```
import keras
keras.__version__
```

```
'2.4.3'
```

```
from google.colab import drive
drive.mount('/content/gdrive')
```

```
Mounted at /content/gdrive
```

```
import os
import shutil

base_dir = '/content/gdrive/MyDrive/ML Assignment 2/cats_and_dogs_2'
!ls '/content/gdrive/MyDrive/ML Assignment 2/cats_and_dogs_2'
```

```
test  train  validation
```

Read Cats and Dogs

```
# Directories for our training,
# validation and test splits
train_dir = os.path.join(base_dir, 'train')
validation_dir = os.path.join(base_dir, 'validation')
test_dir = os.path.join(base_dir, 'test')

# Directory with our training cat pictures
train_cats_dir = os.path.join(train_dir, 'cats')

# Directory with our training dog pictures
train_dogs_dir = os.path.join(train_dir, 'dogs')

# Directory with our validation cat pictures
validation_cats_dir = os.path.join(validation_dir, 'cats')

# Directory with our validation dog pictures
validation_dogs_dir = os.path.join(validation_dir, 'dogs')

# Directory with our validation cat pictures
test_cats_dir = os.path.join(test_dir, 'cats')

# Directory with our validation dog pictures
test_dogs_dir = os.path.join(test_dir, 'dogs')
```

```
print('total training cat images:', len(os.listdir(train_cats_dir)))
print('total training dog images:', len(os.listdir(train_dogs_dir)))
print('total validation cat images:', len(os.listdir(validation_cats_dir)))
print('total validation dog images:', len(os.listdir(validation_dogs_dir)))
print('total test cat images:', len(os.listdir(test_cats_dir)))
print('total test dog images:', len(os.listdir(test_dogs_dir)))
```

```
total training cat images: 1500
total training dog images: 1510
total validation cat images: 500
total validation dog images: 500
total test cat images: 500
total test dog images: 500
```

```
from keras import layers
from keras import models

model = models.Sequential()
model.add(layers.Conv2D(32, (3, 3), activation='relu',
                        input_shape=(150, 150, 3)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(64, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(128, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(128, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Flatten())
model.add(layers.Dense(512, activation='relu'))
model.add(layers.Dense(1, activation='sigmoid'))
```

```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d (Conv2D)              (None, 148, 148, 32)      896       
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 74, 74, 32)        0         
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 72, 72, 64)        18496     
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 36, 36, 64)        0         
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 34, 34, 128)       73856     
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 17, 17, 128)       0         
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 15, 15, 128)       147584    
```

```
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 7, 7, 128)         0
_________________________________________________________________
flatten (Flatten)            (None, 6272)              0
_________________________________________________________________
dense (Dense)                (None, 512)               3211776
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 513
=================================================================
Total params: 3,453,121
Trainable params: 3,453,121
Non-trainable params: 0
_________________________________________________________________
```

```
from keras import optimizers

model.compile(loss='binary_crossentropy',
              optimizer=optimizers.RMSprop(lr=1e-4),
              metrics=['acc'])
```

```
from keras.preprocessing.image import ImageDataGenerator

# All images will be rescaled by 1./255
train_datagen = ImageDataGenerator(rescale=1./255)
test_datagen = ImageDataGenerator(rescale=1./255)

train_generator = train_datagen.flow_from_directory(
        # This is the target directory
        train_dir,
        # All images will be resized to 150x150
        target_size=(150, 150),
        batch_size=20,
        # Since we use binary_crossentropy loss, we need binary labels
        class_mode='binary')

validation_generator = test_datagen.flow_from_directory(
        validation_dir,
        target_size=(150, 150),
        batch_size=20,
        class_mode='binary')
```

```
Found 3010 images belonging to 2 classes.
Found 1000 images belonging to 2 classes.
```

```
for data_batch, labels_batch in train_generator:
    print('data batch shape:', data_batch.shape)
    print('labels batch shape:', labels_batch.shape)
    break
```

```
data batch shape: (20, 150, 150, 3)
labels batch shape: (20,)
```

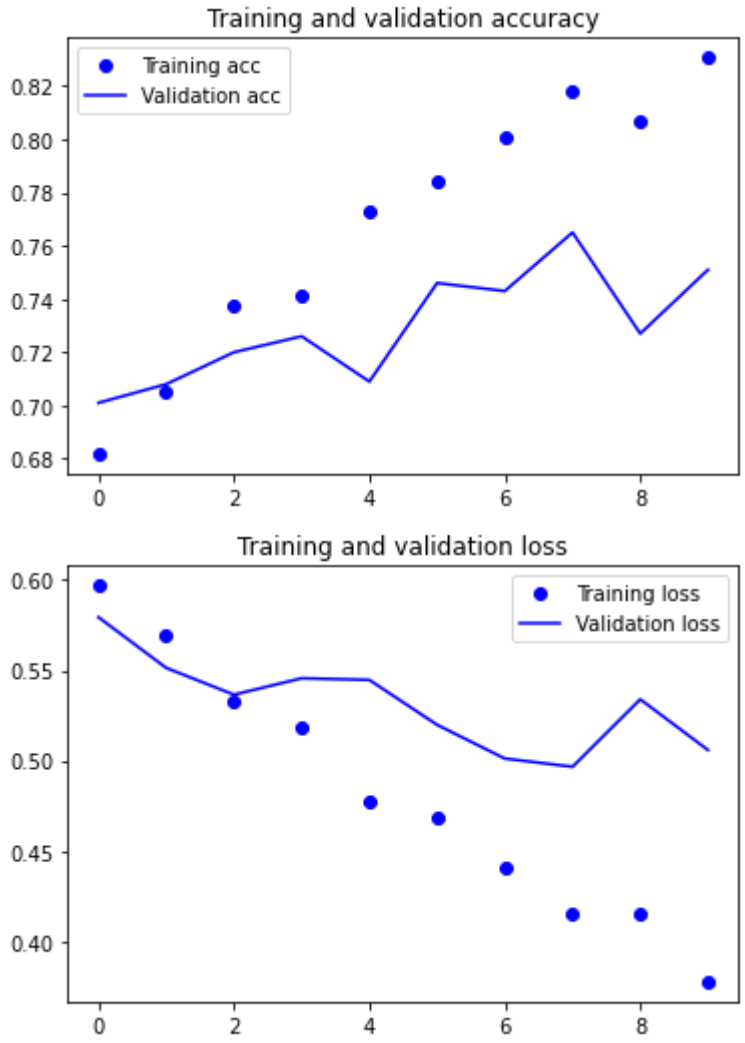
```
history = model.fit_generator(
      train_generator,
      steps_per_epoch=100,
      epochs=10,
      validation_data=validation_generator,
      validation_steps=50)
```

```
/usr/local/lib/python3.7/dist-packages/tensorflow/python/keras/engine/training.py:1844:
  warnings.warn('`Model.fit_generator` is deprecated and '
Epoch 1/10
100/100 [==============================] - 107s 1s/step - loss: 0.5968 - acc: 0.6819 - \
Epoch 2/10
100/100 [==============================] - 107s 1s/step - loss: 0.5690 - acc: 0.7055 - \
Epoch 3/10
100/100 [==============================] - 106s 1s/step - loss: 0.5332 - acc: 0.7377 - \
Epoch 4/10
100/100 [==============================] - 106s 1s/step - loss: 0.5185 - acc: 0.7412 - \
Epoch 5/10
100/100 [==============================] - 106s 1s/step - loss: 0.4775 - acc: 0.7730 - \
Epoch 6/10
100/100 [==============================] - 107s 1s/step - loss: 0.4687 - acc: 0.7845 - \
Epoch 7/10
100/100 [==============================] - 107s 1s/step - loss: 0.4410 - acc: 0.8005 - \
Epoch 8/10
100/100 [==============================] - 107s 1s/step - loss: 0.4150 - acc: 0.8180 - \
Epoch 9/10
100/100 [==============================] - 107s 1s/step - loss: 0.4154 - acc: 0.8065 - \
Epoch 10/10
100/100 [==============================] - 107s 1s/step - loss: 0.3777 - acc: 0.8307 - \
```

```
model.save('cats_and_dogs_small_1.h5')
```

```
import matplotlib.pyplot as plt

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()
```

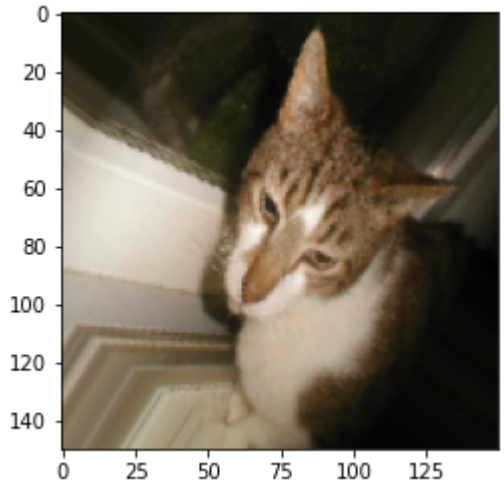


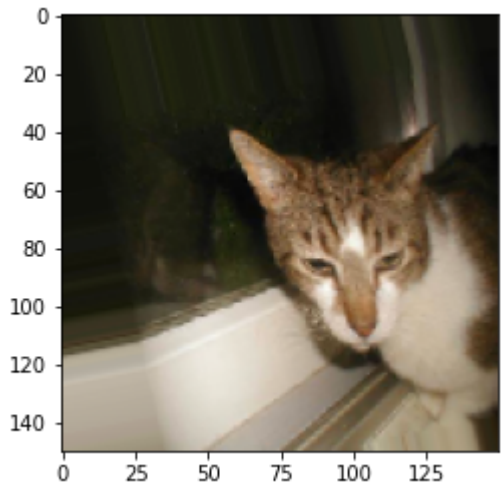
Data Augmentation

```
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')
```

```
# This is module with image preprocessing utilities
from keras.preprocessing import image
```

```
fnames = [os.path.join(train_cats_dir, fname) for fname in os.listdir(train_cats_dir)]

# We pick one image to "augment"
img_path = fnames[3]

# Read the image and resize it
img = image.load_img(img_path, target_size=(150, 150))

# Convert it to a Numpy array with shape (150, 150, 3)
x = image.img_to_array(img)

# Reshape it to (1, 150, 150, 3)
x = x.reshape((1,) + x.shape)

# The .flow() command below generates batches of randomly transformed images.
# It will loop indefinitely, so we need to `break` the loop at some point!
i = 0
for batch in datagen.flow(x, batch_size=1):
    plt.figure(i)
    imgplot = plt.imshow(image.array_to_img(batch[0]))
    i += 1
    if i % 4 == 0:
        break

plt.show()
```






```
model = models.Sequential()
model.add(layers.Conv2D(32, (3, 3), activation='relu',
                        input_shape=(150, 150, 3)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(64, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(128, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(128, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Flatten())
model.add(layers.Dropout(0.5))
model.add(layers.Dense(512, activation='relu'))
model.add(layers.Dense(1, activation='sigmoid'))

model.compile(loss='binary_crossentropy',
              optimizer=optimizers.RMSprop(lr=1e-4),
              metrics=['acc'])
```

```
train_datagen = ImageDataGenerator(
    rescale=1./255,
    rotation_range=40,
    width_shift_range=0.2
```

```
        width_shift_range=0.2,
        height_shift_range=0.2,
        shear_range=0.2,
        zoom_range=0.2,
        horizontal_flip=True,)

    # Note that the validation data should not be augmented!
    test_datagen = ImageDataGenerator(rescale=1./255)

    train_generator = train_datagen.flow_from_directory(
            # This is the target directory
            train_dir,
            # All images will be resized to 150x150
            target_size=(150, 150),
            batch_size=32,
            # Since we use binary_crossentropy loss, we need binary labels
            class_mode='binary')

    validation_generator = test_datagen.flow_from_directory(
            validation_dir,
            target_size=(150, 150),
            batch_size=32,
            class_mode='binary')

    history = model.fit_generator(
          train_generator,
          steps_per_epoch=50,
          epochs=10,
          validation_data=validation_generator,
          validation_steps=50)
```

```
    Found 3010 images belonging to 2 classes.
    Found 1000 images belonging to 2 classes.
    /usr/local/lib/python3.7/dist-packages/tensorflow/python/keras/engine/training.py:1844:
      warnings.warn('`Model.fit_generator` is deprecated and '
    Epoch 1/10
    50/50 [==============================] - ETA: 0s - loss: 0.6881 - acc: 0.5248WARNING:ter
    50/50 [==============================] - 92s 2s/step - loss: 0.6881 - acc: 0.5248 - val_
    Epoch 2/10
    50/50 [==============================] - 79s 2s/step - loss: 0.6869 - acc: 0.5406
    Epoch 3/10
    50/50 [==============================] - 78s 2s/step - loss: 0.6807 - acc: 0.5720
    Epoch 4/10
    50/50 [==============================] - 79s 2s/step - loss: 0.6811 - acc: 0.5619
    Epoch 5/10
    50/50 [==============================] - 79s 2s/step - loss: 0.6702 - acc: 0.5987
    Epoch 6/10
    50/50 [==============================] - 78s 2s/step - loss: 0.6648 - acc: 0.5924
    Epoch 7/10
    50/50 [==============================] - 78s 2s/step - loss: 0.6490 - acc: 0.6070
    Epoch 8/10
    50/50 [==============================] - 79s 2s/step - loss: 0.6495 - acc: 0.6181
    Epoch 9/10
    50/50 [==============================] - 79s 2s/step - loss: 0.6444 - acc: 0.6331
```

```
Epoch 10/10
50/50 [==============================] - 79s 2s/step - loss: 0.6371 - acc: 0.6444
```

```
model.save('cats_and_dogs_small_2.h5')
```

```
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()
```