fine-tune-2class

January 23, 2020

[9]:
```
from tensorflow.keras import applications
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras import optimizers
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dropout, Flatten, Dense
from tensorflow.keras.layers import Input
from tensorflow.keras.models import load_model
from tensorflow.keras.models import Model
from tensorflow.keras.utils import plot_model
from sklearn.metrics import classification_report
import matplotlib.pyplot as plt
import numpy as np
import os
import tensorflow as tf
```

[4]:
```
tf.config.threading.set_inter_op_parallelism_threads(6)
tf.config.threading.set_intra_op_parallelism_threads(2)

# path to the model weights files.
weights_path = '/home/user/models/pretrained/vgg16_weights.h5'
top_model_weights_path = '/home/user/models/top_tuned/
 ↪bottleneck_fc_model_2class.h5'
# dimensions of our images.
img_width, img_height = 224, 224

train_data_dir = '/home/user/     /convnets/transfer-learning-keras/dataset/
 ↪training'
validation_data_dir = '/home/user/     /convnets/transfer-learning-keras/
 ↪dataset/validation'
evaluation_data_dir = '/home/user/     /convnets/transfer-learning-keras/
 ↪dataset/evaluation'
nb_train_samples = 3000
nb_validation_samples = 1000
nb_evaluation_samples = 1000
epochs = 10
batch_size = 20
```

```
# build the VGG16 network
base_model = applications.VGG16(weights='imagenet', include_top=False,
                                input_tensor=Input(shape=(224, 224, 3)))
print('VGG16 model loaded.')
```

```
VGG16 model loaded.
```

[5]:
```
# build a classifier model to put on top of the convolutional model
top_model = base_model.output
top_model = Flatten(name='flatten')(top_model)
top_model = Dense(512, activation='relu')(top_model)
top_model = Dropout(0.5)(top_model)
top_model = Dense(1, activation='sigmoid')(top_model)

# note that it is necessary to start with a fully-trained
# classifier, including the top classifier,
# in order to successfully do fine-tuning

# add the model on top of the convolutional base
model = Model(inputs=base_model.input, outputs=top_model)

# set the first 15 layers (up to the last conv block)
# to non-trainable (weights will not be updated)
for layer in base_model.layers:
    layer.trainable = False
for layer in model.layers:
    print("{}: {}".format(layer, layer.trainable))
```

```
<tensorflow.python.keras.engine.input_layer.InputLayer object at
0x7f45bc2b58d0>: False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc323d50>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc2b5f10>:
False
<tensorflow.python.keras.layers.pooling.MaxPooling2D object at 0x7f45bc2bf2d0>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc2c4990>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc2d25d0>:
False
<tensorflow.python.keras.layers.pooling.MaxPooling2D object at 0x7f45bc2e20d0>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc2e8e90>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc276450>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc280750>:
False
```

```
<tensorflow.python.keras.layers.pooling.MaxPooling2D object at 0x7f45bc292650>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc29f2d0>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc2a5bd0>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc1f6a90>:
False
<tensorflow.python.keras.layers.pooling.MaxPooling2D object at 0x7f45bc209590>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc20f390>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc21c990>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc1ae550>:
False
<tensorflow.python.keras.layers.pooling.MaxPooling2D object at 0x7f45bc1c0090>:
False
<tensorflow.python.keras.layers.core.Flatten object at 0x7f45bc194510>: True
<tensorflow.python.keras.layers.core.Dense object at 0x7f45bc18dcd0>: True
<tensorflow.python.keras.layers.core.Dropout object at 0x7f45bc18db10>: True
<tensorflow.python.keras.layers.core.Dense object at 0x7f45bc18dd10>: True
```

[6]:
```
# compile the model with a SGD/momentum optimizer
# and a very slow learning rate.
model.compile(loss='binary_crossentropy',
              optimizer=optimizers.SGD(lr=1e-4, momentum=0.9),
              metrics=['accuracy'])

# prepare data augmentation configuration
train_datagen = ImageDataGenerator(
        rotation_range=40,
        width_shift_range=0.2,
        height_shift_range=0.2,
        shear_range=0.2,
        zoom_range=0.2,
        horizontal_flip=True,
        fill_mode='nearest'
)

test_datagen = ImageDataGenerator()
mean = np.array([123.68, 116.779, 103.939], dtype="float32")
train_datagen.mean = mean
test_datagen.mean = mean

train_generator = train_datagen.flow_from_directory(
    train_data_dir,
```

```
    color_mode="rgb",
    target_size=(img_height, img_width),
    batch_size=batch_size,
    shuffle=True,
    class_mode='binary')

validation_generator = test_datagen.flow_from_directory(
    validation_data_dir,
    color_mode="rgb",
    target_size=(img_height, img_width),
    batch_size=batch_size,
    shuffle=False,
    class_mode='binary')

test_generator = test_datagen.flow_from_directory(
    evaluation_data_dir,
    color_mode="rgb",
    target_size=(img_height, img_width),
    batch_size=batch_size,
    shuffle=False,
    class_mode='binary')

print("[INFO] training head...")
H = model.fit_generator(
    train_generator,
    steps_per_epoch=nb_train_samples // batch_size,
    epochs=epochs,
    validation_data=validation_generator,
    validation_steps=nb_validation_samples // batch_size)
```

```
Found 3000 images belonging to 2 classes.
Found 1000 images belonging to 2 classes.
Found 1000 images belonging to 2 classes.
[INFO] training head…
Epoch 1/10
149/150 [============================>.] - ETA: 1s - loss: 2.2380 - acc:
0.8513Epoch 1/10
150/150 [==============================] - 287s 2s/step - loss: 2.2250 - acc:
0.8520 - val_loss: 0.4303 - val_acc: 0.9630
Epoch 2/10
149/150 [============================>.] - ETA: 1s - loss: 0.7244 - acc:
0.9101Epoch 1/10
150/150 [==============================] - 287s 2s/step - loss: 0.7219 - acc:
0.9100 - val_loss: 0.3328 - val_acc: 0.9600
Epoch 3/10
149/150 [============================>.] - ETA: 1s - loss: 0.4291 - acc:
0.9228Epoch 1/10
```

```
150/150 [==============================] - 280s 2s/step - loss: 0.4309 - acc:
0.9227 - val_loss: 0.2112 - val_acc: 0.9570
Epoch 4/10
149/150 [============================>.] - ETA: 1s - loss: 0.3319 - acc:
0.9272Epoch 1/10
150/150 [==============================] - 278s 2s/step - loss: 0.3303 - acc:
0.9273 - val_loss: 0.1986 - val_acc: 0.9600
Epoch 5/10
149/150 [============================>.] - ETA: 1s - loss: 0.2206 - acc:
0.9359Epoch 1/10
150/150 [==============================] - 273s 2s/step - loss: 0.2200 - acc:
0.9357 - val_loss: 0.1703 - val_acc: 0.9610
Epoch 6/10
149/150 [============================>.] - ETA: 1s - loss: 0.2049 - acc:
0.9393Epoch 1/10
150/150 [==============================] - 283s 2s/step - loss: 0.2095 - acc:
0.9390 - val_loss: 0.1706 - val_acc: 0.9590
Epoch 7/10
149/150 [============================>.] - ETA: 1s - loss: 0.2010 - acc:
0.9366Epoch 1/10
150/150 [==============================] - 284s 2s/step - loss: 0.2002 - acc:
0.9363 - val_loss: 0.1454 - val_acc: 0.9580
Epoch 8/10
149/150 [============================>.] - ETA: 1s - loss: 0.2130 - acc:
0.9329Epoch 1/10
150/150 [==============================] - 282s 2s/step - loss: 0.2126 - acc:
0.9327 - val_loss: 0.1459 - val_acc: 0.9600
Epoch 9/10
149/150 [============================>.] - ETA: 1s - loss: 0.1776 - acc:
0.9433Epoch 1/10
150/150 [==============================] - 285s 2s/step - loss: 0.1770 - acc:
0.9433 - val_loss: 0.1499 - val_acc: 0.9580
Epoch 10/10
149/150 [============================>.] - ETA: 1s - loss: 0.1754 - acc:
0.9409Epoch 1/10
150/150 [==============================] - 279s 2s/step - loss: 0.1754 - acc:
0.9410 - val_loss: 0.1452 - val_acc: 0.9580
```

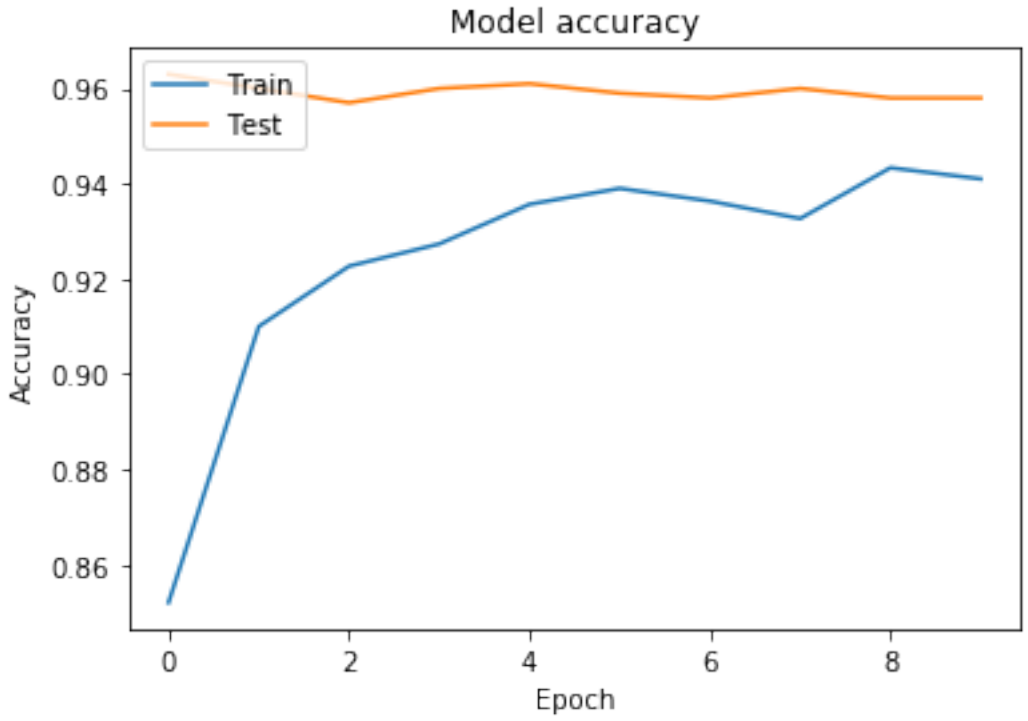
[7]:
```
model.save_weights('/home/user/models/fine_tuned/fine_tuned_2class.h5')
```

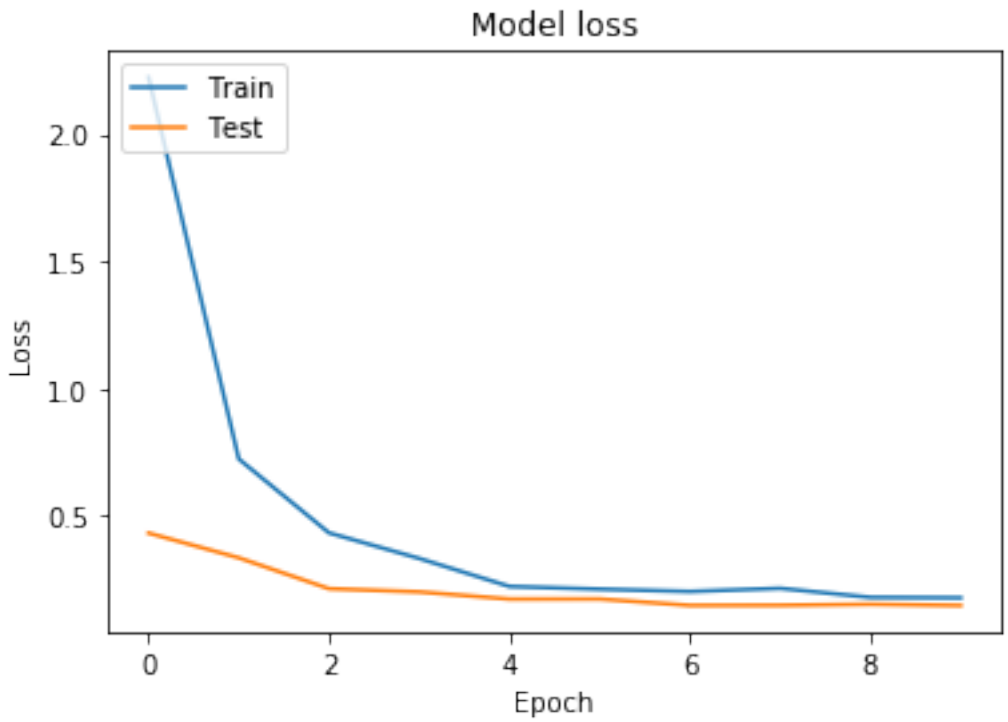
[11]:
```
plot_model(model, to_file='model.png')
    # Plot training & validation accuracy values
plt.plot(H.history['acc'])
plt.plot(H.history['val_acc'])
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
```

```
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()

    # Plot training & validation loss values
plt.plot(H.history['loss'])
plt.plot(H.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()
```

```
Failed to import pydot. You must install pydot and graphviz for `pydotprint` to
work.
```





[13]:
```
for layer in base_model.layers[15:]:
    layer.trainable = True
for layer in model.layers:
    print("{}: {}".format(layer, layer.trainable))
```

```
<tensorflow.python.keras.engine.input_layer.InputLayer object at
0x7f45bc2b58d0>: False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc323d50>:
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<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc2b5f10>:
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<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc2c4990>:
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<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc2d25d0>:
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<tensorflow.python.keras.layers.pooling.MaxPooling2D object at 0x7f45bc2e20d0>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc2e8e90>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc276450>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc280750>:
```

```
False
<tensorflow.python.keras.layers.pooling.MaxPooling2D object at 0x7f45bc292650>:
False
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc29f2d0>:
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<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc2a5bd0>:
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<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc1f6a90>:
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<tensorflow.python.keras.layers.pooling.MaxPooling2D object at 0x7f45bc209590>:
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<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc20f390>:
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<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc21c990>:
True
<tensorflow.python.keras.layers.convolutional.Conv2D object at 0x7f45bc1ae550>:
True
<tensorflow.python.keras.layers.pooling.MaxPooling2D object at 0x7f45bc1c0090>:
True
<tensorflow.python.keras.layers.core.Flatten object at 0x7f45bc194510>: True
<tensorflow.python.keras.layers.core.Dense object at 0x7f45bc18dcd0>: True
<tensorflow.python.keras.layers.core.Dropout object at 0x7f45bc18db10>: True
<tensorflow.python.keras.layers.core.Dense object at 0x7f45bc18dd10>: True
```

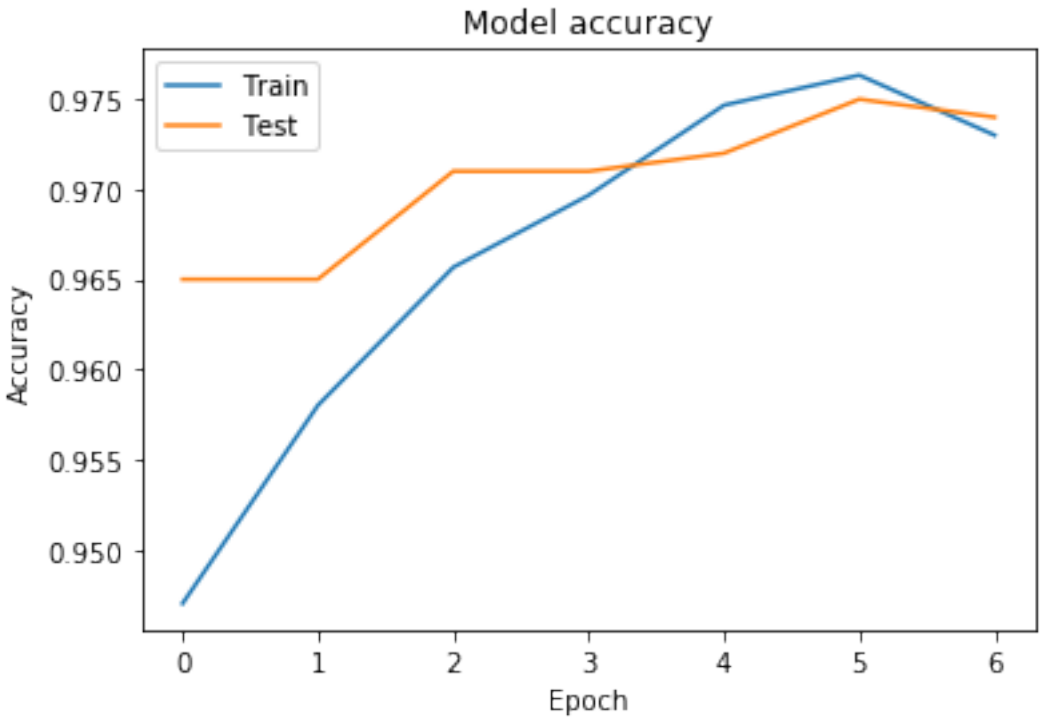
[16]:
```
train_generator.reset()
validation_generator.reset()
print("[INFO] re-compiling model...")
opt = optimizers.SGD(lr=1e-4, momentum=0.9)
model.compile(loss="binary_crossentropy", optimizer=opt,
    metrics=["accuracy"])
print("[INFO] training with last conv block...")
H = model.fit_generator(
    train_generator,
    steps_per_epoch=nb_train_samples // batch_size,
    epochs=7,
    validation_data=validation_generator,
    validation_steps=nb_validation_samples // batch_size)
```

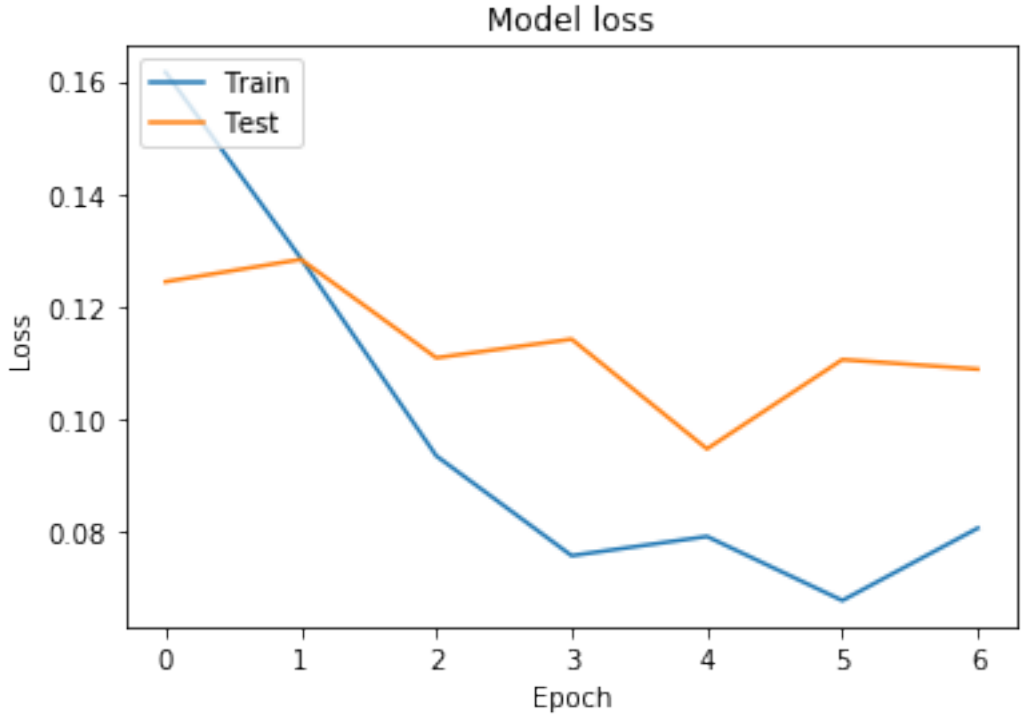
```
[INFO] re-compiling model…
[INFO] training with last conv block…
Epoch 1/7
149/150 [============================>.] - ETA: 1s - loss: 0.1622 - acc:
0.9470Epoch 1/7
150/150 [==============================] - 320s 2s/step - loss: 0.1616 - acc:
0.9470 - val_loss: 0.1243 - val_acc: 0.9650
Epoch 2/7
149/150 [============================>.] - ETA: 1s - loss: 0.1265 - acc:
0.9591Epoch 1/7
```

```
150/150 [==============================] - 319s 2s/step - loss: 0.1285 - acc:
0.9580 - val_loss: 0.1283 - val_acc: 0.9650
Epoch 3/7
149/150 [============================>.] - ETA: 1s - loss: 0.0939 - acc:
0.9654Epoch 1/7
150/150 [==============================] - 341s 2s/step - loss: 0.0934 - acc:
0.9657 - val_loss: 0.1108 - val_acc: 0.9710
Epoch 4/7
149/150 [============================>.] - ETA: 1s - loss: 0.0747 - acc:
0.9701Epoch 1/7
150/150 [==============================] - 328s 2s/step - loss: 0.0756 - acc:
0.9697 - val_loss: 0.1141 - val_acc: 0.9710
Epoch 5/7
149/150 [============================>.] - ETA: 1s - loss: 0.0791 - acc:
0.9748Epoch 1/7
150/150 [==============================] - 327s 2s/step - loss: 0.0790 - acc:
0.9747 - val_loss: 0.0946 - val_acc: 0.9720
Epoch 6/7
149/150 [============================>.] - ETA: 1s - loss: 0.0680 - acc:
0.9762Epoch 1/7
150/150 [==============================] - 323s 2s/step - loss: 0.0676 - acc:
0.9763 - val_loss: 0.1105 - val_acc: 0.9750
Epoch 7/7
149/150 [============================>.] - ETA: 1s - loss: 0.0810 - acc:
0.9728Epoch 1/7
150/150 [==============================] - 328s 2s/step - loss: 0.0805 - acc:
0.9730 - val_loss: 0.1088 - val_acc: 0.9740
```

[17]:
```
model.save_weights('/home/user/models/fine_tuned/fine_tuned_2class_full.h5')
    # Plot training & validation accuracy values
plt.plot(H.history['acc'])
plt.plot(H.history['val_acc'])
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()

    # Plot training & validation loss values
plt.plot(H.history['loss'])
plt.plot(H.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()
```


Model accuracy
Train
Test
0.975
0.970
0.965
0.960
0.955
0.950
Accuracy
0
1
2
3
4
5
6
Epoch


Model loss
Train
Test
0.16
0.14
0.12
0.10
0.08
Loss
0
1
2
3
4
5
6
Epoch

[ ]: