1 训练轮数与callbacks

在本例中，通过比较**同样结构**，**同样优化器**，**同样数据集**下**不同epoch**以及**不同callbacks方法**下训练的值得出训练轮数与callbacks方法对训练的影响。

In [1]:
```
# !pip install --upgrade keras_applications keras
```

1.1 引入相关的包

In [2]:
```
from keras.applications.vgg16 import VGG16
from keras.preprocessing import image
import numpy as np

from keras.preprocessing import image
from keras.models import Model
from keras.layers import Dense, GlobalAveragePooling2D
from keras import backend as K
from keras.models import load_model

from keras.preprocessing.image import ImageDataGenerator
```

```
Using TensorFlow backend.
```

1.2 读取数据

In [3]:
```
import os
from PIL import Image
def load_data():
    dirname = "./data"
    path = "./data"

    num_train_samples = 25000

    x_train = np.empty((num_train_samples, 224,224,3), dtype='uint8')
    y_train = np.empty((num_train_samples,1), dtype='uint8')
    index = 0
    for file in os.listdir("./data"):
        image = Image.open(os.path.join(dirname,file)).resize((224,224))
        image = np.array(image)
        x_train[index,:,:,:] = image

        if "cat" in file:
            y_train[index,0] =1
        elif "dog" in file:
            y_train[index,0] =0

        index += 1
    return (x_train, y_train)
```

In [4]:
```
(x_train, y_train) = load_data()
```

In [5]:
```
print(x_train.shape)
print(y_train.shape)
```

```
(25000, 224, 224, 3)
(25000, 1)
```

1.3 数据处理

In [6]:
```
from keras.utils import np_utils
def process_data(x_train,y_train):
    x_train = x_train.astype(np.float32)
    x_train /= 255
    n_classes = 2
    y_train = np_utils.to_categorical(y_train, n_classes)
    return x_train,y_train
```

In [8]:
```
x_train,y_train= process_data(x_train,y_train)
print(x_train.shape)
print(y_train.shape)
```

```
(25000, 224, 224, 3)
(25000, 2)
```

1.4 构建模型

In [7]:
```
def build_model(base_model):
    x = base_model.output
    x = GlobalAveragePooling2D()(x)
    predictions = Dense(2, activation='softmax')(x)
    model = Model(inputs=base_model.input, outputs=predictions)
    print(type(model))
    return model
```

In [9]:
```
base_model = VGG16(weights=None, include_top=False)
```

```
WARNING:tensorflow:From /home/ma-user/anaconda3/envs/TensorFlow-1.13.1/lib/python3.6/site-packages/tensorflow/python/framework/op_def_library.py:263: colocate_with (from tensorflow.python.framework.ops) is deprecated and will be removed in a future version.
Instructions for updating:
Colocations handled automatically by placer.
```

In [10]:
```
model = build_model(base_model)
model.summary()
```

```
block4_conv3 (Conv2D)        (None, None, None, 512)   2359808
_________________________________________________________________
block4_pool (MaxPooling2D)   (None, None, None, 512)   0
_________________________________________________________________
block5_conv1 (Conv2D)        (None, None, None, 512)   2359808
_________________________________________________________________
block5_conv2 (Conv2D)        (None, None, None, 512)   2359808
_________________________________________________________________
block5_conv3 (Conv2D)        (None, None, None, 512)   2359808
_________________________________________________________________
block5_pool (MaxPooling2D)   (None, None, None, 512)   0
_________________________________________________________________
global_average_pooling2d_1 ( (None, 512)               0
_________________________________________________________________
dense_1 (Dense)              (None, 2)                 1026
=================================================================
Total params: 14,715,714
Trainable params: 14,715,714
Non-trainable params: 0
_________________________________________________________________
```

1.5 模型训练

1.5.1 5 epoch训练

In [11]:
```
import keras
opt = keras.optimizers.rmsprop(lr=0.0001, decay=1e-6)
model.compile(loss='binary_crossentropy',
              optimizer=opt,
              metrics=['accuracy'])

```

In [12]:
```
from keras.callbacks import ModelCheckpoint, EarlyStopping, ReduceLROnPlateau
es = EarlyStopping(monitor='val_acc', baseline=0.9, patience=30, verbose=1, mode
cp = ModelCheckpoint(filepath="./model/ckp_vgg16_dog_and_cat.h5", monitor="va
lr = ReduceLROnPlateau(monitor="val_acc", factor=0.1, patience=10, verbose=1, m
callbacks = [es,cp,lr]
```

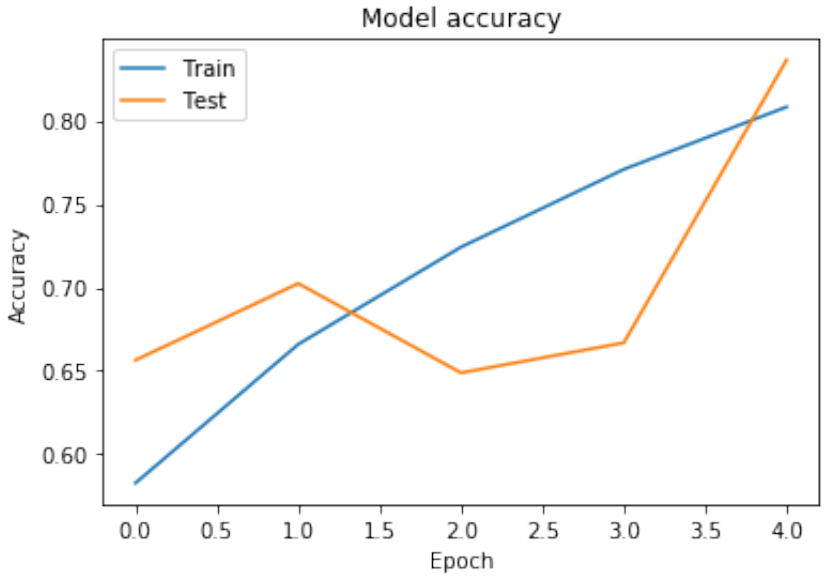
In [13]:

```
history = model.fit(x=x_train,
                    y=y_train,
                    batch_size=32,
                    epochs=5,
                    verbose=1,
                    callbacks=callbacks,
                    validation_split=0.1,
                    shuffle=True,
                    initial_epoch=0,
                   )
```

```
WARNING:tensorflow:From /home/ma-user/anaconda3/envs/TensorFlow-1.13.1/lib/python3.6/site-packages/tensorflow/python/ops/math_ops.py:3066: to_int32 (from tensorflow.python.ops.math_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use tf.cast instead.
Train on 22500 samples, validate on 2500 samples
Epoch 1/5
22500/22500 [==============================] - 110s 5ms/step - loss: 0.6681 - acc: 0.5827 - val_loss: 0.6254 - val_acc: 0.6564

Epoch 00001: val_acc improved from -inf to 0.65640, saving model to ./model/ckp_vgg16_dog_and_cat.h5
Epoch 2/5
22500/22500 [==============================] - 106s 5ms/step - loss: 0.6132 - acc: 0.6659 - val_loss: 0.5633 - val_acc: 0.7024

Epoch 00002: val_acc improved from 0.65640 to 0.70240, saving model to ./model/ckp_vgg16_dog_and_cat.h5
Epoch 3/5
22500/22500 [==============================] - 107s 5ms/step - loss: 0.5473 - acc: 0.7242 - val_loss: 0.7010 - val_acc: 0.6488

Epoch 00003: val_acc did not improve from 0.70240
Epoch 4/5
22500/22500 [==============================] - 107s 5ms/step - loss: 0.4898 - acc: 0.7708 - val_loss: 0.5868 - val_acc: 0.6668

Epoch 00004: val_acc did not improve from 0.70240
Epoch 5/5
22500/22500 [==============================] - 106s 5ms/step - loss: 0.4286 - acc: 0.8083 - val_loss: 0.3695 - val_acc: 0.8364

Epoch 00005: val_acc improved from 0.70240 to 0.83640, saving model to ./model/ckp_vgg16_dog_and_cat.h5
```

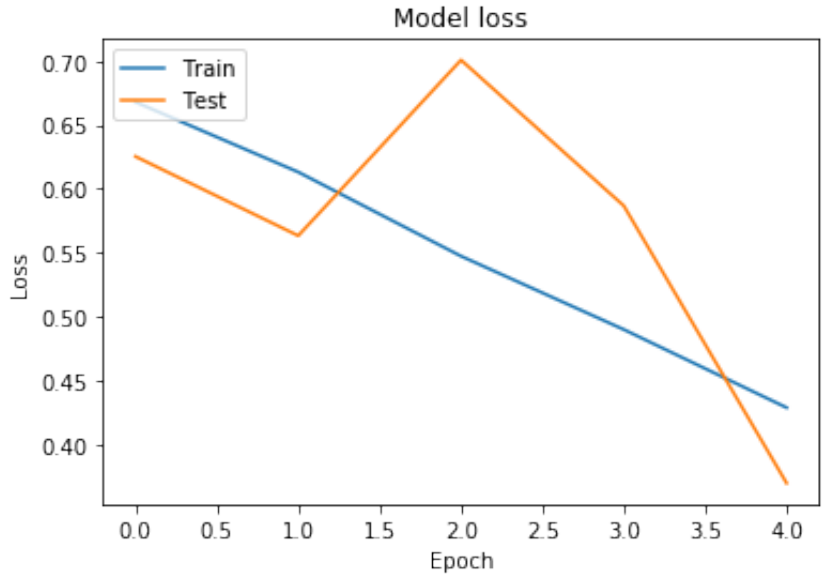
In [19]:

```
import matplotlib.pyplot as plt

# 绘制训练 & 验证的准确率值
plt.plot(history.history['acc'])
plt.plot(history.history['val_acc'])
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()
```



In [15]:

```
# 绘制训练 & 验证的损失值
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()
```

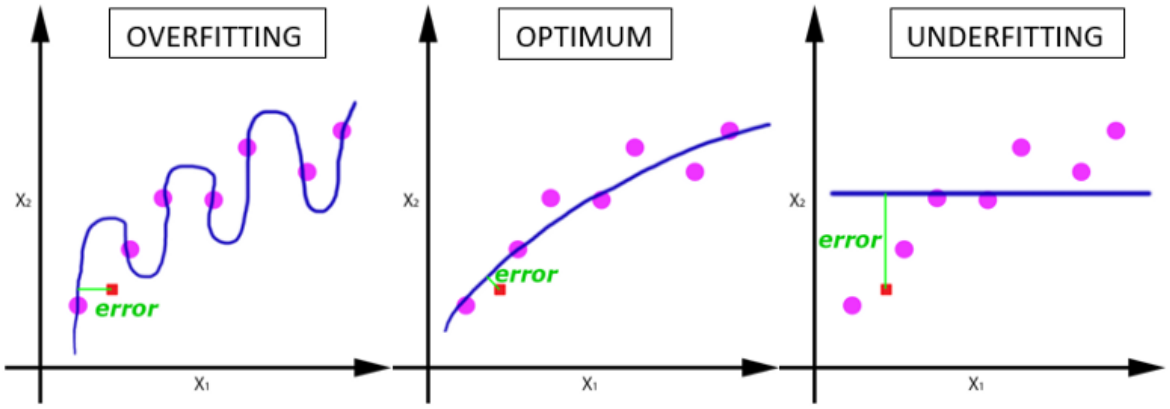


1.5.2 50 epoch 训练

在下面的训练中，epoch的数值由5变为50

1.5.2.1 Epoch

每一个epoch，训练集中的每一条数据都进行一次训练。 在Epoch数值较小时，出现了上一个训练中出现的欠拟合情况，模型没有很好收敛训练便结束了。在接下来的训练中，我们提高了epoch的值，通过训练结果我们可以看到模型逐渐收敛。但是epoch的值并非越大越好，过大的epoch值可能会导致过拟合现象。



epoch的值没有具体的公式进行计算，需要根据经验和具体的情况进行制定。

1.5.2.2 ModelCheckpoint

在模型训练过程中，ModelCheckpoint将出现的最好的权重进行保存。 在下面的训练中，每一次出现更好的模型，epoch完成后都进行了保存。

1.5.2.3 ReduceLROnPlateau

学习率衰减方法，在指定epoch数量结束后检测指标时候有提升，如果提升较小，便进行学习率衰减。在接下来的训练中，通过 ReduceLROnPlateau 方法，学习率进行了多次调整，调整之后的模型的指标有所提升。

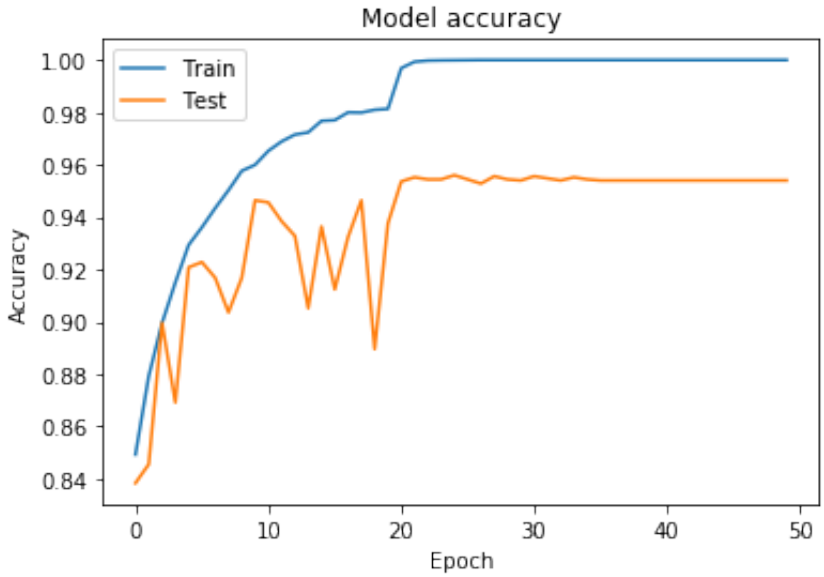
In [16]:

```
history_more_steps = model.fit(x=x_train,
                    y=y_train,
                    batch_size=32,
                    epochs=50,
                    verbose=1,
                    callbacks=callbacks,
                    validation_split=0.1,
                    shuffle=True,
                    initial_epoch=0,
                   )
```

```
Train on 22500 samples, validate on 2500 samples
Epoch 1/50
22500/22500 [==============================] - 105s 5ms/step - loss: 0.348
5 - acc: 0.8493 - val_loss: 0.3592 - val_acc: 0.8384

Epoch 00001: val_acc improved from 0.83640 to 0.83840, saving model to ./model/ck
p_vgg16_dog_and_cat.h5
Epoch 2/50
22500/22500 [==============================] - 105s 5ms/step - loss: 0.286
4 - acc: 0.8793 - val_loss: 0.3462 - val_acc: 0.8456

Epoch 00002: val_acc improved from 0.83840 to 0.84560, saving model to ./model/c
kp_vgg16_dog_and_cat.h5
Epoch 3/50
22500/22500 [==============================] - 105s 5ms/step - loss: 0.241
2 - acc: 0.8995 - val_loss: 0.2485 - val_acc: 0.8996

Epoch 00003: val_acc improved from 0.84560 to 0.89960, saving model to ./model/c
kp_vgg16_dog_and_cat.h5
Epoch 4/50
```

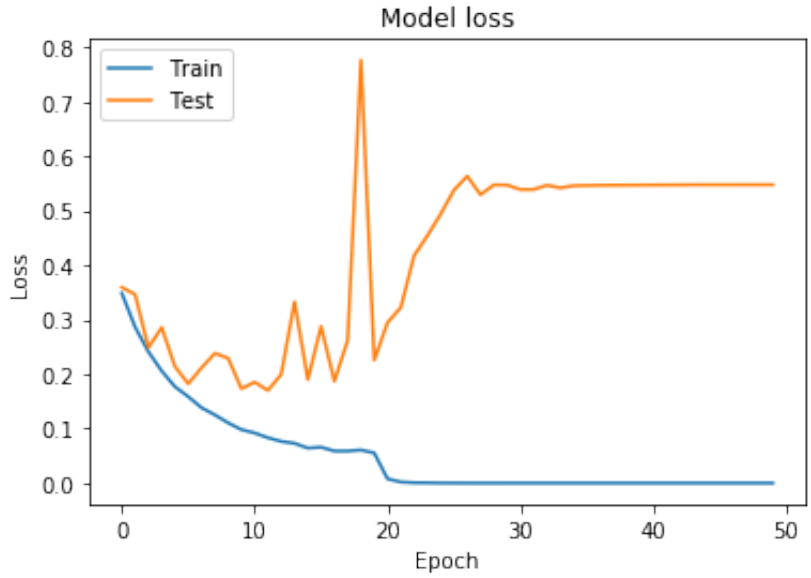
In [17]:

```
import matplotlib.pyplot as plt

# 绘制训练 & 验证的准确率值
plt.plot(history_more_steps.history['acc'])
plt.plot(history_more_steps.history['val_acc'])
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()
```



In [18]:

```
# 绘制训练 & 验证的损失值
plt.plot(history_more_steps.history['loss'])
plt.plot(history_more_steps.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()
```



1.5.2.4 EarlyStopping 早停法

根据上一个训练可以看到，在训练的后期模型的loss和acc数值已经稳定，这时候继续训练没有对数值产生影响还有可能产生过拟合情况，所以需要及时将模型训练停止。
EarlyStopping（早停法）检测模型的某一项指标，如果在指定步数中指标没有提升，则将模型训练停止。

在下面的训练中可以看到模型已经很好收敛了，模型在训练中几乎没有提升空间了，所以没有完成fit函数中规定的50个epoch，而是在第6个epoch完成后训练便停止了。

In [20]:

```
es = EarlyStopping(monitor='val_acc', baseline=0.9, patience=5, verbose=1, mode=
cp = ModelCheckpoint(filepath="./model/ckp_vgg16_dog_and_cat.h5", monitor="va
lr = ReduceLROnPlateau(monitor="val_acc", factor=0.1, patience=2, verbose=1, mo
callbacks = [es,cp,lr]
```

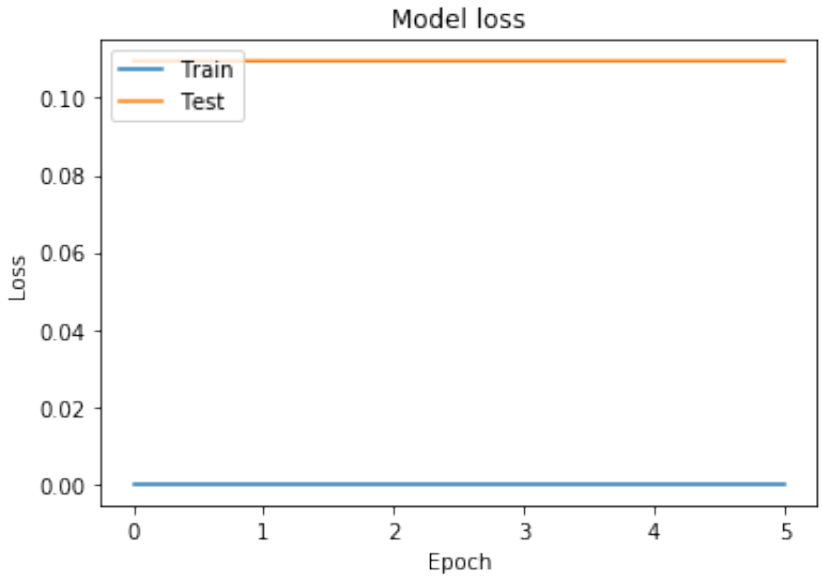
In [27]:

```
history_steps_55 = model.fit(x=x_train,
                    y=y_train,
                    batch_size=32,
                    epochs=50,
                    verbose=1,
                    callbacks=callbacks,
                    validation_split=0.5,
                    shuffle=True,
                    initial_epoch=0,
                   )
```

```
Train on 12500 samples, validate on 12500 samples
Epoch 1/50
12500/12500 [==============================] – 75s 6ms/step – loss: 1.0962e
–07 – acc: 1.0000 – val_loss: 0.1095 – val_acc: 0.9909

Epoch 00001: val_acc did not improve from 0.99088
Epoch 2/50
12500/12500 [==============================] – 75s 6ms/step – loss: 1.0962e
–07 – acc: 1.0000 – val_loss: 0.1095 – val_acc: 0.9909

Epoch 00002: val_acc did not improve from 0.99088
Epoch 3/50
12500/12500 [==============================] – 75s 6ms/step – loss: 1.0962e
–07 – acc: 1.0000 – val_loss: 0.1095 – val_acc: 0.9909

Epoch 00003: val_acc did not improve from 0.99088

Epoch 00003: ReduceLROnPlateau reducing learning rate to 1.0000000116860975e–0
8.
Epoch 4/50
12500/12500 [==============================] – 75s 6ms/step – loss: 1.0962e
–07 – acc: 1.0000 – val_loss: 0.1095 – val_acc: 0.9909

Epoch 00004: val_acc did not improve from 0.99088
Epoch 5/50
12500/12500 [==============================] – 75s 6ms/step – loss: 1.0962e
–07 – acc: 1.0000 – val_loss: 0.1095 – val_acc: 0.9909

Epoch 00005: val_acc did not improve from 0.99088

Epoch 00005: ReduceLROnPlateau reducing learning rate to 9.999999939225292e–1
0.
Epoch 6/50
12500/12500 [==============================] – 75s 6ms/step – loss: 1.0962e
–07 – acc: 1.0000 – val_loss: 0.1095 – val_acc: 0.9909

Epoch 00006: val_acc did not improve from 0.99088
Epoch 00006: early stopping
```

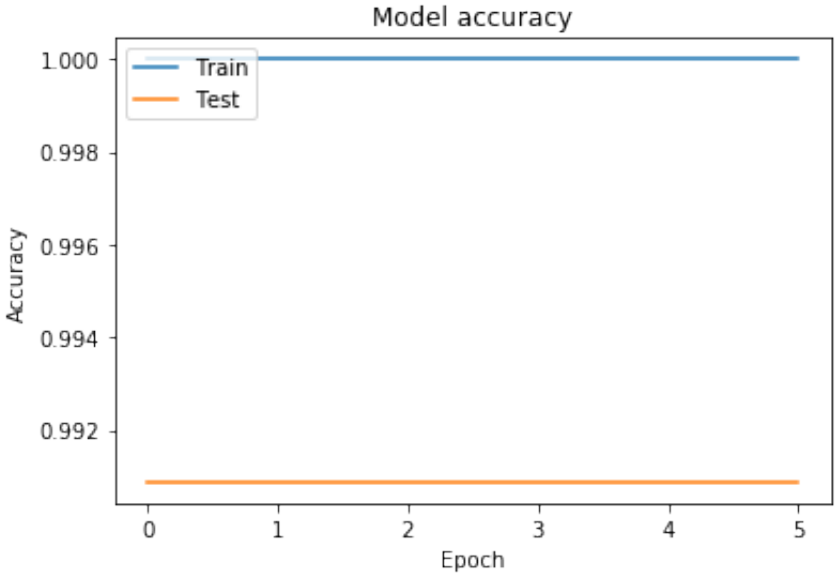
In [28]:

```
# 绘制训练 & 验证的损失值
plt.plot(history_steps_55.history['loss'])
plt.plot(history_steps_55.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()
```



In [31]:

```
# 绘制训练 & 验证的准确率值
plt.plot(history_steps_55.history['acc'])
plt.plot(history_steps_55.history['val_acc'])
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper left')
plt.show()
```



2 拓展

模型在训练过程中还有那些可以提升的地方?

- 可以尝试更多的epoch数量
- 可以尝试自己定义学习率衰减规律。使用 LearningRateScheduler 方法，自己定义学习率衰减。

In [ ]:
```
1
```