

Image Classification

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1. Dogs & Cats Dataset

<https://www.kaggle.com/datasets/chetankv/dogs-cats-images> (<https://www.kaggle.com/datasets/chetankv/dogs-cats-images>)

The dataset contains images of dogs and cats. The model, given an image, should be able to predict whether the image contains a cat or a dog.

```
In [1]: import tensorflow as tf
        from tensorflow import keras
        from keras import layers
        from keras.models import Sequential

        # Prepare dataset
        !unzip dataset.zip
        train = tf.keras.utils.image_dataset_from_directory('dataset/training_set/', 1
        label_mode='binary')
        test = tf.keras.utils.image_dataset_from_directory('dataset/test_set/', label_
        mode='binary')
```

Streaming output truncated to the last 5000 lines.

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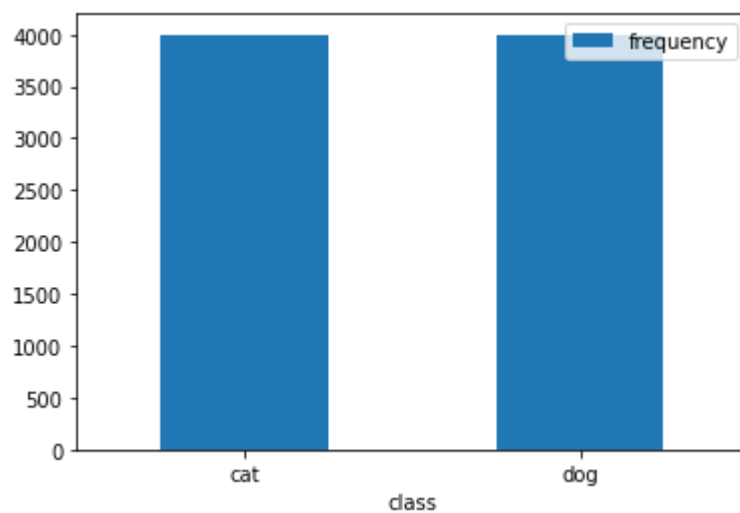
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Found 8000 files belonging to 2 classes.
Found 2000 files belonging to 2 classes.

In [2]: *# Distribution of the target classes for the training data*

```
import pandas as pd
import os
num_cats = len(os.listdir('dataset/training_set/cats'))
num_dogs = len(os.listdir('dataset/training_set/dogs'))
df = pd.DataFrame(
    {
        'class': ['cat', 'dog'],
        'frequency': [num_cats, num_dogs]
    }
)
df.plot.bar(x='class', y='frequency', rot=0)
```

Out[2]: <matplotlib.axes._subplots.AxesSubplot at 0x7f5c2c78a820>



2. Sequential Model

```
In [3]: model = tf.keras.models.Sequential([
    tf.keras.layers.Rescaling(1./255, input_shape=(256, 256, 3)),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(32, activation='relu'),
    tf.keras.layers.Dropout(0.2),
    tf.keras.layers.Dense(32, activation='relu'),
    tf.keras.layers.Dropout(0.2),
    tf.keras.layers.Dense(1, activation='sigmoid'),
])
model.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Param #
=====		
rescaling (Rescaling)	(None, 256, 256, 3)	0
flatten (Flatten)	(None, 196608)	0
dense (Dense)	(None, 32)	6291488
dropout (Dropout)	(None, 32)	0
dense_1 (Dense)	(None, 32)	1056
dropout_1 (Dropout)	(None, 32)	0
dense_2 (Dense)	(None, 1)	33
=====		
Total params: 6,292,577		
Trainable params: 6,292,577		
Non-trainable params: 0		

```
In [4]: model.compile(loss='binary_crossentropy',
    optimizer='rmsprop',
    metrics=['accuracy'])
```

```
In [5]: history = model.fit(
        train,
        validation_data=test,
        epochs=10
    )
```

```
Epoch 1/10
250/250 [=====] - 20s 66ms/step - loss: 1.9279 - acc
uracy: 0.4986 - val_loss: 0.6932 - val_accuracy: 0.5000
Epoch 2/10
250/250 [=====] - 17s 67ms/step - loss: 0.7604 - acc
uracy: 0.4992 - val_loss: 0.6932 - val_accuracy: 0.5000
Epoch 3/10
250/250 [=====] - 17s 67ms/step - loss: 0.7069 - acc
uracy: 0.4956 - val_loss: 0.6932 - val_accuracy: 0.5000
Epoch 4/10
250/250 [=====] - 17s 66ms/step - loss: 0.6932 - acc
uracy: 0.4956 - val_loss: 0.6932 - val_accuracy: 0.5000
Epoch 5/10
250/250 [=====] - 17s 66ms/step - loss: 0.6932 - acc
uracy: 0.4895 - val_loss: 0.6932 - val_accuracy: 0.5000
Epoch 6/10
250/250 [=====] - 17s 66ms/step - loss: 0.6932 - acc
uracy: 0.4927 - val_loss: 0.6931 - val_accuracy: 0.5000
Epoch 7/10
250/250 [=====] - 17s 67ms/step - loss: 0.6932 - acc
uracy: 0.4966 - val_loss: 0.6931 - val_accuracy: 0.5000
Epoch 8/10
250/250 [=====] - 17s 67ms/step - loss: 0.6932 - acc
uracy: 0.4955 - val_loss: 0.6931 - val_accuracy: 0.5000
Epoch 9/10
250/250 [=====] - 18s 71ms/step - loss: 0.6932 - acc
uracy: 0.4952 - val_loss: 0.6931 - val_accuracy: 0.5000
Epoch 10/10
250/250 [=====] - 17s 67ms/step - loss: 0.6932 - acc
uracy: 0.4947 - val_loss: 0.6931 - val_accuracy: 0.5000
```

```
In [6]: # Evaluate sequential model on the test data
```

```
import numpy as np
x_test = np.concatenate([x for x, y in test], axis=0)
y_test = np.concatenate([y for x, y in test], axis=0)

score = model.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
Test loss: 0.6931478381156921
Test accuracy: 0.5
```

3. Different Architectures

CNN

```
In [7]: model2 = tf.keras.models.Sequential([
    tf.keras.layers.Rescaling(1./255, input_shape=(256, 256, 3)),
    tf.keras.layers.Conv2D(32, kernel_size=(3, 3), activation="relu"),
    tf.keras.layers.MaxPooling2D(pool_size=(2, 2)),
    tf.keras.layers.Conv2D(64, kernel_size=(3, 3), activation="relu"),
    tf.keras.layers.MaxPooling2D(pool_size=(2, 2)),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dropout(0.5),
    tf.keras.layers.Dense(1, activation="sigmoid")
])
model2.summary()
```

Model: "sequential_1"

Layer (type)	Output Shape	Param #
rescaling_1 (Rescaling)	(None, 256, 256, 3)	0
conv2d (Conv2D)	(None, 254, 254, 32)	896
max_pooling2d (MaxPooling2D)	(None, 127, 127, 32)	0
conv2d_1 (Conv2D)	(None, 125, 125, 64)	18496
max_pooling2d_1 (MaxPooling2D)	(None, 62, 62, 64)	0
flatten_1 (Flatten)	(None, 246016)	0
dropout_2 (Dropout)	(None, 246016)	0
dense_3 (Dense)	(None, 1)	246017
Total params: 265,409		
Trainable params: 265,409		
Non-trainable params: 0		

```
In [8]: model2.compile(loss='binary_crossentropy',
    optimizer='rmsprop',
    metrics=['accuracy'])
```

```
In [9]: history = model2.fit(
        train,
        validation_data=test,
        epochs=10
    )
```

```
Epoch 1/10
250/250 [=====] - 30s 89ms/step - loss: 0.7084 - acc
uracy: 0.6191 - val_loss: 0.6080 - val_accuracy: 0.6725
Epoch 2/10
250/250 [=====] - 22s 86ms/step - loss: 0.5464 - acc
uracy: 0.7201 - val_loss: 0.5398 - val_accuracy: 0.7375
Epoch 3/10
250/250 [=====] - 22s 86ms/step - loss: 0.4587 - acc
uracy: 0.7854 - val_loss: 0.5592 - val_accuracy: 0.7335
Epoch 4/10
250/250 [=====] - 22s 85ms/step - loss: 0.3741 - acc
uracy: 0.8360 - val_loss: 0.5899 - val_accuracy: 0.7315
Epoch 5/10
250/250 [=====] - 22s 87ms/step - loss: 0.3036 - acc
uracy: 0.8741 - val_loss: 0.7216 - val_accuracy: 0.7220
Epoch 6/10
250/250 [=====] - 22s 87ms/step - loss: 0.2422 - acc
uracy: 0.8971 - val_loss: 0.7384 - val_accuracy: 0.7445
Epoch 7/10
250/250 [=====] - 22s 87ms/step - loss: 0.1852 - acc
uracy: 0.9269 - val_loss: 0.8518 - val_accuracy: 0.7250
Epoch 8/10
250/250 [=====] - 22s 87ms/step - loss: 0.1542 - acc
uracy: 0.9390 - val_loss: 0.9486 - val_accuracy: 0.7265
Epoch 9/10
250/250 [=====] - 22s 87ms/step - loss: 0.1188 - acc
uracy: 0.9563 - val_loss: 1.0332 - val_accuracy: 0.7190
Epoch 10/10
250/250 [=====] - 22s 87ms/step - loss: 0.1060 - acc
uracy: 0.9589 - val_loss: 1.1831 - val_accuracy: 0.7145
```

```
In [10]: # Evaluate CNN model on the test data
```

```
score2 = model2.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score2[0])
print('Test accuracy:', score2[1])
```

```
Test loss: 3.0154285430908203
Test accuracy: 0.4975000023841858
```

RNN

```
In [11]: model3 = tf.keras.models.Sequential([
    tf.keras.layers.Rescaling(1./255, input_shape=(256, 256, 3)),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Embedding(196608, 32),
    tf.keras.layers.SimpleRNN(32),
    tf.keras.layers.Dense(1, activation='sigmoid')
])
model3.summary()
```

Model: "sequential_2"

Layer (type)	Output Shape	Param #
rescaling_2 (Rescaling)	(None, 256, 256, 3)	0
flatten_2 (Flatten)	(None, 196608)	0
embedding (Embedding)	(None, 196608, 32)	6291456
simple_rnn (SimpleRNN)	(None, 32)	2080
dense_4 (Dense)	(None, 1)	33
Total params: 6,293,569		
Trainable params: 6,293,569		
Non-trainable params: 0		

```
In [12]: model3.compile(loss='binary_crossentropy',
    optimizer='rmsprop',
    metrics=['accuracy'])
```

```
In [ ]: #history = model3.fit(
    # train,
    # validation_data=test,
    # epochs=10,
    # batch_size=128
    #)
```

Epoch 1/10

```
In [ ]: # Evaluate RNN model on the test data

#score3 = model3.evaluate(x_test, y_test, verbose=0)
#print('Test loss:', score3[0])
#print('Test accuracy:', score3[1])
```


4. Pretrained Model - MobileNetV2

```
In [13]: base_model = tf.keras.applications.MobileNetV2(include_top=False,
                                                    weights='imagenet')
image_batch, label_batch = next(iter(train))
feature_batch = base_model(image_batch)

global_average_layer = tf.keras.layers.GlobalAveragePooling2D()
feature_batch_average = global_average_layer(feature_batch)
prediction_layer = tf.keras.layers.Dense(1)
prediction_batch = prediction_layer(feature_batch_average)

data_augmentation = tf.keras.Sequential([
    tf.keras.layers.RandomFlip('horizontal'),
    tf.keras.layers.RandomRotation(0.2),
])

inputs = tf.keras.Input(shape=(256, 256, 3))
x = data_augmentation(inputs)
x = tf.keras.applications.mobilenet_v2.preprocess_input(x)
x = base_model(x, training=False)
x = global_average_layer(x)
x = tf.keras.layers.Dropout(0.2)(x)
model4 = tf.keras.Model(inputs, prediction_layer(x))
model4.summary()
```

WARNING:tensorflow:`input_shape` is undefined or non-square, or `rows` is not in [96, 128, 160, 192, 224]. Weights for input shape (224, 224) will be loaded as the default.

Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/mobilenet_v2/mobilenet_v2_weights_tf_dim_ordering_tf_kernels_1.0_224_no_top.h5

9406464/9406464 [=====] - 0s 0us/step

Model: "model"

Layer (type)	Output Shape	Param #
=====		
input_2 (InputLayer)	[(None, 256, 256, 3)]	0
sequential_3 (Sequential)	(None, 256, 256, 3)	0
tf.math.truediv (TFOpLambda)	(None, 256, 256, 3)	0
tf.math.subtract (TFOpLambda)	(None, 256, 256, 3)	0
mobilenetv2_1.0_224 (Functional)	(None, None, None, 1280)	2257984
global_average_pooling2d (GlobalAveragePooling2D)	(None, 1280)	0
dropout_3 (Dropout)	(None, 1280)	0
dense_5 (Dense)	(None, 1)	1281
=====		
Total params: 2,259,265		
Trainable params: 2,225,153		
Non-trainable params: 34,112		

```
In [14]: model4.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=0.001),
                    loss=tf.keras.losses.BinaryCrossentropy(from_logits=True),
                    metrics=['accuracy'])
```

```
In [15]: history = model4.fit(
        train,
        validation_data=test,
        epochs=10
    )
```

```
Epoch 1/10
250/250 [=====] - 95s 358ms/step - loss: 0.7457 - ac
curacy: 0.4911 - val_loss: 0.6951 - val_accuracy: 0.5000
Epoch 2/10
250/250 [=====] - 88s 351ms/step - loss: 0.7035 - ac
curacy: 0.4979 - val_loss: 0.7027 - val_accuracy: 0.5000
Epoch 3/10
250/250 [=====] - 88s 353ms/step - loss: 0.6973 - ac
curacy: 0.4995 - val_loss: 0.6954 - val_accuracy: 0.5000
Epoch 4/10
250/250 [=====] - 89s 353ms/step - loss: 0.6945 - ac
curacy: 0.5000 - val_loss: 0.7012 - val_accuracy: 0.5000
Epoch 5/10
250/250 [=====] - 88s 349ms/step - loss: 0.6972 - ac
curacy: 0.5000 - val_loss: 0.6935 - val_accuracy: 0.5000
Epoch 6/10
250/250 [=====] - 88s 351ms/step - loss: 0.6962 - ac
curacy: 0.5000 - val_loss: 0.7018 - val_accuracy: 0.5000
Epoch 7/10
250/250 [=====] - 88s 352ms/step - loss: 0.6975 - ac
curacy: 0.5000 - val_loss: 0.7046 - val_accuracy: 0.5000
Epoch 8/10
250/250 [=====] - 88s 352ms/step - loss: 0.6965 - ac
curacy: 0.4997 - val_loss: 0.6939 - val_accuracy: 0.5000
Epoch 9/10
250/250 [=====] - 88s 350ms/step - loss: 0.6963 - ac
curacy: 0.4999 - val_loss: 0.6984 - val_accuracy: 0.5000
Epoch 10/10
250/250 [=====] - 88s 352ms/step - loss: 0.6967 - ac
curacy: 0.4999 - val_loss: 0.6996 - val_accuracy: 0.5000
```

```
In [16]: # Evaluate pretrained MobileNetV2 model on the test data
```

```
score4 = model4.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score4[0])
print('Test accuracy:', score4[1])
```

```
Test loss: 0.6995699405670166
Test accuracy: 0.5
```

5. Analysis

Out of the sequential, CNN, and pretrained MobileNetV2 model, the sequential and MobileNetV2 models had the best performances with 50% accuracy on the test data. The CNN model had 49.75% accuracy on the test data. This could be because CNNs work by learning global patterns in the data, which may not have been suitable for this dataset.