In [3]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
import tensorflow as tf
from keras.preprocessing.image import load_img, ImageDataGenerator
import os
import random
```

In [4]:

```
data_gen = ImageDataGenerator()
```

In [5]:

```
# read the images from directory and classify them
train_images = data_gen.flow_from_directory('Datasets/Assessment3_DL/train', classes=['dogs', 'cats'])
```

```
Found 40 images belonging to 2 classes.
```

In [32]:

```
# read the test images from directory and classify them
test_images = data_gen.flow_from_directory('Datasets/Assessment3_DL/test', classes=['dogs', 'cats'])
```

```
Found 20 images belonging to 2 classes.
```

In [6]:

```
train_images
```

Out[6]:

```
<tensorflow.python.keras.preprocessing.image.DirectoryIterator at 0x1a8cd2f8588>
```

In [7]:

```
train_images.num_classes
```

Out[7]:

```
2
```

In [8]:

```
train_images.classes
```

Out[8]:

```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1,
       1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1])
```

In [9]:

```
train_images.image_shape
```

Out[9]:

```
(256, 256, 3)
```

In [10]:

```
# list file names
fn_cats = os.listdir('Datasets/Assessment3_DL/train/cats')
fn_dogs = os.listdir('Datasets/Assessment3_DL/train/dogs')
```

In [11]:

```
# categorize 0 for cats and 1 for dogs
categories = []

for image in fn_cats:
    category = image.split('.')[0]
    categories.append(0)

for image in fn_dogs:
    category = image.split('.')[0]
    categories.append(1)

df = pd.DataFrame({'filename': fn_cats+fn_dogs,
                   'category': categories})
```

In [12]:

```
# cat = 0
# dog = 1
```

In [13]:

```
df.head(n=40)
```

Out[13]:

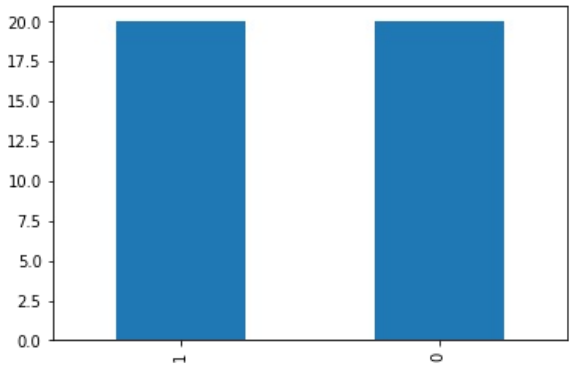
	filename	category
0	1.jpg	0
1	10.jpg	0
2	11.jpg	0
3	12.jpg	0
4	13.jpg	0
5	14.jpg	0
6	15.jpg	0
7	16.jpg	0
8	17.jpg	0
9	18.jpg	0
10	19.jpg	0
11	2.jpg	0
12	20.jpg	0
13	3.jpg	0
14	4.jpg	0
15	5.jpg	0
16	6.jpg	0
17	7.jpg	0
18	8.jpg	0
19	9.jpg	0
20	1.jpg	1
21	10.jpg	1
22	11.jpg	1
23	12.jpg	1
24	13.jpg	1
25	14.jpg	1
26	15.jpg	1
27	16.jpg	1
28	17.jpg	1
29	18.jpg	1
30	19.jpg	1
31	2.jpg	1
32	20.jpg	1
33	3.jpg	1
34	4.jpg	1
35	5.jpg	1
36	6.jpg	1
37	7.jpg	1
38	8.jpg	1
39	9.jpg	1

In [14]:

```
df.category.value_counts().plot.bar()
```

Out[14]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a8cd451ec8>
```



In [15]:

```
# view the cat random sample
sample_cat = random.choice(fn_cats)
image_cat = load_img('Datasets\\Assessment3_DL\\train\\cats\\'+ sample_cat)
plt.imshow(image_cat)
```

Out[15]:

```
<matplotlib.image.AxesImage at 0x1a8cdc89b48>
```

In [16]:

```
#view the dog random sample
sample_dog = random.choice(fn_dogs)
image_dog = load_img('Datasets\\Assessment3_DL\\train\\dogs\\'+ sample_dog)
plt.imshow(image_dog)
```

Out[16]:

```
<matplotlib.image.AxesImage at 0x1a8cdd04b88>
```

In [18]:

```
model = tf.keras.models.Sequential()

model.add(tf.keras.layers.Conv2D(32, (5,5), activation='relu', input_shape=(256,256,3)))
model.add(tf.keras.layers.BatchNormalization())
model.add(tf.keras.layers.MaxPooling2D(pool_size=(2,2)))

model.add(tf.keras.layers.Conv2D(64, (5,5), activation='relu'))
model.add(tf.keras.layers.BatchNormalization())
model.add(tf.keras.layers.MaxPooling2D(pool_size=(2,2)))
```

In [19]:

```
model.add(tf.keras.layers.Flatten())
model.add(tf.keras.layers.Dense(32, activation='relu'))
model.add(tf.keras.layers.Dropout(0.4))
model.add(tf.keras.layers.BatchNormalization())
```

In [20]:

```
model.add(tf.keras.layers.Dense(2, activation='softmax'))
```

In [22]:

```
model.compile(loss='categorical_crossentropy', optimizer='rmsprop', metrics=['accuracy'])
```

In [23]:

```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 252, 252, 32)      2432
_________________________________________________________________
batch_normalization (BatchNo (None, 252, 252, 32)      128
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 126, 126, 32)      0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 122, 122, 64)      51264
_________________________________________________________________
batch_normalization_1 (Batch (None, 122, 122, 64)      256
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 61, 61, 64)        0
_________________________________________________________________
flatten (Flatten)            (None, 238144)            0
_________________________________________________________________
dense (Dense)                (None, 32)                7620640
_________________________________________________________________
dropout (Dropout)            (None, 32)                0
_________________________________________________________________
batch_normalization_2 (Batch (None, 32)                128
_________________________________________________________________
dense_1 (Dense)              (None, 2)                 66
=================================================================
Total params: 7,674,914
Trainable params: 7,674,658
Non-trainable params: 256
_________________________________________________________________
```

In [24]:

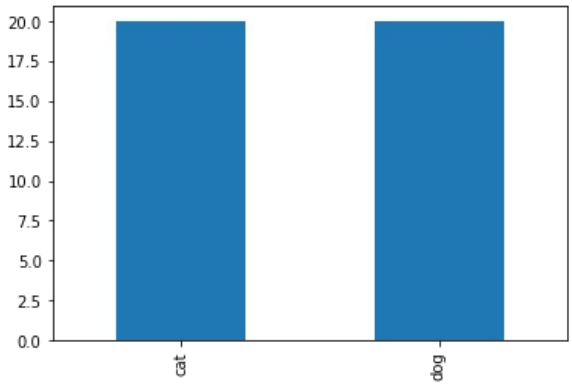
```
df['category'] = df['category'].replace({0:'cat', 1:'dog'})
```

In [25]:

```
df.category.value_counts().plot.bar()
```

Out[25]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a8d4b55fc8>
```



In [27]:

```
# list file names
fn_test_cats = os.listdir('Datasets/Assessment3_DL/test/cats')
fn_test_dogs = os.listdir('Datasets/Assessment3_DL/test/dogs')
```

In [28]:

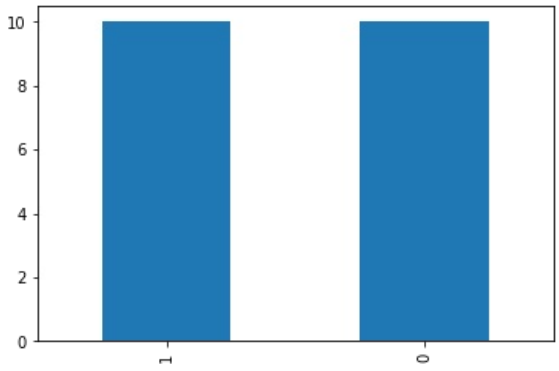
```
# categorize 0 for cats and 1 for dogs for test data
categories = []

for image in fn_test_cats:
    category = image.split('.')[0]
    categories.append(0)

for image in fn_test_dogs:
    category = image.split('.')[0]
    categories.append(1)

df_test = pd.DataFrame({'filename': fn_test_cats+fn_test_dogs,
                   'category': categories})
```

In [29]:

```
df_test.category.value_counts().plot.bar()
```

Out[29]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a8d510da48>
```



In [30]:

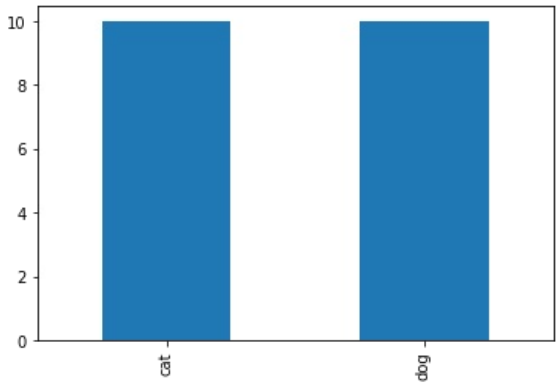
```
# converting into 0 = cat and 1 = dog
df_test.category = df_test.category.replace({0:'cat', 1:'dog'})
```

In [31]:

```
df_test.category.value_counts().plot.bar()
```

Out[31]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a8d50f7f48>
```



In [33]:

```
# fit the model
model_fit = model.fit(train_images, epochs=100, batch_size=10, validation_data=test_images)
```

```
Epoch 1/100
2/2 [==============================] - 3s 2s/step - loss: 0.8933 - accuracy: 0.5500 - val_loss: 211.
5386 - val_accuracy: 0.5000
Epoch 2/100
2/2 [==============================] - 3s 1s/step - loss: 0.5190 - accuracy: 0.8000 - val_loss: 24.7
976 - val_accuracy: 0.4000
Epoch 3/100
2/2 [==============================] - 3s 1s/step - loss: 0.2227 - accuracy: 0.9250 - val_loss: 9.62
95 - val_accuracy: 0.4000
Epoch 4/100
2/2 [==============================] - 7s 3s/step - loss: 0.2326 - accuracy: 0.9500 - val_loss: 5.59
34 - val_accuracy: 0.5000
Epoch 5/100
2/2 [==============================] - 3s 1s/step - loss: 0.1694 - accuracy: 0.9750 - val_loss: 5.47
41 - val_accuracy: 0.3500
Epoch 6/100
2/2 [==============================] - 7s 4s/step - loss: 0.1848 - accuracy: 0.9750 - val_loss: 4.80
61 - val_accuracy: 0.3500
Epoch 7/100
2/2 [==============================] - 3s 1s/step - loss: 0.1784 - accuracy: 0.9750 - val_loss: 13.0
485 - val_accuracy: 0.3500
Epoch 8/100
2/2 [==============================] - 2s 1s/step - loss: 0.1318 - accuracy: 0.9750 - val_loss: 9.29
41 - val_accuracy: 0.4000
Epoch 9/100
2/2 [==============================] - 3s 2s/step - loss: 0.1031 - accuracy: 1.0000 - val_loss: 7.94
76 - val_accuracy: 0.4000
Epoch 10/100
2/2 [==============================] - 3s 1s/step - loss: 0.1498 - accuracy: 0.9500 - val_loss: 10.7
302 - val_accuracy: 0.4500
Epoch 11/100
2/2 [==============================] - 3s 1s/step - loss: 0.1231 - accuracy: 1.0000 - val_loss: 7.80
14 - val_accuracy: 0.4000
Epoch 12/100
2/2 [==============================] - 8s 4s/step - loss: 0.1214 - accuracy: 0.9750 - val_loss: 5.98
08 - val_accuracy: 0.4500
Epoch 13/100
2/2 [==============================] - 3s 1s/step - loss: 0.1375 - accuracy: 0.9750 - val_loss: 7.00
05 - val_accuracy: 0.4500
Epoch 14/100
2/2 [==============================] - 10s 5s/step - loss: 0.1111 - accuracy: 1.0000 - val_loss: 5.5
046 - val_accuracy: 0.4500
Epoch 15/100
2/2 [==============================] - 3s 1s/step - loss: 0.0814 - accuracy: 1.0000 - val_loss: 4.67
88 - val_accuracy: 0.4000
Epoch 16/100
2/2 [==============================] - 3s 2s/step - loss: 0.0773 - accuracy: 0.9750 - val_loss: 4.84
56 - val_accuracy: 0.4500
Epoch 17/100
2/2 [==============================] - 8s 4s/step - loss: 0.0565 - accuracy: 1.0000 - val_loss: 3.60
57 - val_accuracy: 0.4500
Epoch 18/100
2/2 [==============================] - 12s 6s/step - loss: 0.0688 - accuracy: 1.0000 - val_loss: 3.7
379 - val_accuracy: 0.4000
Epoch 19/100
```

```
2/2 [==============================] - 8s 4s/step - loss: 0.0716 - accuracy: 1.0000 - val_loss: 2.80
15 - val_accuracy: 0.4500
Epoch 20/100
2/2 [==============================] - 3s 1s/step - loss: 0.0865 - accuracy: 1.0000 - val_loss: 2.25
23 - val_accuracy: 0.4000
Epoch 21/100
2/2 [==============================] - 9s 5s/step - loss: 0.0848 - accuracy: 1.0000 - val_loss: 2.99
24 - val_accuracy: 0.4000
Epoch 22/100
2/2 [==============================] - 3s 1s/step - loss: 0.0828 - accuracy: 1.0000 - val_loss: 2.34
77 - val_accuracy: 0.4500
Epoch 23/100
2/2 [==============================] - 9s 4s/step - loss: 0.0515 - accuracy: 1.0000 - val_loss: 2.66
42 - val_accuracy: 0.4000
Epoch 24/100
2/2 [==============================] - 8s 4s/step - loss: 0.0783 - accuracy: 1.0000 - val_loss: 1.97
78 - val_accuracy: 0.3500
Epoch 25/100
2/2 [==============================] - 8s 4s/step - loss: 0.0772 - accuracy: 1.0000 - val_loss: 1.66
23 - val_accuracy: 0.4500
Epoch 26/100
2/2 [==============================] - 8s 4s/step - loss: 0.0725 - accuracy: 0.9750 - val_loss: 1.36
68 - val_accuracy: 0.4000
Epoch 27/100
2/2 [==============================] - 3s 1s/step - loss: 0.0941 - accuracy: 0.9500 - val_loss: 2.18
68 - val_accuracy: 0.4000
Epoch 28/100
2/2 [==============================] - 3s 1s/step - loss: 0.0672 - accuracy: 1.0000 - val_loss: 1.91
36 - val_accuracy: 0.4000
Epoch 29/100
2/2 [==============================] - 3s 2s/step - loss: 0.0346 - accuracy: 1.0000 - val_loss: 1.62
10 - val_accuracy: 0.4500
Epoch 30/100
2/2 [==============================] - 7s 4s/step - loss: 0.0343 - accuracy: 1.0000 - val_loss: 2.03
10 - val_accuracy: 0.3000
Epoch 31/100
2/2 [==============================] - 7s 4s/step - loss: 0.0562 - accuracy: 1.0000 - val_loss: 1.93
37 - val_accuracy: 0.3500
Epoch 32/100
2/2 [==============================] - 2s 1s/step - loss: 0.0434 - accuracy: 1.0000 - val_loss: 1.16
85 - val_accuracy: 0.4500
Epoch 33/100
2/2 [==============================] - 2s 1s/step - loss: 0.0456 - accuracy: 1.0000 - val_loss: 1.85
69 - val_accuracy: 0.5000
Epoch 34/100
2/2 [==============================] - 2s 1s/step - loss: 0.0375 - accuracy: 1.0000 - val_loss: 1.61
96 - val_accuracy: 0.4500
Epoch 35/100
2/2 [==============================] - 7s 3s/step - loss: 0.0754 - accuracy: 1.0000 - val_loss: 2.10
04 - val_accuracy: 0.4000
Epoch 36/100
2/2 [==============================] - 7s 4s/step - loss: 0.0464 - accuracy: 1.0000 - val_loss: 1.62
96 - val_accuracy: 0.5000
Epoch 37/100
2/2 [==============================] - 7s 4s/step - loss: 0.0365 - accuracy: 1.0000 - val_loss: 1.71
79 - val_accuracy: 0.4500
Epoch 38/100
2/2 [==============================] - 2s 1s/step - loss: 0.0786 - accuracy: 0.9750 - val_loss: 2.87
99 - val_accuracy: 0.4000
Epoch 39/100
2/2 [==============================] - 3s 1s/step - loss: 0.0511 - accuracy: 0.9750 - val_loss: 2.00
74 - val_accuracy: 0.4500
Epoch 40/100
2/2 [==============================] - 3s 1s/step - loss: 0.0462 - accuracy: 1.0000 - val_loss: 3.61
30 - val_accuracy: 0.3500
Epoch 41/100
2/2 [==============================] - 8s 4s/step - loss: 0.0423 - accuracy: 1.0000 - val_loss: 1.83
42 - val_accuracy: 0.5000
Epoch 42/100
2/2 [==============================] - 3s 1s/step - loss: 0.0328 - accuracy: 1.0000 - val_loss: 1.61
35 - val_accuracy: 0.5000
Epoch 43/100
2/2 [==============================] - 7s 3s/step - loss: 0.0319 - accuracy: 1.0000 - val_loss: 1.75
11 - val_accuracy: 0.5000
Epoch 44/100
2/2 [==============================] - 7s 3s/step - loss: 0.0399 - accuracy: 1.0000 - val_loss: 2.16
57 - val_accuracy: 0.5000
Epoch 45/100
2/2 [==============================] - 2s 1s/step - loss: 0.0305 - accuracy: 1.0000 - val_loss: 2.23
15 - val_accuracy: 0.5000
Epoch 46/100
2/2 [==============================] - 2s 1s/step - loss: 0.0540 - accuracy: 1.0000 - val_loss: 1.69
58 - val_accuracy: 0.5500
```

```
Epoch 47/100
2/2 [==============================] - 7s 4s/step - loss: 0.0356 - accuracy: 1.0000 - val_loss: 3.74
67 - val_accuracy: 0.3500
Epoch 48/100
2/2 [==============================] - 2s 1s/step - loss: 0.0415 - accuracy: 1.0000 - val_loss: 2.86
19 - val_accuracy: 0.3500
Epoch 49/100
2/2 [==============================] - 9s 4s/step - loss: 0.0288 - accuracy: 1.0000 - val_loss: 3.58
60 - val_accuracy: 0.5500
Epoch 50/100
2/2 [==============================] - 3s 1s/step - loss: 0.0520 - accuracy: 1.0000 - val_loss: 2.16
72 - val_accuracy: 0.4000
Epoch 51/100
2/2 [==============================] - 3s 1s/step - loss: 0.0327 - accuracy: 1.0000 - val_loss: 3.39
55 - val_accuracy: 0.4500
Epoch 52/100
2/2 [==============================] - 7s 4s/step - loss: 0.0552 - accuracy: 1.0000 - val_loss: 1.82
10 - val_accuracy: 0.4000
Epoch 53/100
2/2 [==============================] - 7s 4s/step - loss: 0.0393 - accuracy: 1.0000 - val_loss: 2.11
41 - val_accuracy: 0.4500
Epoch 54/100
2/2 [==============================] - 3s 2s/step - loss: 0.0696 - accuracy: 0.9500 - val_loss: 1.91
34 - val_accuracy: 0.3000
Epoch 55/100
2/2 [==============================] - 8s 4s/step - loss: 0.0526 - accuracy: 1.0000 - val_loss: 1.82
55 - val_accuracy: 0.4000
Epoch 56/100
2/2 [==============================] - 8s 4s/step - loss: 0.0299 - accuracy: 1.0000 - val_loss: 2.01
65 - val_accuracy: 0.3000
Epoch 57/100
2/2 [==============================] - 7s 3s/step - loss: 0.0297 - accuracy: 1.0000 - val_loss: 1.88
66 - val_accuracy: 0.3000
Epoch 58/100
2/2 [==============================] - 2s 1s/step - loss: 0.0100 - accuracy: 1.0000 - val_loss: 1.85
79 - val_accuracy: 0.3000
Epoch 59/100
2/2 [==============================] - 7s 4s/step - loss: 0.0192 - accuracy: 1.0000 - val_loss: 1.90
53 - val_accuracy: 0.4500
Epoch 60/100
2/2 [==============================] - 3s 1s/step - loss: 0.0281 - accuracy: 1.0000 - val_loss: 3.42
12 - val_accuracy: 0.3000
Epoch 61/100
2/2 [==============================] - 2s 1s/step - loss: 0.0318 - accuracy: 1.0000 - val_loss: 2.91
36 - val_accuracy: 0.4000
Epoch 62/100
2/2 [==============================] - 2s 1s/step - loss: 0.0165 - accuracy: 1.0000 - val_loss: 3.65
91 - val_accuracy: 0.3500
Epoch 63/100
2/2 [==============================] - 7s 3s/step - loss: 0.1019 - accuracy: 0.9750 - val_loss: 1.76
24 - val_accuracy: 0.5000
Epoch 64/100
2/2 [==============================] - 2s 1s/step - loss: 0.0283 - accuracy: 1.0000 - val_loss: 1.77
43 - val_accuracy: 0.5000
Epoch 65/100
2/2 [==============================] - 7s 3s/step - loss: 0.0295 - accuracy: 1.0000 - val_loss: 1.93
22 - val_accuracy: 0.3500
Epoch 66/100
2/2 [==============================] - 2s 1s/step - loss: 0.0410 - accuracy: 1.0000 - val_loss: 1.43
22 - val_accuracy: 0.3500
Epoch 67/100
2/2 [==============================] - 8s 4s/step - loss: 0.0318 - accuracy: 1.0000 - val_loss: 1.70
59 - val_accuracy: 0.3500
Epoch 68/100
2/2 [==============================] - 3s 1s/step - loss: 0.0409 - accuracy: 1.0000 - val_loss: 1.59
99 - val_accuracy: 0.4500
Epoch 69/100
2/2 [==============================] - 2s 1s/step - loss: 0.0993 - accuracy: 0.9500 - val_loss: 1.38
43 - val_accuracy: 0.4000
Epoch 70/100
2/2 [==============================] - 2s 1s/step - loss: 0.0181 - accuracy: 1.0000 - val_loss: 1.81
74 - val_accuracy: 0.4500
Epoch 71/100
2/2 [==============================] - 2s 1s/step - loss: 0.0412 - accuracy: 1.0000 - val_loss: 2.21
21 - val_accuracy: 0.4500
Epoch 72/100
2/2 [==============================] - 6s 3s/step - loss: 0.0221 - accuracy: 1.0000 - val_loss: 1.69
46 - val_accuracy: 0.5500
Epoch 73/100
2/2 [==============================] - 2s 1s/step - loss: 0.0189 - accuracy: 1.0000 - val_loss: 1.52
82 - val_accuracy: 0.5500
Epoch 74/100
2/2 [==============================] - 2s 1s/step - loss: 0.0169 - accuracy: 1.0000 - val_loss: 1.65
```

```
83 - val_accuracy: 0.5000
Epoch 75/100
2/2 [==============================] - 2s 1s/step - loss: 0.0204 - accuracy: 1.0000 - val_loss: 1.81
86 - val_accuracy: 0.5500
Epoch 76/100
2/2 [==============================] - 6s 3s/step - loss: 0.0200 - accuracy: 1.0000 - val_loss: 2.07
48 - val_accuracy: 0.4000
Epoch 77/100
2/2 [==============================] - 6s 3s/step - loss: 0.0154 - accuracy: 1.0000 - val_loss: 2.00
86 - val_accuracy: 0.4000
Epoch 78/100
2/2 [==============================] - 6s 3s/step - loss: 0.0465 - accuracy: 0.9750 - val_loss: 1.40
23 - val_accuracy: 0.4000
Epoch 79/100
2/2 [==============================] - 6s 3s/step - loss: 0.0512 - accuracy: 1.0000 - val_loss: 2.40
70 - val_accuracy: 0.4000
Epoch 80/100
2/2 [==============================] - 2s 1s/step - loss: 0.0551 - accuracy: 1.0000 - val_loss: 2.98
62 - val_accuracy: 0.4000
Epoch 81/100
2/2 [==============================] - 6s 3s/step - loss: 0.0271 - accuracy: 1.0000 - val_loss: 1.92
19 - val_accuracy: 0.5000
Epoch 82/100
2/2 [==============================] - 2s 1s/step - loss: 0.0312 - accuracy: 1.0000 - val_loss: 2.00
04 - val_accuracy: 0.5000
Epoch 83/100
2/2 [==============================] - 7s 3s/step - loss: 0.0240 - accuracy: 1.0000 - val_loss: 1.93
31 - val_accuracy: 0.4500
Epoch 84/100
2/2 [==============================] - 2s 1s/step - loss: 0.0230 - accuracy: 1.0000 - val_loss: 1.66
72 - val_accuracy: 0.4500
Epoch 85/100
2/2 [==============================] - 2s 1s/step - loss: 0.0102 - accuracy: 1.0000 - val_loss: 1.68
62 - val_accuracy: 0.4500
Epoch 86/100
2/2 [==============================] - 2s 1s/step - loss: 0.0194 - accuracy: 1.0000 - val_loss: 1.73
31 - val_accuracy: 0.4000
Epoch 87/100
2/2 [==============================] - 6s 3s/step - loss: 0.0204 - accuracy: 1.0000 - val_loss: 1.50
18 - val_accuracy: 0.4500
Epoch 88/100
2/2 [==============================] - 2s 1s/step - loss: 0.0111 - accuracy: 1.0000 - val_loss: 1.37
28 - val_accuracy: 0.4500
Epoch 89/100
2/2 [==============================] - 2s 1s/step - loss: 0.0124 - accuracy: 1.0000 - val_loss: 1.49
43 - val_accuracy: 0.4000
Epoch 90/100
2/2 [==============================] - 6s 3s/step - loss: 0.0162 - accuracy: 1.0000 - val_loss: 1.43
22 - val_accuracy: 0.5000
Epoch 91/100
2/2 [==============================] - 7s 3s/step - loss: 0.0160 - accuracy: 1.0000 - val_loss: 1.29
53 - val_accuracy: 0.5500
Epoch 92/100
2/2 [==============================] - 2s 1s/step - loss: 0.0119 - accuracy: 1.0000 - val_loss: 1.47
31 - val_accuracy: 0.4000
Epoch 93/100
2/2 [==============================] - 6s 3s/step - loss: 0.0159 - accuracy: 1.0000 - val_loss: 1.27
80 - val_accuracy: 0.5000
Epoch 94/100
2/2 [==============================] - 2s 1s/step - loss: 0.0262 - accuracy: 1.0000 - val_loss: 1.09
00 - val_accuracy: 0.5000
Epoch 95/100
2/2 [==============================] - 2s 1s/step - loss: 0.0123 - accuracy: 1.0000 - val_loss: 1.17
37 - val_accuracy: 0.5000
Epoch 96/100
2/2 [==============================] - 2s 1s/step - loss: 0.0231 - accuracy: 1.0000 - val_loss: 1.49
81 - val_accuracy: 0.4500
Epoch 97/100
2/2 [==============================] - 2s 1s/step - loss: 0.0120 - accuracy: 1.0000 - val_loss: 1.86
61 - val_accuracy: 0.4500
Epoch 98/100
2/2 [==============================] - 7s 3s/step - loss: 0.0240 - accuracy: 1.0000 - val_loss: 1.65
60 - val_accuracy: 0.5500
Epoch 99/100
2/2 [==============================] - 2s 1s/step - loss: 0.0086 - accuracy: 1.0000 - val_loss: 1.76
96 - val_accuracy: 0.5500
Epoch 100/100
2/2 [==============================] - 2s 1s/step - loss: 0.0131 - accuracy: 1.0000 - val_loss: 1.63
75 - val_accuracy: 0.5500
```

In [48]:

```
loss, accuracy = model.evaluate(test_images)
```

```
1/1 [==============================] - 0s 5ms/step - loss: 1.6375 - accuracy: 0.5500
```

In [49]:

```
# fit the model - 200 iterations
model_fit_200 = model.fit(train_images, epochs=200, batch_size=10, validation_data=test_images)
```

```
Epoch 1/200
2/2 [==============================] - 8s 4s/step - loss: 0.0163 - accuracy: 1.0000 - val_loss: 2.11
00 - val_accuracy: 0.4000
Epoch 2/200
2/2 [==============================] - 2s 1s/step - loss: 0.0100 - accuracy: 1.0000 - val_loss: 1.84
74 - val_accuracy: 0.4500
Epoch 3/200
2/2 [==============================] - 2s 1s/step - loss: 0.0046 - accuracy: 1.0000 - val_loss: 1.91
24 - val_accuracy: 0.5000
Epoch 4/200
2/2 [==============================] - 2s 1s/step - loss: 0.0244 - accuracy: 1.0000 - val_loss: 2.17
13 - val_accuracy: 0.5500
Epoch 5/200
2/2 [==============================] - 6s 3s/step - loss: 0.0639 - accuracy: 0.9500 - val_loss: 2.77
06 - val_accuracy: 0.3500
Epoch 6/200
2/2 [==============================] - 6s 3s/step - loss: 0.0289 - accuracy: 1.0000 - val_loss: 2.67
89 - val_accuracy: 0.4000
Epoch 7/200
2/2 [==============================] - 6s 3s/step - loss: 0.0303 - accuracy: 1.0000 - val_loss: 2.90
58 - val_accuracy: 0.4000
Epoch 8/200
2/2 [==============================] - 2s 1s/step - loss: 0.0278 - accuracy: 1.0000 - val_loss: 2.57
45 - val_accuracy: 0.4000
Epoch 9/200
2/2 [==============================] - 6s 3s/step - loss: 0.0595 - accuracy: 1.0000 - val_loss: 2.14
55 - val_accuracy: 0.4000
Epoch 10/200
2/2 [==============================] - 6s 3s/step - loss: 0.0121 - accuracy: 1.0000 - val_loss: 2.47
41 - val_accuracy: 0.4000
Epoch 11/200
2/2 [==============================] - 3s 1s/step - loss: 0.0401 - accuracy: 0.9750 - val_loss: 1.22
29 - val_accuracy: 0.4500
Epoch 12/200
2/2 [==============================] - 2s 1s/step - loss: 0.0310 - accuracy: 1.0000 - val_loss: 1.10
79 - val_accuracy: 0.5000
Epoch 13/200
2/2 [==============================] - 2s 1s/step - loss: 0.0275 - accuracy: 1.0000 - val_loss: 2.22
80 - val_accuracy: 0.4000
Epoch 14/200
2/2 [==============================] - 2s 1s/step - loss: 0.0254 - accuracy: 1.0000 - val_loss: 1.54
02 - val_accuracy: 0.4000
Epoch 15/200
2/2 [==============================] - 7s 3s/step - loss: 0.0188 - accuracy: 1.0000 - val_loss: 1.25
27 - val_accuracy: 0.4500
Epoch 16/200
2/2 [==============================] - 2s 1s/step - loss: 0.0180 - accuracy: 1.0000 - val_loss: 1.14
33 - val_accuracy: 0.4500
Epoch 17/200
2/2 [==============================] - 7s 4s/step - loss: 0.0120 - accuracy: 1.0000 - val_loss: 1.30
91 - val_accuracy: 0.4500
Epoch 18/200
2/2 [==============================] - 2s 1s/step - loss: 0.0097 - accuracy: 1.0000 - val_loss: 1.55
15 - val_accuracy: 0.4500
Epoch 19/200
2/2 [==============================] - 2s 1s/step - loss: 0.0231 - accuracy: 1.0000 - val_loss: 1.79
88 - val_accuracy: 0.4500
Epoch 20/200
2/2 [==============================] - 2s 1s/step - loss: 0.0096 - accuracy: 1.0000 - val_loss: 1.76
79 - val_accuracy: 0.4500
Epoch 21/200
2/2 [==============================] - 6s 3s/step - loss: 0.0152 - accuracy: 1.0000 - val_loss: 1.59
16 - val_accuracy: 0.4500
Epoch 22/200
2/2 [==============================] - 2s 1s/step - loss: 0.0052 - accuracy: 1.0000 - val_loss: 1.60
68 - val_accuracy: 0.4500
Epoch 23/200
2/2 [==============================] - 6s 3s/step - loss: 0.0161 - accuracy: 1.0000 - val_loss: 1.59
10 - val_accuracy: 0.4500
Epoch 24/200
2/2 [==============================] - 2s 1s/step - loss: 0.0248 - accuracy: 1.0000 - val_loss: 2.62
71 - val_accuracy: 0.4500
```

```
Epoch 25/200
2/2 [==============================] - 6s 3s/step - loss: 0.0098 - accuracy: 1.0000 - val_loss: 2.12
62 - val_accuracy: 0.4500
Epoch 26/200
2/2 [==============================] - 7s 3s/step - loss: 0.0099 - accuracy: 1.0000 - val_loss: 2.06
88 - val_accuracy: 0.4000
Epoch 27/200
2/2 [==============================] - 7s 3s/step - loss: 0.0139 - accuracy: 1.0000 - val_loss: 0.92
22 - val_accuracy: 0.5500
Epoch 28/200
2/2 [==============================] - 2s 1s/step - loss: 0.0088 - accuracy: 1.0000 - val_loss: 0.89
15 - val_accuracy: 0.6000
Epoch 29/200
2/2 [==============================] - 3s 1s/step - loss: 0.0083 - accuracy: 1.0000 - val_loss: 0.95
56 - val_accuracy: 0.4500
Epoch 30/200
2/2 [==============================] - 7s 3s/step - loss: 0.0062 - accuracy: 1.0000 - val_loss: 1.06
61 - val_accuracy: 0.4500
Epoch 31/200
2/2 [==============================] - 6s 3s/step - loss: 0.0073 - accuracy: 1.0000 - val_loss: 1.39
18 - val_accuracy: 0.4500
Epoch 32/200
2/2 [==============================] - 8s 4s/step - loss: 0.0257 - accuracy: 0.9750 - val_loss: 1.24
75 - val_accuracy: 0.5000
Epoch 33/200
2/2 [==============================] - 3s 2s/step - loss: 0.0134 - accuracy: 1.0000 - val_loss: 1.16
58 - val_accuracy: 0.5500
Epoch 34/200
2/2 [==============================] - 9s 4s/step - loss: 0.0084 - accuracy: 1.0000 - val_loss: 1.23
74 - val_accuracy: 0.5000
Epoch 35/200
2/2 [==============================] - 12s 6s/step - loss: 0.0073 - accuracy: 1.0000 - val_loss: 1.3
243 - val_accuracy: 0.4500
Epoch 36/200
2/2 [==============================] - 4s 2s/step - loss: 0.0102 - accuracy: 1.0000 - val_loss: 1.27
56 - val_accuracy: 0.5000
Epoch 37/200
2/2 [==============================] - 3s 1s/step - loss: 0.0041 - accuracy: 1.0000 - val_loss: 1.22
53 - val_accuracy: 0.5500
Epoch 38/200
2/2 [==============================] - 8s 4s/step - loss: 0.0110 - accuracy: 1.0000 - val_loss: 1.51
24 - val_accuracy: 0.5000
Epoch 39/200
2/2 [==============================] - 2s 1s/step - loss: 0.0180 - accuracy: 1.0000 - val_loss: 1.09
73 - val_accuracy: 0.5500
Epoch 40/200
2/2 [==============================] - 8s 4s/step - loss: 0.0193 - accuracy: 1.0000 - val_loss: 1.71
33 - val_accuracy: 0.3000
Epoch 41/200
2/2 [==============================] - 7s 4s/step - loss: 0.0205 - accuracy: 1.0000 - val_loss: 1.27
33 - val_accuracy: 0.4500
Epoch 42/200
2/2 [==============================] - 2s 1s/step - loss: 0.0157 - accuracy: 1.0000 - val_loss: 1.56
80 - val_accuracy: 0.3000
Epoch 43/200
2/2 [==============================] - 7s 4s/step - loss: 0.0158 - accuracy: 1.0000 - val_loss: 1.43
11 - val_accuracy: 0.4500
Epoch 44/200
2/2 [==============================] - 2s 1s/step - loss: 0.0152 - accuracy: 1.0000 - val_loss: 1.40
65 - val_accuracy: 0.4500
Epoch 45/200
2/2 [==============================] - 8s 4s/step - loss: 0.0116 - accuracy: 1.0000 - val_loss: 2.01
99 - val_accuracy: 0.5000
Epoch 46/200
2/2 [==============================] - 2s 1s/step - loss: 0.0392 - accuracy: 1.0000 - val_loss: 1.31
47 - val_accuracy: 0.4500
Epoch 47/200
2/2 [==============================] - 2s 1s/step - loss: 0.0071 - accuracy: 1.0000 - val_loss: 1.48
00 - val_accuracy: 0.4000
Epoch 48/200
2/2 [==============================] - 7s 3s/step - loss: 0.0087 - accuracy: 1.0000 - val_loss: 1.44
59 - val_accuracy: 0.6000
Epoch 49/200
2/2 [==============================] - 2s 1s/step - loss: 0.0086 - accuracy: 1.0000 - val_loss: 1.40
53 - val_accuracy: 0.6000
Epoch 50/200
2/2 [==============================] - 2s 1s/step - loss: 0.0053 - accuracy: 1.0000 - val_loss: 1.31
35 - val_accuracy: 0.5000
Epoch 51/200
2/2 [==============================] - 2s 1s/step - loss: 0.0067 - accuracy: 1.0000 - val_loss: 1.34
57 - val_accuracy: 0.5500
Epoch 52/200
2/2 [==============================] - 6s 3s/step - loss: 0.0078 - accuracy: 1.0000 - val_loss: 1.45
```

```
56 - val_accuracy: 0.5500
Epoch 53/200
2/2 [==============================] - 2s 1s/step - loss: 0.0034 - accuracy: 1.0000 - val_loss: 1.48
19 - val_accuracy: 0.5500
Epoch 54/200
2/2 [==============================] - 7s 3s/step - loss: 0.0141 - accuracy: 1.0000 - val_loss: 1.58
75 - val_accuracy: 0.4000
Epoch 55/200
2/2 [==============================] - 2s 1s/step - loss: 0.0060 - accuracy: 1.0000 - val_loss: 1.60
53 - val_accuracy: 0.4500
Epoch 56/200
2/2 [==============================] - 6s 3s/step - loss: 0.0078 - accuracy: 1.0000 - val_loss: 1.55
78 - val_accuracy: 0.5000
Epoch 57/200
2/2 [==============================] - 6s 3s/step - loss: 0.0070 - accuracy: 1.0000 - val_loss: 1.58
72 - val_accuracy: 0.5000
Epoch 58/200
2/2 [==============================] - 6s 3s/step - loss: 0.0029 - accuracy: 1.0000 - val_loss: 1.77
90 - val_accuracy: 0.5000
Epoch 59/200
2/2 [==============================] - 2s 1s/step - loss: 0.0235 - accuracy: 1.0000 - val_loss: 1.29
21 - val_accuracy: 0.6000
Epoch 60/200
2/2 [==============================] - 3s 1s/step - loss: 0.0880 - accuracy: 0.9500 - val_loss: 1.16
32 - val_accuracy: 0.3500
Epoch 61/200
2/2 [==============================] - 7s 3s/step - loss: 0.0114 - accuracy: 1.0000 - val_loss: 1.07
17 - val_accuracy: 0.3500
Epoch 62/200
2/2 [==============================] - 6s 3s/step - loss: 0.0259 - accuracy: 1.0000 - val_loss: 2.17
39 - val_accuracy: 0.5000
Epoch 63/200
2/2 [==============================] - 2s 1s/step - loss: 0.0135 - accuracy: 1.0000 - val_loss: 1.72
55 - val_accuracy: 0.4000
Epoch 64/200
2/2 [==============================] - 7s 3s/step - loss: 0.0029 - accuracy: 1.0000 - val_loss: 1.50
23 - val_accuracy: 0.4000
Epoch 65/200
2/2 [==============================] - 6s 3s/step - loss: 0.0057 - accuracy: 1.0000 - val_loss: 1.46
95 - val_accuracy: 0.4000
Epoch 66/200
2/2 [==============================] - 2s 1s/step - loss: 0.0044 - accuracy: 1.0000 - val_loss: 1.28
57 - val_accuracy: 0.4000
Epoch 67/200
2/2 [==============================] - 6s 3s/step - loss: 0.0168 - accuracy: 1.0000 - val_loss: 2.22
46 - val_accuracy: 0.3000
Epoch 68/200
2/2 [==============================] - 7s 3s/step - loss: 0.0061 - accuracy: 1.0000 - val_loss: 1.74
85 - val_accuracy: 0.3000
Epoch 69/200
2/2 [==============================] - 2s 1s/step - loss: 0.0069 - accuracy: 1.0000 - val_loss: 1.60
52 - val_accuracy: 0.3000
Epoch 70/200
2/2 [==============================] - 7s 3s/step - loss: 0.0033 - accuracy: 1.0000 - val_loss: 1.48
79 - val_accuracy: 0.3000
Epoch 71/200
2/2 [==============================] - 2s 1s/step - loss: 0.0516 - accuracy: 0.9750 - val_loss: 1.05
04 - val_accuracy: 0.4500
Epoch 72/200
2/2 [==============================] - 7s 3s/step - loss: 0.0211 - accuracy: 1.0000 - val_loss: 0.78
81 - val_accuracy: 0.4500
Epoch 73/200
2/2 [==============================] - 2s 1s/step - loss: 0.0266 - accuracy: 1.0000 - val_loss: 0.92
43 - val_accuracy: 0.4500
Epoch 74/200
2/2 [==============================] - 2s 1s/step - loss: 0.0160 - accuracy: 1.0000 - val_loss: 0.93
11 - val_accuracy: 0.5500
Epoch 75/200
2/2 [==============================] - 7s 4s/step - loss: 0.0031 - accuracy: 1.0000 - val_loss: 0.88
89 - val_accuracy: 0.5500
Epoch 76/200
2/2 [==============================] - 2s 1s/step - loss: 0.0312 - accuracy: 1.0000 - val_loss: 1.23
04 - val_accuracy: 0.4500
Epoch 77/200
2/2 [==============================] - 2s 1s/step - loss: 0.1272 - accuracy: 0.9500 - val_loss: 1.45
52 - val_accuracy: 0.4500
Epoch 78/200
2/2 [==============================] - 2s 1s/step - loss: 0.0146 - accuracy: 1.0000 - val_loss: 0.84
00 - val_accuracy: 0.4500
Epoch 79/200
2/2 [==============================] - 7s 3s/step - loss: 0.0332 - accuracy: 1.0000 - val_loss: 0.89
81 - val_accuracy: 0.4000
Epoch 80/200
```

```
2/2 [==============================] - 6s 3s/step - loss: 0.0107 - accuracy: 1.0000 - val_loss: 0.95
78 - val_accuracy: 0.4000
Epoch 81/200
2/2 [==============================] - 6s 3s/step - loss: 0.0135 - accuracy: 1.0000 - val_loss: 0.92
21 - val_accuracy: 0.3500
Epoch 82/200
2/2 [==============================] - 2s 1s/step - loss: 0.0383 - accuracy: 1.0000 - val_loss: 0.87
80 - val_accuracy: 0.3500
Epoch 83/200
2/2 [==============================] - 2s 1s/step - loss: 0.0104 - accuracy: 1.0000 - val_loss: 0.83
84 - val_accuracy: 0.3500
Epoch 84/200
2/2 [==============================] - 2s 1s/step - loss: 0.0569 - accuracy: 0.9500 - val_loss: 0.84
57 - val_accuracy: 0.5500
Epoch 85/200
2/2 [==============================] - 2s 1s/step - loss: 0.0129 - accuracy: 1.0000 - val_loss: 0.80
52 - val_accuracy: 0.5500
Epoch 86/200
2/2 [==============================] - 6s 3s/step - loss: 0.0060 - accuracy: 1.0000 - val_loss: 0.81
06 - val_accuracy: 0.5500
Epoch 87/200
2/2 [==============================] - 2s 1s/step - loss: 0.0910 - accuracy: 0.9500 - val_loss: 1.04
87 - val_accuracy: 0.4500
Epoch 88/200
2/2 [==============================] - 2s 1s/step - loss: 0.0611 - accuracy: 0.9750 - val_loss: 1.02
52 - val_accuracy: 0.5000
Epoch 89/200
2/2 [==============================] - 6s 3s/step - loss: 0.0127 - accuracy: 1.0000 - val_loss: 1.06
43 - val_accuracy: 0.4500
Epoch 90/200
2/2 [==============================] - 2s 1s/step - loss: 0.0122 - accuracy: 1.0000 - val_loss: 1.36
48 - val_accuracy: 0.5000
Epoch 91/200
2/2 [==============================] - 2s 1s/step - loss: 0.0089 - accuracy: 1.0000 - val_loss: 1.29
43 - val_accuracy: 0.5500
Epoch 92/200
2/2 [==============================] - 2s 1s/step - loss: 0.0138 - accuracy: 1.0000 - val_loss: 1.13
50 - val_accuracy: 0.6000
Epoch 93/200
2/2 [==============================] - 6s 3s/step - loss: 0.0377 - accuracy: 1.0000 - val_loss: 1.36
27 - val_accuracy: 0.4500
Epoch 94/200
2/2 [==============================] - 6s 3s/step - loss: 0.0174 - accuracy: 1.0000 - val_loss: 0.92
70 - val_accuracy: 0.6000
Epoch 95/200
2/2 [==============================] - 6s 3s/step - loss: 0.0083 - accuracy: 1.0000 - val_loss: 0.92
69 - val_accuracy: 0.6000
Epoch 96/200
2/2 [==============================] - 2s 1s/step - loss: 0.0112 - accuracy: 1.0000 - val_loss: 0.90
64 - val_accuracy: 0.6000
Epoch 97/200
2/2 [==============================] - 2s 1s/step - loss: 0.0090 - accuracy: 1.0000 - val_loss: 1.77
48 - val_accuracy: 0.4000
Epoch 98/200
2/2 [==============================] - 7s 4s/step - loss: 0.0053 - accuracy: 1.0000 - val_loss: 1.56
78 - val_accuracy: 0.4500
Epoch 99/200
2/2 [==============================] - 6s 3s/step - loss: 0.0048 - accuracy: 1.0000 - val_loss: 1.58
85 - val_accuracy: 0.5000
Epoch 100/200
2/2 [==============================] - 6s 3s/step - loss: 0.0056 - accuracy: 1.0000 - val_loss: 1.51
12 - val_accuracy: 0.6500
Epoch 101/200
2/2 [==============================] - 6s 3s/step - loss: 0.0027 - accuracy: 1.0000 - val_loss: 1.49
06 - val_accuracy: 0.6500
Epoch 102/200
2/2 [==============================] - 7s 3s/step - loss: 0.0870 - accuracy: 0.9500 - val_loss: 1.01
02 - val_accuracy: 0.5500
Epoch 103/200
2/2 [==============================] - 2s 1s/step - loss: 0.0038 - accuracy: 1.0000 - val_loss: 1.01
35 - val_accuracy: 0.5500
Epoch 104/200
2/2 [==============================] - 8s 4s/step - loss: 0.0201 - accuracy: 1.0000 - val_loss: 0.96
59 - val_accuracy: 0.5500
Epoch 105/200
2/2 [==============================] - 8s 4s/step - loss: 0.0043 - accuracy: 1.0000 - val_loss: 1.00
11 - val_accuracy: 0.5500
Epoch 106/200
2/2 [==============================] - 3s 2s/step - loss: 0.0183 - accuracy: 1.0000 - val_loss: 1.23
87 - val_accuracy: 0.5500
Epoch 107/200
2/2 [==============================] - 7s 4s/step - loss: 0.0269 - accuracy: 0.9750 - val_loss: 0.82
84 - val_accuracy: 0.5000
```

```
Epoch 108/200
2/2 [==============================] - 2s 1s/step - loss: 0.0857 - accuracy: 0.9750 - val_loss: 2.06
22 - val_accuracy: 0.4000
Epoch 109/200
2/2 [==============================] - 7s 3s/step - loss: 0.0051 - accuracy: 1.0000 - val_loss: 1.30
49 - val_accuracy: 0.3500
Epoch 110/200
2/2 [==============================] - 7s 4s/step - loss: 0.0038 - accuracy: 1.0000 - val_loss: 1.14
34 - val_accuracy: 0.3500
Epoch 111/200
2/2 [==============================] - 7s 4s/step - loss: 0.0083 - accuracy: 1.0000 - val_loss: 1.10
07 - val_accuracy: 0.5500
Epoch 112/200
2/2 [==============================] - 3s 1s/step - loss: 0.0066 - accuracy: 1.0000 - val_loss: 1.04
29 - val_accuracy: 0.5000
Epoch 113/200
2/2 [==============================] - 2s 1s/step - loss: 0.0278 - accuracy: 1.0000 - val_loss: 1.04
14 - val_accuracy: 0.5000
Epoch 114/200
2/2 [==============================] - 7s 4s/step - loss: 0.0158 - accuracy: 1.0000 - val_loss: 1.05
08 - val_accuracy: 0.5500
Epoch 115/200
2/2 [==============================] - 7s 3s/step - loss: 0.0050 - accuracy: 1.0000 - val_loss: 1.05
38 - val_accuracy: 0.5000
Epoch 116/200
2/2 [==============================] - 2s 1s/step - loss: 0.0041 - accuracy: 1.0000 - val_loss: 0.93
27 - val_accuracy: 0.4500
Epoch 117/200
2/2 [==============================] - 2s 1s/step - loss: 0.0036 - accuracy: 1.0000 - val_loss: 0.90
04 - val_accuracy: 0.4500
Epoch 118/200
2/2 [==============================] - 2s 1s/step - loss: 0.0051 - accuracy: 1.0000 - val_loss: 0.89
10 - val_accuracy: 0.5000
Epoch 119/200
2/2 [==============================] - 2s 1s/step - loss: 0.0087 - accuracy: 1.0000 - val_loss: 0.91
90 - val_accuracy: 0.5000
Epoch 120/200
2/2 [==============================] - 7s 4s/step - loss: 0.0450 - accuracy: 0.9750 - val_loss: 0.88
32 - val_accuracy: 0.6000
Epoch 121/200
2/2 [==============================] - 2s 1s/step - loss: 0.0052 - accuracy: 1.0000 - val_loss: 0.90
53 - val_accuracy: 0.6000
Epoch 122/200
2/2 [==============================] - 2s 1s/step - loss: 0.0097 - accuracy: 1.0000 - val_loss: 0.96
34 - val_accuracy: 0.6000
Epoch 123/200
2/2 [==============================] - 6s 3s/step - loss: 0.0041 - accuracy: 1.0000 - val_loss: 0.93
93 - val_accuracy: 0.6000
Epoch 124/200
2/2 [==============================] - 2s 1s/step - loss: 0.0094 - accuracy: 1.0000 - val_loss: 0.96
11 - val_accuracy: 0.6000
Epoch 125/200
2/2 [==============================] - 2s 1s/step - loss: 0.0077 - accuracy: 1.0000 - val_loss: 1.06
45 - val_accuracy: 0.5500
Epoch 126/200
2/2 [==============================] - 2s 1s/step - loss: 0.0193 - accuracy: 1.0000 - val_loss: 1.02
73 - val_accuracy: 0.5500
Epoch 127/200
2/2 [==============================] - 2s 1s/step - loss: 0.0061 - accuracy: 1.0000 - val_loss: 1.02
83 - val_accuracy: 0.6000
Epoch 128/200
2/2 [==============================] - 6s 3s/step - loss: 0.0210 - accuracy: 1.0000 - val_loss: 1.00
59 - val_accuracy: 0.5500
Epoch 129/200
2/2 [==============================] - 7s 3s/step - loss: 0.0087 - accuracy: 1.0000 - val_loss: 1.06
48 - val_accuracy: 0.5500
Epoch 130/200
2/2 [==============================] - 7s 3s/step - loss: 0.0110 - accuracy: 1.0000 - val_loss: 1.06
46 - val_accuracy: 0.5000
Epoch 131/200
2/2 [==============================] - 2s 1s/step - loss: 0.0022 - accuracy: 1.0000 - val_loss: 1.07
72 - val_accuracy: 0.5000
Epoch 132/200
2/2 [==============================] - 7s 3s/step - loss: 0.0072 - accuracy: 1.0000 - val_loss: 1.10
36 - val_accuracy: 0.5000
Epoch 133/200
2/2 [==============================] - 7s 3s/step - loss: 0.0018 - accuracy: 1.0000 - val_loss: 1.11
73 - val_accuracy: 0.5000
Epoch 134/200
2/2 [==============================] - 6s 3s/step - loss: 0.0025 - accuracy: 1.0000 - val_loss: 1.12
81 - val_accuracy: 0.5000
Epoch 135/200
2/2 [==============================] - 7s 3s/step - loss: 0.0024 - accuracy: 1.0000 - val_loss: 1.14
```

```
56 - val_accuracy: 0.5000
Epoch 136/200
2/2 [==============================] - 7s 3s/step - loss: 0.0161 - accuracy: 1.0000 - val_loss: 1.20
26 - val_accuracy: 0.4000
Epoch 137/200
2/2 [==============================] - 2s 1s/step - loss: 0.0059 - accuracy: 1.0000 - val_loss: 1.14
63 - val_accuracy: 0.5000
Epoch 138/200
2/2 [==============================] - 2s 1s/step - loss: 0.0017 - accuracy: 1.0000 - val_loss: 1.17
07 - val_accuracy: 0.5000
Epoch 139/200
2/2 [==============================] - 6s 3s/step - loss: 0.0256 - accuracy: 1.0000 - val_loss: 1.38
78 - val_accuracy: 0.5000
Epoch 140/200
2/2 [==============================] - 7s 3s/step - loss: 0.0100 - accuracy: 1.0000 - val_loss: 1.41
79 - val_accuracy: 0.4500
Epoch 141/200
2/2 [==============================] - 7s 4s/step - loss: 0.0021 - accuracy: 1.0000 - val_loss: 1.42
70 - val_accuracy: 0.4500
Epoch 142/200
2/2 [==============================] - 7s 3s/step - loss: 0.0320 - accuracy: 1.0000 - val_loss: 1.30
64 - val_accuracy: 0.5500
Epoch 143/200
2/2 [==============================] - 2s 1s/step - loss: 0.0049 - accuracy: 1.0000 - val_loss: 1.39
92 - val_accuracy: 0.5500
Epoch 144/200
2/2 [==============================] - 8s 4s/step - loss: 0.0085 - accuracy: 1.0000 - val_loss: 1.49
11 - val_accuracy: 0.4500
Epoch 145/200
2/2 [==============================] - 3s 1s/step - loss: 0.0028 - accuracy: 1.0000 - val_loss: 1.57
95 - val_accuracy: 0.4500
Epoch 146/200
2/2 [==============================] - 2s 1s/step - loss: 0.0120 - accuracy: 1.0000 - val_loss: 1.86
54 - val_accuracy: 0.5000
Epoch 147/200
2/2 [==============================] - 2s 1s/step - loss: 0.0170 - accuracy: 1.0000 - val_loss: 1.61
54 - val_accuracy: 0.5000
Epoch 148/200
2/2 [==============================] - 2s 1s/step - loss: 0.0733 - accuracy: 0.9750 - val_loss: 1.38
82 - val_accuracy: 0.6000
Epoch 149/200
2/2 [==============================] - 3s 1s/step - loss: 0.1015 - accuracy: 0.9750 - val_loss: 2.20
79 - val_accuracy: 0.5000
Epoch 150/200
2/2 [==============================] - 7s 4s/step - loss: 0.0050 - accuracy: 1.0000 - val_loss: 2.07
07 - val_accuracy: 0.5500
Epoch 151/200
2/2 [==============================] - 7s 3s/step - loss: 0.0056 - accuracy: 1.0000 - val_loss: 1.97
73 - val_accuracy: 0.5500
Epoch 152/200
2/2 [==============================] - 2s 1s/step - loss: 0.0575 - accuracy: 0.9750 - val_loss: 0.94
65 - val_accuracy: 0.7000
Epoch 153/200
2/2 [==============================] - 6s 3s/step - loss: 0.0042 - accuracy: 1.0000 - val_loss: 1.01
63 - val_accuracy: 0.6500
Epoch 154/200
2/2 [==============================] - 6s 3s/step - loss: 0.0044 - accuracy: 1.0000 - val_loss: 1.01
35 - val_accuracy: 0.6500
Epoch 155/200
2/2 [==============================] - 2s 1s/step - loss: 0.0038 - accuracy: 1.0000 - val_loss: 1.09
21 - val_accuracy: 0.6500
Epoch 156/200
2/2 [==============================] - 2s 1s/step - loss: 0.0124 - accuracy: 1.0000 - val_loss: 1.06
76 - val_accuracy: 0.6000
Epoch 157/200
2/2 [==============================] - 2s 1s/step - loss: 0.0122 - accuracy: 1.0000 - val_loss: 1.17
77 - val_accuracy: 0.6500
Epoch 158/200
2/2 [==============================] - 7s 4s/step - loss: 0.0048 - accuracy: 1.0000 - val_loss: 1.20
03 - val_accuracy: 0.5500
Epoch 159/200
2/2 [==============================] - 7s 4s/step - loss: 0.0027 - accuracy: 1.0000 - val_loss: 1.24
82 - val_accuracy: 0.6000
Epoch 160/200
2/2 [==============================] - 7s 3s/step - loss: 0.0021 - accuracy: 1.0000 - val_loss: 1.22
64 - val_accuracy: 0.6000
Epoch 161/200
2/2 [==============================] - 7s 3s/step - loss: 0.0074 - accuracy: 1.0000 - val_loss: 1.12
90 - val_accuracy: 0.5500
Epoch 162/200
2/2 [==============================] - 7s 4s/step - loss: 0.0035 - accuracy: 1.0000 - val_loss: 1.19
89 - val_accuracy: 0.5500
Epoch 163/200
```

```
2/2 [==============================] - 3s 1s/step - loss: 0.0023 - accuracy: 1.0000 - val_loss: 1.23
66 - val_accuracy: 0.5500
Epoch 164/200
2/2 [==============================] - 8s 4s/step - loss: 0.0039 - accuracy: 1.0000 - val_loss: 1.42
02 - val_accuracy: 0.6500
Epoch 165/200
2/2 [==============================] - 2s 1s/step - loss: 0.0112 - accuracy: 1.0000 - val_loss: 1.21
32 - val_accuracy: 0.4500
Epoch 166/200
2/2 [==============================] - 2s 1s/step - loss: 0.0042 - accuracy: 1.0000 - val_loss: 1.22
64 - val_accuracy: 0.5000
Epoch 167/200
2/2 [==============================] - 2s 1s/step - loss: 0.0037 - accuracy: 1.0000 - val_loss: 1.28
15 - val_accuracy: 0.5000
Epoch 168/200
2/2 [==============================] - 7s 3s/step - loss: 0.0046 - accuracy: 1.0000 - val_loss: 1.31
66 - val_accuracy: 0.5000
Epoch 169/200
2/2 [==============================] - 2s 1s/step - loss: 0.0026 - accuracy: 1.0000 - val_loss: 1.33
24 - val_accuracy: 0.5000
Epoch 170/200
2/2 [==============================] - 9s 4s/step - loss: 0.0011 - accuracy: 1.0000 - val_loss: 1.35
63 - val_accuracy: 0.5000
Epoch 171/200
2/2 [==============================] - 8s 4s/step - loss: 0.0132 - accuracy: 1.0000 - val_loss: 1.18
79 - val_accuracy: 0.5500
Epoch 172/200
2/2 [==============================] - 7s 3s/step - loss: 0.0025 - accuracy: 1.0000 - val_loss: 1.12
16 - val_accuracy: 0.5500
Epoch 173/200
2/2 [==============================] - 2s 1s/step - loss: 0.0081 - accuracy: 1.0000 - val_loss: 1.13
82 - val_accuracy: 0.5500
Epoch 174/200
2/2 [==============================] - 8s 4s/step - loss: 0.0013 - accuracy: 1.0000 - val_loss: 1.17
57 - val_accuracy: 0.5500
Epoch 175/200
2/2 [==============================] - 8s 4s/step - loss: 0.0047 - accuracy: 1.0000 - val_loss: 1.01
83 - val_accuracy: 0.5500
Epoch 176/200
2/2 [==============================] - 3s 1s/step - loss: 0.0112 - accuracy: 1.0000 - val_loss: 1.13
38 - val_accuracy: 0.5500
Epoch 177/200
2/2 [==============================] - 9s 5s/step - loss: 0.0029 - accuracy: 1.0000 - val_loss: 1.19
41 - val_accuracy: 0.5000
Epoch 178/200
2/2 [==============================] - 2s 1s/step - loss: 0.0011 - accuracy: 1.0000 - val_loss: 1.19
49 - val_accuracy: 0.5000
Epoch 179/200
2/2 [==============================] - 3s 1s/step - loss: 0.0022 - accuracy: 1.0000 - val_loss: 1.21
42 - val_accuracy: 0.5000
Epoch 180/200
2/2 [==============================] - 2s 1s/step - loss: 0.0037 - accuracy: 1.0000 - val_loss: 1.62
00 - val_accuracy: 0.4500
Epoch 181/200
2/2 [==============================] - 2s 1s/step - loss: 0.0034 - accuracy: 1.0000 - val_loss: 1.64
68 - val_accuracy: 0.4500
Epoch 182/200
2/2 [==============================] - 2s 1s/step - loss: 0.0018 - accuracy: 1.0000 - val_loss: 1.58
09 - val_accuracy: 0.5000
Epoch 183/200
2/2 [==============================] - 8s 4s/step - loss: 8.4242e-04 - accuracy: 1.0000 - val_loss:
1.5801 - val_accuracy: 0.5500
Epoch 184/200
2/2 [==============================] - 9s 4s/step - loss: 0.0046 - accuracy: 1.0000 - val_loss: 1.73
20 - val_accuracy: 0.5000
Epoch 185/200
2/2 [==============================] - 2s 1s/step - loss: 0.0028 - accuracy: 1.0000 - val_loss: 1.76
47 - val_accuracy: 0.5000
Epoch 186/200
2/2 [==============================] - 2s 1s/step - loss: 0.0033 - accuracy: 1.0000 - val_loss: 1.70
17 - val_accuracy: 0.5500
Epoch 187/200
2/2 [==============================] - 7s 4s/step - loss: 0.0213 - accuracy: 0.9750 - val_loss: 2.15
69 - val_accuracy: 0.4000
Epoch 188/200
2/2 [==============================] - 8s 4s/step - loss: 0.0075 - accuracy: 1.0000 - val_loss: 1.76
70 - val_accuracy: 0.4500
Epoch 189/200
2/2 [==============================] - 7s 3s/step - loss: 0.0018 - accuracy: 1.0000 - val_loss: 1.83
31 - val_accuracy: 0.4500
Epoch 190/200
2/2 [==============================] - 3s 2s/step - loss: 0.0026 - accuracy: 1.0000 - val_loss: 1.78
61 - val_accuracy: 0.4500
```

```
Epoch 191/200
2/2 [==============================] - 2s 1s/step - loss: 0.0045 - accuracy: 1.0000 - val_loss: 1.91
35 - val_accuracy: 0.4500
Epoch 192/200
2/2 [==============================] - 2s 1s/step - loss: 7.2849e-04 - accuracy: 1.0000 - val_loss:
1.9168 - val_accuracy: 0.4500
Epoch 193/200
2/2 [==============================] - 7s 3s/step - loss: 0.0215 - accuracy: 0.9750 - val_loss: 1.68
27 - val_accuracy: 0.5000
Epoch 194/200
2/2 [==============================] - 6s 3s/step - loss: 0.0059 - accuracy: 1.0000 - val_loss: 0.85
06 - val_accuracy: 0.5500
Epoch 195/200
2/2 [==============================] - 6s 3s/step - loss: 0.0020 - accuracy: 1.0000 - val_loss: 0.84
74 - val_accuracy: 0.4500
Epoch 196/200
2/2 [==============================] - 7s 3s/step - loss: 0.0443 - accuracy: 0.9750 - val_loss: 1.18
28 - val_accuracy: 0.4000
Epoch 197/200
2/2 [==============================] - 7s 3s/step - loss: 0.0024 - accuracy: 1.0000 - val_loss: 1.19
58 - val_accuracy: 0.4000
Epoch 198/200
2/2 [==============================] - 2s 1s/step - loss: 0.0118 - accuracy: 1.0000 - val_loss: 1.15
71 - val_accuracy: 0.4000
Epoch 199/200
2/2 [==============================] - 2s 1s/step - loss: 0.0228 - accuracy: 0.9750 - val_loss: 1.13
27 - val_accuracy: 0.4000
Epoch 200/200
2/2 [==============================] - 2s 1s/step - loss: 0.0043 - accuracy: 1.0000 - val_loss: 1.09
73 - val_accuracy: 0.4000
```

In [50]:

```
# loss and accuracy after 200 iterations
loss, accuracy = model.evaluate(test_images)
```

```
1/1 [==============================] - 0s 2ms/step - loss: 1.0973 - accuracy: 0.4000
```

accuracy is reduced after 200 iterations. One reason could be less number of sample messages.

In [51]:

```
pred = model.predict(test_images)
```

In [52]:

```
df_test['pred_category']  = np.argmax(pred, axis=1)
```

In [53]:

```
df_test['pred_category'] = df_test['pred_category'].replace({0:'cat', 1: 'dog'})
```

In [54]:

```
df_test.head(20)
```

Out[54]:

	filename	category	pred_category
0	101.jpg	cat	cat
1	102.jpg	cat	dog
2	103.jpg	cat	cat
3	104.jpg	cat	dog
4	105.jpg	cat	cat
5	106.jpg	cat	cat
6	107.jpg	cat	dog
7	108.jpg	cat	dog
8	109.jpg	cat	dog
9	110.jpg	cat	dog
10	101.jpg	dog	cat
11	102.jpg	dog	cat
12	103.jpg	dog	dog
13	104.jpg	dog	dog
14	105.jpg	dog	dog
15	106.jpg	dog	cat
16	107.jpg	dog	cat
17	108.jpg	dog	dog
18	109.jpg	dog	dog
19	110.jpg	dog	dog

In [ ]:

```

```