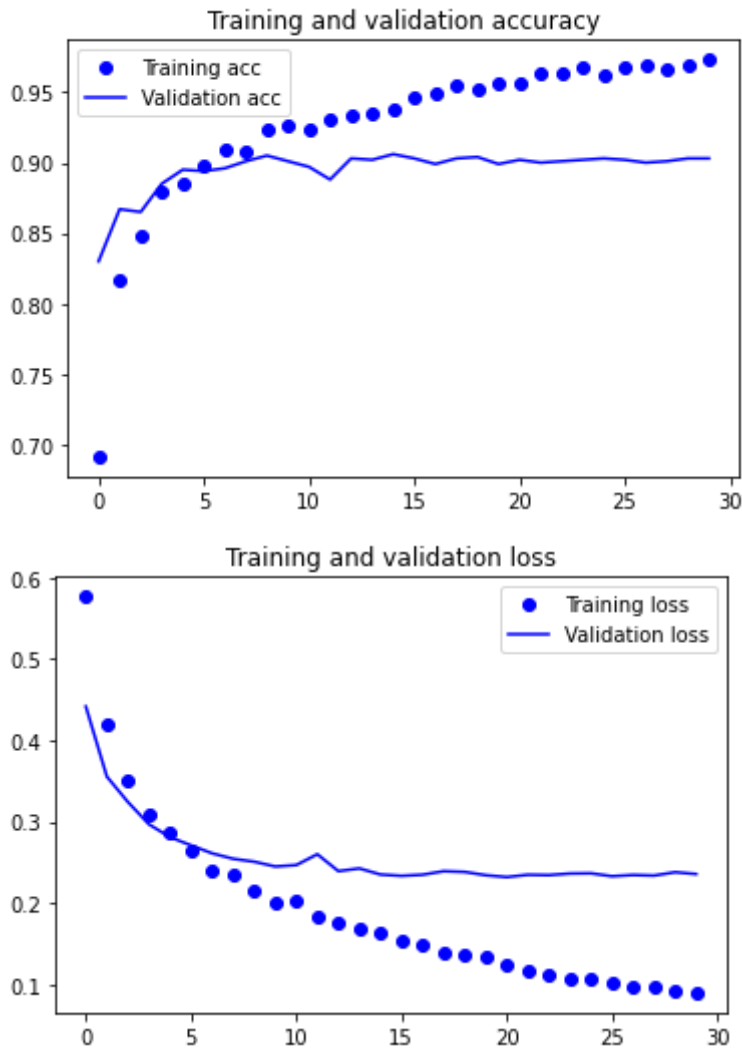
plt.plot(epochs, acc, 'bo', label='Training acc')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.legend()

plt.figure()

plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.legend()

plt.show()

```



Summary

- 90%의 검증 정확도에 도달
- 처음부터 훈련시킨 작은 모델에서 얻은 것보다 훨씬 좋음.
- 드롭아웃을 사용했음에도 불구하고 훈련이 시작하면서 거의 바로 과대적합되고 있다는 것
- 작은 이미지 데이터셋에서는 과대적합을 막기 위해 필수적인 데이터 증식을 사용하지 않음.

In []: