```
from google.colab import files
files.upload()
```

```
Choose Files No file chosen    Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.
Saving kaggle.json to kaggle.json
{'kaggle.json': b'{"username":"adityamunagala","key":"0c876f34b72b2247deb7fb26ae97be9b"}'}
```

```
!mkdir ~/.kaggle/
```

```
!cp kaggle.json ~/.kaggle/
!chmod 600 ~/.kaggle/kaggle.json
```

```
!kaggle competitions download -c dogs-vs-cats
```

```
Downloading dogs-vs-cats.zip to /content
100% 810M/812M [00:28<00:00, 27.5MB/s]
100% 812M/812M [00:28<00:00, 29.5MB/s]
```

```
!unzip -qq dogs-vs-cats.zip
```

```
!unzip -qq train.zip
```

```
import os, shutil, pathlib

original_dir = pathlib.Path("train")
new_base_dir = pathlib.Path("cats_vs_dogs_small_1")

def make_subset(subset_name, start_index, end_index):
    for category in ("cat", "dog"):
        dir = new_base_dir / subset_name / category
        os.makedirs(dir)
        fnames = [f"{category}.{i}.jpg" for i in range(start_index, end_index)]
        for fname in fnames:
            shutil.copyfile(src=original_dir / fname,
                            dst=dir / fname)

make_subset("train", start_index=0, end_index=1000)
make_subset("validation", start_index=1000, end_index=1500)
make_subset("test", start_index=1500, end_index=2000)
```

```
from tensorflow import keras
from tensorflow.keras import layers

inputs = keras.Input(shape=(180, 180, 3))
x = layers.Rescaling(1./255)(inputs)
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)
```

```
model.summary()
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 180, 180, 3)]     0

 rescaling (Rescaling)       (None, 180, 180, 3)       0

 conv2d (Conv2D)             (None, 178, 178, 32)      896
```

```
 max_pooling2d (MaxPooling2  (None, 89, 89, 32)        0
 D)

 conv2d_1 (Conv2D)           (None, 87, 87, 64)        18496

 max_pooling2d_1 (MaxPoolin  (None, 43, 43, 64)        0
 g2D)

 conv2d_2 (Conv2D)           (None, 41, 41, 128)       73856

 max_pooling2d_2 (MaxPoolin  (None, 20, 20, 128)       0
 g2D)

 conv2d_3 (Conv2D)           (None, 18, 18, 256)       295168

 max_pooling2d_3 (MaxPoolin  (None, 9, 9, 256)         0
 g2D)

 conv2d_4 (Conv2D)           (None, 7, 7, 256)         590080

 flatten (Flatten)           (None, 12544)             0

 dense (Dense)               (None, 1)                 12545

=================================================================
Total params: 991041 (3.78 MB)
Trainable params: 991041 (3.78 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

```
model.compile(loss="binary_crossentropy",
              optimizer="rmsprop",
              metrics=["accuracy"])
```

```
from tensorflow.keras.utils import image_dataset_from_directory

train_dataset = image_dataset_from_directory(
    new_base_dir / "train",
    image_size=(180, 180),
    batch_size=32)
validation_dataset = image_dataset_from_directory(
    new_base_dir / "validation",
    image_size=(180, 180),
    batch_size=32)
test_dataset = image_dataset_from_directory(
    new_base_dir / "test",
    image_size=(180, 180),
    batch_size=32)
```

```
 Found 2000 files belonging to 2 classes.
 Found 1000 files belonging to 2 classes.
 Found 1000 files belonging to 2 classes.
```

```
from tensorflow import keras
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch1.x",
        save_best_only=True,
        monitor="val_loss"
    )
]
history = model.fit(
    train_dataset,
    epochs=10,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

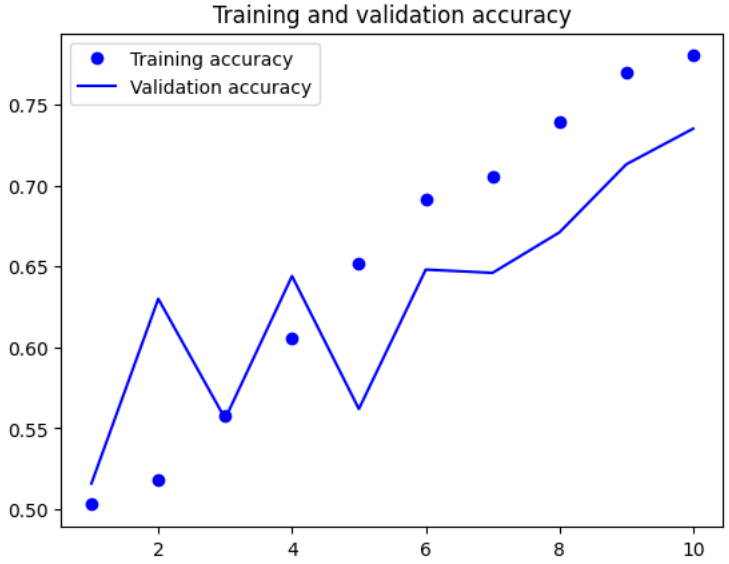
```
 Epoch 1/10
 63/63 [==============================] - 168s 3s/step - loss: 0.6985 - accuracy: 0.5030 - val_loss: 0.6924 - val_accuracy: 0.5160
 Epoch 2/10
 63/63 [==============================] - 191s 3s/step - loss: 0.6961 - accuracy: 0.5185 - val_loss: 0.6856 - val_accuracy: 0.6300
 Epoch 3/10
 63/63 [==============================] - 161s 3s/step - loss: 0.6913 - accuracy: 0.5580 - val_loss: 0.6768 - val_accuracy: 0.5560
 Epoch 4/10
 63/63 [==============================] - 181s 3s/step - loss: 0.6617 - accuracy: 0.6060 - val_loss: 0.6251 - val_accuracy: 0.6440
 Epoch 5/10
 63/63 [==============================] - 181s 3s/step - loss: 0.6182 - accuracy: 0.6515 - val_loss: 0.7889 - val_accuracy: 0.5620
 Epoch 6/10
 63/63 [==============================] - 161s 3s/step - loss: 0.5904 - accuracy: 0.6915 - val_loss: 0.6178 - val_accuracy: 0.6480
```

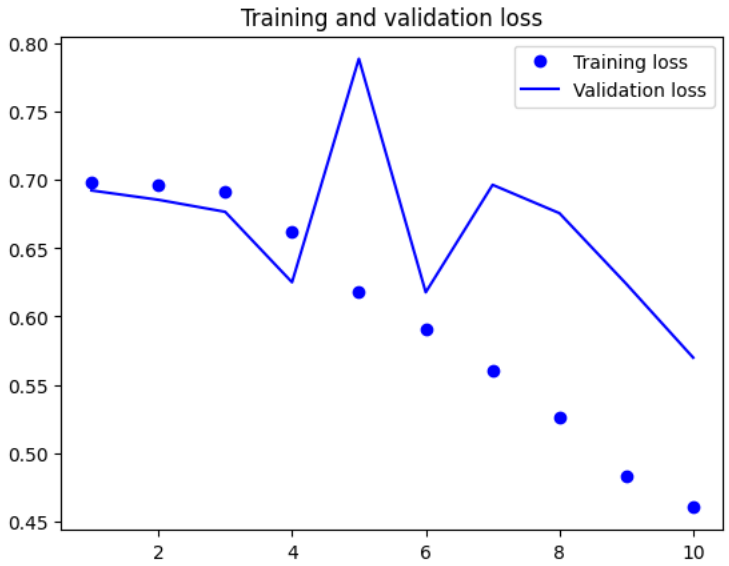
```
Epoch 7/10
63/63 [==============================] - 156s 2s/step - loss: 0.5599 - accuracy: 0.7050 - val_loss: 0.6965 - val_accuracy: 0.6460
Epoch 8/10
63/63 [==============================] - 179s 3s/step - loss: 0.5259 - accuracy: 0.7390 - val_loss: 0.6757 - val_accuracy: 0.6710
Epoch 9/10
63/63 [==============================] - 165s 3s/step - loss: 0.4827 - accuracy: 0.7695 - val_loss: 0.6239 - val_accuracy: 0.7130
Epoch 10/10
63/63 [==============================] - 182s 3s/step - loss: 0.4600 - accuracy: 0.7800 - val_loss: 0.5699 - val_accuracy: 0.7350
```

It can be shown that as the number of epochs increases, accuracy increases.

Accuracy=77.2% Val_acc=67.7% test accuracy=63.6%

```
import matplotlib.pyplot as plt
accuracy = history.history["accuracy"]
val_accuracy = history.history["val_accuracy"]
loss = history.history["loss"]
val_loss = history.history["val_loss"]
epochs = range(1, len(accuracy) + 1)
plt.plot(epochs, accuracy, "bo", label="Training accuracy")
plt.plot(epochs, val_accuracy, "b", label="Validation accuracy")
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()
```





```
test_model = keras.models.load_model("convnet_from_scratch1.x")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
 32/32 [==============================] - 20s 627ms/step - loss: 0.5584 - accuracy: 0.7330
 Test accuracy: 0.733
```

```
data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)
```

```
inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = layers.Rescaling(1./255)(x)
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)

model.compile(loss="binary_crossentropy",
              optimizer="rmsprop",
              metrics=["accuracy"])
```

```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch_with_augmentation1.x",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=10,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
 Epoch 1/10
 63/63 [==============================] - 185s 3s/step - loss: 0.7005 - accuracy: 0.5190 - val_loss: 0.6927 - val_accuracy: 0.5000
 Epoch 2/10
 63/63 [==============================] - 195s 3s/step - loss: 0.6929 - accuracy: 0.5265 - val_loss: 0.7032 - val_accuracy: 0.5000
 Epoch 3/10
 63/63 [==============================] - 197s 3s/step - loss: 0.6936 - accuracy: 0.5450 - val_loss: 0.6878 - val_accuracy: 0.5050
 Epoch 4/10
 63/63 [==============================] - 178s 3s/step - loss: 0.6956 - accuracy: 0.5430 - val_loss: 0.6946 - val_accuracy: 0.5090
 Epoch 5/10
 63/63 [==============================] - 194s 3s/step - loss: 0.6737 - accuracy: 0.5985 - val_loss: 0.6526 - val_accuracy: 0.6460
 Epoch 6/10
 63/63 [==============================] - 171s 3s/step - loss: 0.6689 - accuracy: 0.6015 - val_loss: 0.6510 - val_accuracy: 0.6020
 Epoch 7/10
 63/63 [==============================] - 175s 3s/step - loss: 0.6366 - accuracy: 0.6470 - val_loss: 1.1360 - val_accuracy: 0.5010
 Epoch 8/10
 63/63 [==============================] - 171s 3s/step - loss: 0.6149 - accuracy: 0.6650 - val_loss: 1.1188 - val_accuracy: 0.5110
 Epoch 9/10
 63/63 [==============================] - 172s 3s/step - loss: 0.6079 - accuracy: 0.6565 - val_loss: 0.5953 - val_accuracy: 0.6600
 Epoch 10/10
 63/63 [==============================] - 169s 3s/step - loss: 0.5946 - accuracy: 0.6825 - val_loss: 0.6078 - val_accuracy: 0.6580
```

```
test_model = keras.models.load_model(
    "convnet_from_scratch_with_augmentation1.x")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
 32/32 [==============================] - 19s 579ms/step - loss: 0.6203 - accuracy: 0.6740
 Test accuracy: 0.674
```

```
import os, shutil, pathlib

original_dir = pathlib.Path("train")
new_base_dir = pathlib.Path("cats_vs_dogs_small_2")

def make_subset(subset_name, start_index, end_index):
    for category in ("cat", "dog"):
        dir = new_base_dir / subset_name / category
        os.makedirs(dir, exist_ok=True)
        fnames = [f"{category}.{i}.jpg" for i in range(start_index, end_index)]
        for fname in fnames:
            shutil.copyfile(src=original_dir / fname,
                            dst=dir / fname)

make_subset("train", start_index=0, end_index=1500)
make_subset("validation", start_index=1500, end_index=2000)
make_subset("test", start_index=2000, end_index=2500)


from tensorflow.keras.utils import image_dataset_from_directory

train_dataset = image_dataset_from_directory(
    new_base_dir / "train",
    image_size=(180, 180),
    batch_size=32)
validation_dataset = image_dataset_from_directory(
    new_base_dir / "validation",
    image_size=(180, 180),
    batch_size=32)
test_dataset = image_dataset_from_directory(
    new_base_dir / "test",
    image_size=(180, 180),
    batch_size=32)
```

```
 Found 3000 files belonging to 2 classes.
 Found 1000 files belonging to 2 classes.
 Found 1000 files belonging to 2 classes.
```

```
inputs = keras.Input(shape=(180, 180, 3))
x = layers.Rescaling(1./255)(inputs)
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)

model.compile(loss="binary_crossentropy",
              optimizer="rmsprop",
              metrics=["accuracy"])


callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch2.x",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=10,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
 Epoch 1/10
 94/94 [==============================] - 229s 2s/step - loss: 0.6978 - accuracy: 0.5293 - val_loss: 0.6835 - val_accuracy: 0.5450
 Epoch 2/10
 94/94 [==============================] - 225s 2s/step - loss: 0.6782 - accuracy: 0.5913 - val_loss: 0.6605 - val_accuracy: 0.6280
 Epoch 3/10
 94/94 [==============================] - 225s 2s/step - loss: 0.6375 - accuracy: 0.6577 - val_loss: 0.6477 - val_accuracy: 0.6400
```

```
Epoch 4/10
94/94 [==============================] - 249s 3s/step - loss: 0.6086 - accuracy: 0.6680 - val_loss: 0.6404 - val_accuracy: 0.6220
Epoch 5/10
94/94 [==============================] - 224s 2s/step - loss: 0.5624 - accuracy: 0.7040 - val_loss: 0.7732 - val_accuracy: 0.5960
Epoch 6/10
94/94 [==============================] - 225s 2s/step - loss: 0.5234 - accuracy: 0.7410 - val_loss: 0.5908 - val_accuracy: 0.6910
Epoch 7/10
94/94 [==============================] - 223s 2s/step - loss: 0.4714 - accuracy: 0.7777 - val_loss: 0.5460 - val_accuracy: 0.7240
Epoch 8/10
94/94 [==============================] - 226s 2s/step - loss: 0.4135 - accuracy: 0.8093 - val_loss: 0.6275 - val_accuracy: 0.7230
Epoch 9/10
94/94 [==============================] - 245s 3s/step - loss: 0.3662 - accuracy: 0.8390 - val_loss: 0.5625 - val_accuracy: 0.7350
Epoch 10/10
94/94 [==============================] - 224s 2s/step - loss: 0.3049 - accuracy: 0.8720 - val_loss: 0.6284 - val_accuracy: 0.7160
```

```
test_model = keras.models.load_model(
    "convnet_from_scratch2.x")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
32/32 [==============================] - 19s 583ms/step - loss: 0.5138 - accuracy: 0.7490
Test accuracy: 0.749
```

```
data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)
```

```
inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = layers.Rescaling(1./255)(x)
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)

model.compile(loss="binary_crossentropy",
              optimizer="adam",
              metrics=["accuracy"])
```

```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch_with_augmentation2.x",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=10,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
Epoch 1/10
94/94 [==============================] - 249s 3s/step - loss: 0.6924 - accuracy: 0.5263 - val_loss: 0.7081 - val_accuracy: 0.5400
Epoch 2/10
94/94 [==============================] - 262s 3s/step - loss: 0.6800 - accuracy: 0.5670 - val_loss: 0.6654 - val_accuracy: 0.6150
Epoch 3/10
94/94 [==============================] - 239s 3s/step - loss: 0.6567 - accuracy: 0.6160 - val_loss: 0.6599 - val_accuracy: 0.6280
Epoch 4/10
94/94 [==============================] - 241s 3s/step - loss: 0.6521 - accuracy: 0.6243 - val_loss: 0.6278 - val_accuracy: 0.6620
Epoch 5/10
94/94 [==============================] - 238s 3s/step - loss: 0.6334 - accuracy: 0.6547 - val_loss: 0.6521 - val_accuracy: 0.6100
Epoch 6/10
94/94 [==============================] - 240s 3s/step - loss: 0.6209 - accuracy: 0.6590 - val_loss: 0.6373 - val_accuracy: 0.6230
```

```
Epoch 7/10
94/94 [==============================] - 246s 3s/step - loss: 0.5840 - accuracy: 0.6870 - val_loss: 0.5703 - val_accuracy: 0.6920
Epoch 8/10
94/94 [==============================] - 242s 3s/step - loss: 0.5841 - accuracy: 0.6830 - val_loss: 0.6220 - val_accuracy: 0.6550
Epoch 9/10
94/94 [==============================] - 244s 3s/step - loss: 0.5527 - accuracy: 0.7227 - val_loss: 0.5654 - val_accuracy: 0.7050
Epoch 10/10
94/94 [==============================] - 242s 3s/step - loss: 0.5464 - accuracy: 0.7197 - val_loss: 0.5550 - val_accuracy: 0.7200
```

```
test_model = keras.models.load_model(
    "convnet_from_scratch_with_augmentation2.x")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
32/32 [==============================] - 20s 620ms/step - loss: 0.5373 - accuracy: 0.7340
Test accuracy: 0.734
```

```
import os, shutil, pathlib

original_dir = pathlib.Path("train")
new_base_dir = pathlib.Path("cats_vs_dogs_small_3")

def make_subset(subset_name, start_index, end_index):
    for category in ("cat", "dog"):
        dir = new_base_dir / subset_name / category
        os.makedirs(dir, exist_ok=True)
        fnames = [f"{category}.{i}.jpg" for i in range(start_index, end_index)]
        for fname in fnames:
            shutil.copyfile(src=original_dir / fname,
                            dst=dir / fname)

make_subset("train", start_index=0, end_index=1500)
make_subset("validation", start_index=1500, end_index=2500)
make_subset("test", start_index=2500, end_index=3000)
```

```
from tensorflow.keras.utils import image_dataset_from_directory

train_dataset = image_dataset_from_directory(
    new_base_dir / "train",
    image_size=(180, 180),
    batch_size=32)
validation_dataset = image_dataset_from_directory(
    new_base_dir / "validation",
    image_size=(180, 180),
    batch_size=32)
test_dataset = image_dataset_from_directory(
    new_base_dir / "test",
    image_size=(180, 180),
    batch_size=32)
```

```
Found 3000 files belonging to 2 classes.
Found 2000 files belonging to 2 classes.
Found 1000 files belonging to 2 classes.
```

```
inputs = keras.Input(shape=(180, 180, 3))
x = layers.Rescaling(1./255)(inputs)
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)

model.compile(loss="binary_crossentropy",
              optimizer="rmsprop",
              metrics=["accuracy"])
```

```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch3.x",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=10,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
 Epoch 1/10
 94/94 [==============================] - 249s 3s/step - loss: 0.6994 - accuracy: 0.5160 - val_loss: 0.6895 - val_accuracy: 0.5220
 Epoch 2/10
 94/94 [==============================] - 244s 3s/step - loss: 0.6874 - accuracy: 0.5627 - val_loss: 0.7314 - val_accuracy: 0.5005
 Epoch 3/10
 94/94 [==============================] - 246s 3s/step - loss: 0.6567 - accuracy: 0.6133 - val_loss: 0.6334 - val_accuracy: 0.6595
 Epoch 4/10
 94/94 [==============================] - 246s 3s/step - loss: 0.6124 - accuracy: 0.6650 - val_loss: 0.6216 - val_accuracy: 0.6475
 Epoch 5/10
 94/94 [==============================] - 245s 3s/step - loss: 0.5933 - accuracy: 0.6907 - val_loss: 0.5856 - val_accuracy: 0.7010
 Epoch 6/10
 94/94 [==============================] - 244s 3s/step - loss: 0.5427 - accuracy: 0.7253 - val_loss: 0.6702 - val_accuracy: 0.6860
 Epoch 7/10
 94/94 [==============================] - 244s 3s/step - loss: 0.5017 - accuracy: 0.7550 - val_loss: 0.6098 - val_accuracy: 0.7130
 Epoch 8/10
 94/94 [==============================] - 242s 3s/step - loss: 0.4589 - accuracy: 0.7877 - val_loss: 0.6190 - val_accuracy: 0.7145
 Epoch 9/10
 94/94 [==============================] - 246s 3s/step - loss: 0.4087 - accuracy: 0.8193 - val_loss: 0.6753 - val_accuracy: 0.6815
 Epoch 10/10
 94/94 [==============================] - 245s 3s/step - loss: 0.3539 - accuracy: 0.8377 - val_loss: 0.6167 - val_accuracy: 0.7460
```

```
test_model = keras.models.load_model(
    "convnet_from_scratch3.x")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
 32/32 [==============================] - 20s 598ms/step - loss: 0.6104 - accuracy: 0.6740
 Test accuracy: 0.674
```

```
data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)
```

```
inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = layers.Rescaling(1./255)(x)
x = layers.Conv2D(filters=32, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=64, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=128, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)
x = layers.Conv2D(filters=256, kernel_size=3, activation="relu")(x)
x = layers.Flatten()(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs=inputs, outputs=outputs)

model.compile(loss="binary_crossentropy",
              optimizer="adam",
              metrics=["accuracy"])
```

```
callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="convnet_from_scratch_with_augmentation3.x",
        save_best_only=True,
        monitor="val_loss")
]
```

```
history = model.fit(
    train_dataset,
    epochs=10,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
Epoch 1/10
94/94 [==============================] - 312s 3s/step - loss: 0.6944 - accuracy: 0.5037 - val_loss: 0.6940 - val_accuracy: 0.5000
Epoch 2/10
94/94 [==============================] - 264s 3s/step - loss: 0.6936 - accuracy: 0.5080 - val_loss: 0.6939 - val_accuracy: 0.5005
Epoch 3/10
94/94 [==============================] - 267s 3s/step - loss: 0.6888 - accuracy: 0.5160 - val_loss: 0.6921 - val_accuracy: 0.5960
Epoch 4/10
94/94 [==============================] - 262s 3s/step - loss: 0.6806 - accuracy: 0.5470 - val_loss: 0.6942 - val_accuracy: 0.5465
Epoch 5/10
94/94 [==============================] - 262s 3s/step - loss: 0.6643 - accuracy: 0.6027 - val_loss: 0.6617 - val_accuracy: 0.5900
Epoch 6/10
94/94 [==============================] - 263s 3s/step - loss: 0.6530 - accuracy: 0.6147 - val_loss: 0.6355 - val_accuracy: 0.6610
Epoch 7/10
94/94 [==============================] - 262s 3s/step - loss: 0.6250 - accuracy: 0.6690 - val_loss: 0.6479 - val_accuracy: 0.6190
Epoch 8/10
94/94 [==============================] - 263s 3s/step - loss: 0.6274 - accuracy: 0.6567 - val_loss: 0.6278 - val_accuracy: 0.6550
Epoch 9/10
94/94 [==============================] - 264s 3s/step - loss: 0.6185 - accuracy: 0.6600 - val_loss: 0.6249 - val_accuracy: 0.6575
Epoch 10/10
94/94 [==============================] - 265s 3s/step - loss: 0.6062 - accuracy: 0.6713 - val_loss: 0.5829 - val_accuracy: 0.6925
```

```
test_model = keras.models.load_model(
    "convnet_from_scratch_with_augmentation3.x")
test_loss, test_acc = test_model.evaluate(test_dataset)
print(f"Test accuracy: {test_acc:.3f}")
```

```
32/32 [==============================] - 22s 643ms/step - loss: 0.6131 - accuracy: 0.6760
Test accuracy: 0.676
```

```
conv_base = keras.applications.vgg16.VGG16(
    weights="imagenet",
    include_top=False,
    input_shape=(180, 180, 3))
conv_base.summary()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vgg16/vgg16_weights_tf_dim_ordering_tf_kernels_notop.
58889256/58889256 [==============================] - 3s 0us/step
Model: "vgg16"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_7 (InputLayer)        [(None, 180, 180, 3)]     0

 block1_conv1 (Conv2D)       (None, 180, 180, 64)      1792

 block1_conv2 (Conv2D)       (None, 180, 180, 64)      36928

 block1_pool (MaxPooling2D)  (None, 90, 90, 64)        0

 block2_conv1 (Conv2D)       (None, 90, 90, 128)       73856

 block2_conv2 (Conv2D)       (None, 90, 90, 128)       147584

 block2_pool (MaxPooling2D)  (None, 45, 45, 128)       0

 block3_conv1 (Conv2D)       (None, 45, 45, 256)       295168

 block3_conv2 (Conv2D)       (None, 45, 45, 256)       590080

 block3_conv3 (Conv2D)       (None, 45, 45, 256)       590080

 block3_pool (MaxPooling2D)  (None, 22, 22, 256)       0

 block4_conv1 (Conv2D)       (None, 22, 22, 512)       1180160

 block4_conv2 (Conv2D)       (None, 22, 22, 512)       2359808

 block4_conv3 (Conv2D)       (None, 22, 22, 512)       2359808

 block4_pool (MaxPooling2D)  (None, 11, 11, 512)       0

 block5_conv1 (Conv2D)       (None, 11, 11, 512)       2359808

 block5_conv2 (Conv2D)       (None, 11, 11, 512)       2359808
```

```
 block5_conv3 (Conv2D)       (None, 11, 11, 512)       2359808

 block5_pool (MaxPooling2D)  (None, 5, 5, 512)         0

=================================================================
Total params: 14714688 (56.13 MB)
Trainable params: 14714688 (56.13 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

```
import numpy as np

def get_features_and_labels(dataset):
    all_features = []
    all_labels = []
    for images, labels in dataset:
        preprocessed_images = keras.applications.vgg16.preprocess_input(images)
        features = conv_base.predict(preprocessed_images)
        all_features.append(features)
        all_labels.append(labels)
    return np.concatenate(all_features), np.concatenate(all_labels)

train_features, train_labels =  get_features_and_labels(train_dataset)
val_features, val_labels =  get_features_and_labels(validation_dataset)
test_features, test_labels =  get_features_and_labels(test_dataset)

train_features.shape
```

```
 1/1 [==============================] - 10s 10s/step
 1/1 [==============================] - 11s 11s/step
 1/1 [==============================] - 11s 11s/step
 1/1 [==============================] - 11s 11s/step
 1/1 [==============================] - 13s 13s/step
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 1/1 [==============================] - 11s 11s/step
 1/1 [==============================] - 13s 13s/step
```

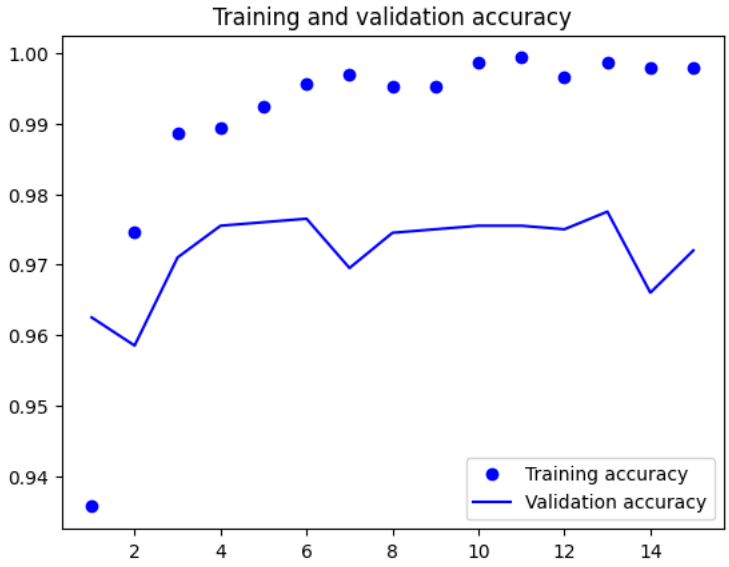
```
1/1 [==============================] - 11s 11s/step
1/1 [==============================] - 11s 11s/step
1/1 [==============================] - 10s 10s/step
1/1 [==============================] - 11s 11s/step
1/1 [==============================] - 11s 11s/step
```

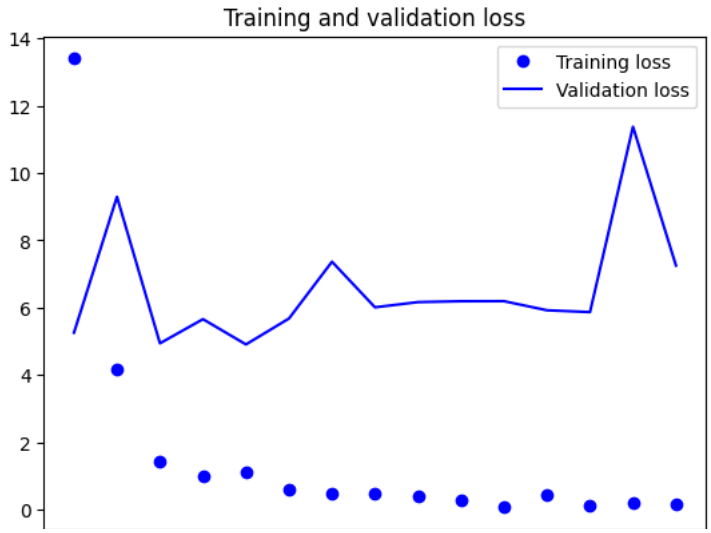
```
inputs = keras.Input(shape=(5, 5, 512))
x = layers.Flatten()(inputs)
x = layers.Dense(256)(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs, outputs)
model.compile(loss="binary_crossentropy",
              optimizer="rmsprop",
              metrics=["accuracy"])

callbacks = [
    keras.callbacks.ModelCheckpoint(
      filepath="feature_extractionPT1.x",
      save_best_only=True,
      monitor="val_loss")
]
history = model.fit(
    train_features, train_labels,
    epochs=15,
    validation_data=(val_features, val_labels),
    callbacks=callbacks)
```

```
Epoch 1/15
94/94 [==============================] - 16s 149ms/step - loss: 13.3925 - accuracy: 0.9357 - val_loss: 5.2545 - val_accuracy: 0.9625
Epoch 2/15
94/94 [==============================] - 6s 60ms/step - loss: 4.1733 - accuracy: 0.9747 - val_loss: 9.2914 - val_accuracy: 0.9585
Epoch 3/15
94/94 [==============================] - 6s 67ms/step - loss: 1.4125 - accuracy: 0.9887 - val_loss: 4.9386 - val_accuracy: 0.9710
Epoch 4/15
94/94 [==============================] - 5s 51ms/step - loss: 0.9839 - accuracy: 0.9893 - val_loss: 5.6567 - val_accuracy: 0.9755
Epoch 5/15
94/94 [==============================] - 7s 76ms/step - loss: 1.1170 - accuracy: 0.9923 - val_loss: 4.9057 - val_accuracy: 0.9760
Epoch 6/15
94/94 [==============================] - 4s 46ms/step - loss: 0.5845 - accuracy: 0.9957 - val_loss: 5.6758 - val_accuracy: 0.9765
Epoch 7/15
94/94 [==============================] - 4s 46ms/step - loss: 0.4703 - accuracy: 0.9970 - val_loss: 7.3636 - val_accuracy: 0.9695
Epoch 8/15
94/94 [==============================] - 5s 53ms/step - loss: 0.4880 - accuracy: 0.9953 - val_loss: 6.0083 - val_accuracy: 0.9745
Epoch 9/15
94/94 [==============================] - 4s 47ms/step - loss: 0.3857 - accuracy: 0.9953 - val_loss: 6.1635 - val_accuracy: 0.9750
Epoch 10/15
94/94 [==============================] - 7s 73ms/step - loss: 0.2643 - accuracy: 0.9987 - val_loss: 6.1887 - val_accuracy: 0.9755
Epoch 11/15
94/94 [==============================] - 5s 49ms/step - loss: 0.0613 - accuracy: 0.9993 - val_loss: 6.1906 - val_accuracy: 0.9755
Epoch 12/15
94/94 [==============================] - 6s 60ms/step - loss: 0.4566 - accuracy: 0.9967 - val_loss: 5.9209 - val_accuracy: 0.9750
Epoch 13/15
94/94 [==============================] - 5s 54ms/step - loss: 0.1049 - accuracy: 0.9987 - val_loss: 5.8666 - val_accuracy: 0.9775
Epoch 14/15
94/94 [==============================] - 5s 49ms/step - loss: 0.1882 - accuracy: 0.9980 - val_loss: 11.3728 - val_accuracy: 0.9660
Epoch 15/15
94/94 [==============================] - 5s 58ms/step - loss: 0.1420 - accuracy: 0.9980 - val_loss: 7.2477 - val_accuracy: 0.9720
```

```
import matplotlib.pyplot as plt
acc = history.history["accuracy"]
val_acc = history.history["val_accuracy"]
loss = history.history["loss"]
val_loss = history.history["val_loss"]
epochs = range(1, len(acc) + 1)
plt.plot(epochs, acc, "bo", label="Training accuracy")
plt.plot(epochs, val_acc, "b", label="Validation accuracy")
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()
```






```
conv_base  = keras.applications.vgg16.VGG16(
    weights="imagenet",
    include_top=False)
conv_base.trainable = False
```

```
conv_base.trainable = True
print("This is the number of trainable weights "
      "before freezing the conv base:", len(conv_base.trainable_weights))
```

```
conv_base.trainable = False
print("This is the number of trainable weights "
      "after freezing the conv base:", len(conv_base.trainable_weights))
```

```
This is the number of trainable weights before freezing the conv base: 26
This is the number of trainable weights after freezing the conv base: 0
```

```
data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)

inputs = keras.Input(shape=(180, 180, 3))
x = data_augmentation(inputs)
x = keras.applications.vgg16.preprocess_input(x)
x = conv_base(x)
x = layers.Flatten()(x)
x = layers.Dense(256)(x)
```

```
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(1, activation="sigmoid")(x)
model = keras.Model(inputs, outputs)
model.compile(loss="binary_crossentropy",
              optimizer="rmsprop",
              metrics=["accuracy"])


callbacks = [
    keras.callbacks.ModelCheckpoint(
        filepath="feature_extraction_with_data_augmentationPT2.x",
        save_best_only=True,
        monitor="val_loss")
]
history = model.fit(
    train_dataset,
    epochs=5,
    validation_data=validation_dataset,
    callbacks=callbacks)
```

```
 Epoch 1/5
 94/94 [==============================] - 1768s 19s/step - loss: 19.0464 - accuracy: 0.9070 - val_loss: 5.1251 - val_accuracy: 0.9680
 Epoch 2/5
 94/94 [==============================] - 1686s 18s/step - loss: 6.5667 - accuracy: 0.9530 - val_loss: 4.1836 - val_accuracy: 0.9765
 Epoch 3/5
 94/94 [==============================] - 1693s 18s/step - loss: 5.9281 - accuracy: 0.9577 - val_loss: 4.6219 - val_accuracy: 0.9740
 Epoch 4/5
 61/94 [==================>...........] - ETA: 5:53 - loss: 4.2165 - accuracy: 0.9652
```