Pet Classification Model using CNN

DESCRIPTION

Project Objective: Build a CNN model that classifies the given pet images correctly into dog and cat images. The project scope document specifies the requirements for the project "Pet Classification Model Using CNN." Apart from specifying the functional and non-functional requirements for the project, it also serves as an input for project scoping.

Project Description and Scope: You are provided with a collection of images of pets, that is, cats and dogs. These images are of different sizes with varied lighting conditions and they should be used as inputs for your model.

You are expected to write the code for CNN image classification model using TensorFlow that trains on the data and calculates the accuracy score on the test data.

```
In [1]:  # Importing required libraries
         import numpy as np
         import pandas as pd
         import matplotlib.pyplot as plt

         from keras.preprocessing.image import load_img, ImageDataGenerator
         from tensorflow.keras.models import Sequential
         from tensorflow.keras.layers import InputLayer, Conv2D, MaxPooling2D, Dense, Dropou
```

```
In [2]:  import os
         os.getcwd()
```

```
Out[2]:  '/content'
```

```
In [3]:  # Loading test and train images
         data_gen = ImageDataGenerator()

         train_images = data_gen.flow_from_directory('/content/drive/MyDrive/datasets/data/t
         test_images = data_gen.flow_from_directory('/content/drive/MyDrive/datasets/data/te
```

```
Found 40 images belonging to 2 classes.
Found 20 images belonging to 2 classes.
```

```
In [4]:  image_data = pd.DataFrame()
         image_data['train_images'] = train_images.filenames
         image_data['train_labels'] = train_images.classes
         image_data.head()
```

Out[4]:

	train_images	train_labels
0	dogs/1.jpg	0
1	dogs/10.jpg	0
2	dogs/11.jpg	0
3	dogs/12.jpg	0
4	dogs/13.jpg	0

```
In [5]:  image_data.train_labels.value_counts()
```

```
Out[5]:  0    20
         1    20
         Name: train_labels, dtype: int64
```

```
In [6]:  # View a sample of the data
         import random
         cat_sample_image = image_data[image_data.train_labels==1].sample(1).values[0][0]
         load_img("/content/drive/MyDrive/datasets/data/train/" + cat_sample_image)
```

Out[6]:


```
In [7]:  dog_sample_image = image_data[image_data.train_labels==0].sample(1).values[0][0]
         load_img("/content/drive/MyDrive/datasets/data/train/" + dog_sample_image)
```

Out[7]:

In [8]:
```python
# Building the CNN model
model = Sequential([
                    InputLayer(input_shape=(256,256,3)),
                    Conv2D(32, (5,5), activation='relu'),
                    BatchNormalization(),
                    MaxPooling2D(pool_size=(2,2), strides=2),
                    Conv2D(64, (5,5), activation='relu'),
                    BatchNormalization(),
                    MaxPooling2D(pool_size=(2,2), strides=2),

                    Flatten(),
                    Dense(32, activation='relu'),
                    Dropout(0.4),
                    BatchNormalization(),

                    Dense(2, activation='softmax')
])

model.compile(loss='categorical_crossentropy', optimizer='rmsprop', metrics=['accu
model.summary()
```

```
Model: "sequential"

_____
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 252, 252, 32)      2432

 batch_normalization (BatchN  (None, 252, 252, 32)     128
 ormalization)

 max_pooling2d (MaxPooling2D  (None, 126, 126, 32)     0
 )

 conv2d_1 (Conv2D)           (None, 122, 122, 64)      51264

 batch_normalization_1 (Batc  (None, 122, 122, 64)     256
 hNormalization)

 max_pooling2d_1 (MaxPooling  (None, 61, 61, 64)       0
 2D)

 flatten (Flatten)           (None, 238144)            0

 dense (Dense)               (None, 32)                7620640

 dropout (Dropout)           (None, 32)                0

 batch_normalization_2 (Batc  (None, 32)               128
 hNormalization)

 dense_1 (Dense)             (None, 2)                 66

=================================================================
Total params: 7,674,914
Trainable params: 7,674,658
Non-trainable params: 256
_____
```

In [9]: `history = model.fit(train_images, epochs=200, batch_size=10, validation_data=test_`

```
Epoch 1/200
2/2 [==============================] - 6s 2s/step - loss: 0.8716 - accuracy: 0.550
0 - val_loss: 1471.1606 - val_accuracy: 0.5000
Epoch 2/200
2/2 [==============================] - 1s 613ms/step - loss: 0.6638 - accuracy: 0.
7750 - val_loss: 36.1675 - val_accuracy: 0.4000
Epoch 3/200
2/2 [==============================] - 1s 756ms/step - loss: 0.3812 - accuracy: 0.
8000 - val_loss: 21.9132 - val_accuracy: 0.3000
Epoch 4/200
2/2 [==============================] - 1s 280ms/step - loss: 0.2405 - accuracy: 0.
9250 - val_loss: 16.5973 - val_accuracy: 0.3500
Epoch 5/200
2/2 [==============================] - 1s 266ms/step - loss: 0.2332 - accuracy: 0.
9000 - val_loss: 22.7031 - val_accuracy: 0.3500
Epoch 6/200
2/2 [==============================] - 1s 406ms/step - loss: 0.2313 - accuracy: 0.
9000 - val_loss: 26.6634 - val_accuracy: 0.4000
Epoch 7/200
2/2 [==============================] - 1s 265ms/step - loss: 0.1200 - accuracy: 0.
9750 - val_loss: 15.8650 - val_accuracy: 0.4000
Epoch 8/200
2/2 [==============================] - 1s 785ms/step - loss: 0.0858 - accuracy: 1.
0000 - val_loss: 11.7850 - val_accuracy: 0.4000
Epoch 9/200
2/2 [==============================] - 1s 387ms/step - loss: 0.0931 - accuracy: 1.
0000 - val_loss: 12.9374 - val_accuracy: 0.4000
Epoch 10/200
2/2 [==============================] - 1s 843ms/step - loss: 0.1046 - accuracy: 0.
9750 - val_loss: 9.0130 - val_accuracy: 0.4500
Epoch 11/200
2/2 [==============================] - 1s 352ms/step - loss: 0.1170 - accuracy: 0.
9750 - val_loss: 11.4859 - val_accuracy: 0.4000
Epoch 12/200
2/2 [==============================] - 0s 342ms/step - loss: 0.0662 - accuracy: 1.
0000 - val_loss: 10.3335 - val_accuracy: 0.4000
Epoch 13/200
2/2 [==============================] - 0s 361ms/step - loss: 0.0648 - accuracy: 1.
0000 - val_loss: 7.5905 - val_accuracy: 0.4500
Epoch 14/200
2/2 [==============================] - 0s 348ms/step - loss: 0.0701 - accuracy: 0.
9750 - val_loss: 8.1267 - val_accuracy: 0.4000
Epoch 15/200
2/2 [==============================] - 0s 182ms/step - loss: 0.0934 - accuracy: 0.
9750 - val_loss: 8.5931 - val_accuracy: 0.4500
Epoch 16/200
2/2 [==============================] - 0s 166ms/step - loss: 0.0445 - accuracy: 1.
0000 - val_loss: 7.1657 - val_accuracy: 0.4500
Epoch 17/200
2/2 [==============================] - 0s 354ms/step - loss: 0.0597 - accuracy: 1.
0000 - val_loss: 4.6559 - val_accuracy: 0.3500
Epoch 18/200
2/2 [==============================] - 0s 364ms/step - loss: 0.0747 - accuracy: 1.
0000 - val_loss: 4.4573 - val_accuracy: 0.3500
Epoch 19/200
2/2 [==============================] - 0s 341ms/step - loss: 0.0806 - accuracy: 1.
0000 - val_loss: 6.9000 - val_accuracy: 0.4500
Epoch 20/200
2/2 [==============================] - 0s 171ms/step - loss: 0.0616 - accuracy: 1.
0000 - val_loss: 1.9438 - val_accuracy: 0.3500
Epoch 21/200
2/2 [==============================] - 0s 164ms/step - loss: 0.0533 - accuracy: 1.
0000 - val_loss: 7.5754 - val_accuracy: 0.4500
Epoch 22/200
```

```
2/2 [==============================] - 0s 362ms/step - loss: 0.0541 - accuracy: 1.
0000 - val_loss: 4.1339 - val_accuracy: 0.5000
Epoch 23/200
2/2 [==============================] - 0s 169ms/step - loss: 0.0662 - accuracy: 0.
9750 - val_loss: 4.8918 - val_accuracy: 0.5000
Epoch 24/200
2/2 [==============================] - 0s 373ms/step - loss: 0.0356 - accuracy: 1.
0000 - val_loss: 4.3631 - val_accuracy: 0.5000
Epoch 25/200
2/2 [==============================] - 0s 169ms/step - loss: 0.0644 - accuracy: 0.
9750 - val_loss: 3.6943 - val_accuracy: 0.4000
Epoch 26/200
2/2 [==============================] - 0s 172ms/step - loss: 0.0388 - accuracy: 1.
0000 - val_loss: 3.3079 - val_accuracy: 0.4500
Epoch 27/200
2/2 [==============================] - 0s 360ms/step - loss: 0.0534 - accuracy: 1.
0000 - val_loss: 2.5599 - val_accuracy: 0.5000
Epoch 28/200
2/2 [==============================] - 0s 165ms/step - loss: 0.0396 - accuracy: 1.
0000 - val_loss: 2.7288 - val_accuracy: 0.5000
Epoch 29/200
2/2 [==============================] - 0s 360ms/step - loss: 0.1080 - accuracy: 0.
9750 - val_loss: 2.3251 - val_accuracy: 0.4500
Epoch 30/200
2/2 [==============================] - 0s 165ms/step - loss: 0.0426 - accuracy: 1.
0000 - val_loss: 2.5709 - val_accuracy: 0.4000
Epoch 31/200
2/2 [==============================] - 0s 349ms/step - loss: 0.0379 - accuracy: 1.
0000 - val_loss: 2.1288 - val_accuracy: 0.4000
Epoch 32/200
2/2 [==============================] - 0s 341ms/step - loss: 0.0577 - accuracy: 1.
0000 - val_loss: 2.5683 - val_accuracy: 0.5000
Epoch 33/200
2/2 [==============================] - 0s 167ms/step - loss: 0.0384 - accuracy: 1.
0000 - val_loss: 2.2442 - val_accuracy: 0.5500
Epoch 34/200
2/2 [==============================] - 0s 362ms/step - loss: 0.0508 - accuracy: 1.
0000 - val_loss: 1.8701 - val_accuracy: 0.5500
Epoch 35/200
2/2 [==============================] - 0s 348ms/step - loss: 0.0360 - accuracy: 1.
0000 - val_loss: 1.8815 - val_accuracy: 0.5500
Epoch 36/200
2/2 [==============================] - 0s 169ms/step - loss: 0.0454 - accuracy: 0.
9750 - val_loss: 2.0963 - val_accuracy: 0.4500
Epoch 37/200
2/2 [==============================] - 0s 165ms/step - loss: 0.0355 - accuracy: 1.
0000 - val_loss: 2.2055 - val_accuracy: 0.5000
Epoch 38/200
2/2 [==============================] - 0s 356ms/step - loss: 0.0369 - accuracy: 1.
0000 - val_loss: 1.6505 - val_accuracy: 0.5000
Epoch 39/200
2/2 [==============================] - 0s 343ms/step - loss: 0.0374 - accuracy: 1.
0000 - val_loss: 1.9041 - val_accuracy: 0.5500
Epoch 40/200
2/2 [==============================] - 0s 173ms/step - loss: 0.0576 - accuracy: 0.
9750 - val_loss: 5.0113 - val_accuracy: 0.4500
Epoch 41/200
2/2 [==============================] - 0s 165ms/step - loss: 0.0745 - accuracy: 0.
9750 - val_loss: 5.2989 - val_accuracy: 0.6000
Epoch 42/200
2/2 [==============================] - 0s 354ms/step - loss: 0.0661 - accuracy: 0.
9750 - val_loss: 4.4069 - val_accuracy: 0.4500
Epoch 43/200
2/2 [==============================] - 0s 170ms/step - loss: 0.1625 - accuracy: 0.
```

```
9750 - val_loss: 4.2989 - val_accuracy: 0.4000
Epoch 44/200
2/2 [==============================] - 0s 358ms/step - loss: 0.0567 - accuracy: 1.
0000 - val_loss: 4.6008 - val_accuracy: 0.3000
Epoch 45/200
2/2 [==============================] - 0s 201ms/step - loss: 0.0480 - accuracy: 1.
0000 - val_loss: 3.5907 - val_accuracy: 0.3500
Epoch 46/200
2/2 [==============================] - 0s 172ms/step - loss: 0.0352 - accuracy: 1.
0000 - val_loss: 3.2444 - val_accuracy: 0.3500
Epoch 47/200
2/2 [==============================] - 0s 167ms/step - loss: 0.0192 - accuracy: 1.
0000 - val_loss: 3.9659 - val_accuracy: 0.3500
Epoch 48/200
2/2 [==============================] - 0s 170ms/step - loss: 0.0242 - accuracy: 1.
0000 - val_loss: 3.2751 - val_accuracy: 0.4500
Epoch 49/200
2/2 [==============================] - 0s 163ms/step - loss: 0.0414 - accuracy: 1.
0000 - val_loss: 2.1342 - val_accuracy: 0.5000
Epoch 50/200
2/2 [==============================] - 0s 168ms/step - loss: 0.0565 - accuracy: 0.
9750 - val_loss: 5.6486 - val_accuracy: 0.3500
Epoch 51/200
2/2 [==============================] - 0s 167ms/step - loss: 0.0402 - accuracy: 1.
0000 - val_loss: 4.9844 - val_accuracy: 0.4000
Epoch 52/200
2/2 [==============================] - 0s 358ms/step - loss: 0.0508 - accuracy: 1.
0000 - val_loss: 4.0055 - val_accuracy: 0.4000
Epoch 53/200
2/2 [==============================] - 0s 167ms/step - loss: 0.0178 - accuracy: 1.
0000 - val_loss: 4.1390 - val_accuracy: 0.4000
Epoch 54/200
2/2 [==============================] - 0s 342ms/step - loss: 0.0354 - accuracy: 1.
0000 - val_loss: 4.1091 - val_accuracy: 0.5000
Epoch 55/200
2/2 [==============================] - 0s 351ms/step - loss: 0.0338 - accuracy: 1.
0000 - val_loss: 3.4925 - val_accuracy: 0.5000
Epoch 56/200
2/2 [==============================] - 0s 345ms/step - loss: 0.0397 - accuracy: 1.
0000 - val_loss: 3.1321 - val_accuracy: 0.5000
Epoch 57/200
2/2 [==============================] - 0s 178ms/step - loss: 0.0403 - accuracy: 1.
0000 - val_loss: 2.3907 - val_accuracy: 0.4500
Epoch 58/200
2/2 [==============================] - 0s 355ms/step - loss: 0.0690 - accuracy: 0.
9750 - val_loss: 2.4176 - val_accuracy: 0.5000
Epoch 59/200
2/2 [==============================] - 0s 164ms/step - loss: 0.0426 - accuracy: 1.
0000 - val_loss: 2.1207 - val_accuracy: 0.5000
Epoch 60/200
2/2 [==============================] - 0s 350ms/step - loss: 0.0242 - accuracy: 1.
0000 - val_loss: 2.1822 - val_accuracy: 0.4500
Epoch 61/200
2/2 [==============================] - 0s 183ms/step - loss: 0.0160 - accuracy: 1.
0000 - val_loss: 2.3000 - val_accuracy: 0.4500
Epoch 62/200
2/2 [==============================] - 0s 360ms/step - loss: 0.0447 - accuracy: 0.
9750 - val_loss: 3.2858 - val_accuracy: 0.4500
Epoch 63/200
2/2 [==============================] - 0s 355ms/step - loss: 0.0215 - accuracy: 1.
0000 - val_loss: 2.7726 - val_accuracy: 0.4000
Epoch 64/200
2/2 [==============================] - 0s 352ms/step - loss: 0.0304 - accuracy: 1.
0000 - val_loss: 2.4709 - val_accuracy: 0.4000
```

```
Epoch 65/200
2/2 [==============================] - 0s 164ms/step - loss: 0.0140 - accuracy: 1.
0000 - val_loss: 2.1004 - val_accuracy: 0.3000
Epoch 66/200
2/2 [==============================] - 0s 166ms/step - loss: 0.0183 - accuracy: 1.
0000 - val_loss: 2.0089 - val_accuracy: 0.4000
Epoch 67/200
2/2 [==============================] - 0s 342ms/step - loss: 0.0150 - accuracy: 1.
0000 - val_loss: 2.2072 - val_accuracy: 0.4000
Epoch 68/200
2/2 [==============================] - 0s 354ms/step - loss: 0.0115 - accuracy: 1.
0000 - val_loss: 2.4151 - val_accuracy: 0.3500
Epoch 69/200
2/2 [==============================] - 0s 178ms/step - loss: 0.0136 - accuracy: 1.
0000 - val_loss: 2.2151 - val_accuracy: 0.4500
Epoch 70/200
2/2 [==============================] - 0s 172ms/step - loss: 0.0249 - accuracy: 1.
0000 - val_loss: 1.8448 - val_accuracy: 0.4500
Epoch 71/200
2/2 [==============================] - 0s 175ms/step - loss: 0.0189 - accuracy: 1.
0000 - val_loss: 1.8355 - val_accuracy: 0.5500
Epoch 72/200
2/2 [==============================] - 0s 346ms/step - loss: 0.0247 - accuracy: 1.
0000 - val_loss: 2.0115 - val_accuracy: 0.4000
Epoch 73/200
2/2 [==============================] - 0s 349ms/step - loss: 0.0391 - accuracy: 1.
0000 - val_loss: 1.5961 - val_accuracy: 0.4000
Epoch 74/200
2/2 [==============================] - 0s 371ms/step - loss: 0.1109 - accuracy: 0.
9500 - val_loss: 3.0774 - val_accuracy: 0.4000
Epoch 75/200
2/2 [==============================] - 0s 351ms/step - loss: 0.0145 - accuracy: 1.
0000 - val_loss: 2.3169 - val_accuracy: 0.4500
Epoch 76/200
2/2 [==============================] - 0s 358ms/step - loss: 0.0234 - accuracy: 1.
0000 - val_loss: 1.9271 - val_accuracy: 0.3500
Epoch 77/200
2/2 [==============================] - 0s 378ms/step - loss: 0.0159 - accuracy: 1.
0000 - val_loss: 2.1458 - val_accuracy: 0.4500
Epoch 78/200
2/2 [==============================] - 0s 358ms/step - loss: 0.0106 - accuracy: 1.
0000 - val_loss: 2.0432 - val_accuracy: 0.3500
Epoch 79/200
2/2 [==============================] - 0s 356ms/step - loss: 0.0259 - accuracy: 1.
0000 - val_loss: 1.9098 - val_accuracy: 0.5500
Epoch 80/200
2/2 [==============================] - 0s 186ms/step - loss: 0.0122 - accuracy: 1.
0000 - val_loss: 1.8839 - val_accuracy: 0.5000
Epoch 81/200
2/2 [==============================] - 0s 343ms/step - loss: 0.0169 - accuracy: 1.
0000 - val_loss: 2.4845 - val_accuracy: 0.3500
Epoch 82/200
2/2 [==============================] - 0s 364ms/step - loss: 0.0383 - accuracy: 1.
0000 - val_loss: 1.7034 - val_accuracy: 0.4000
Epoch 83/200
2/2 [==============================] - 0s 171ms/step - loss: 0.0356 - accuracy: 1.
0000 - val_loss: 1.7547 - val_accuracy: 0.4500
Epoch 84/200
2/2 [==============================] - 0s 175ms/step - loss: 0.0132 - accuracy: 1.
0000 - val_loss: 1.6087 - val_accuracy: 0.4500
Epoch 85/200
2/2 [==============================] - 0s 177ms/step - loss: 0.0144 - accuracy: 1.
0000 - val_loss: 1.6425 - val_accuracy: 0.5000
Epoch 86/200
```

```
2/2 [==============================] - 0s 354ms/step - loss: 0.0317 - accuracy: 1.
0000 - val_loss: 1.4399 - val_accuracy: 0.5000
Epoch 87/200
2/2 [==============================] - 0s 369ms/step - loss: 0.0193 - accuracy: 1.
0000 - val_loss: 1.5919 - val_accuracy: 0.5500
Epoch 88/200
2/2 [==============================] - 0s 169ms/step - loss: 0.0119 - accuracy: 1.
0000 - val_loss: 1.4299 - val_accuracy: 0.4500
Epoch 89/200
2/2 [==============================] - 0s 168ms/step - loss: 0.0138 - accuracy: 1.
0000 - val_loss: 1.4517 - val_accuracy: 0.5000
Epoch 90/200
2/2 [==============================] - 0s 173ms/step - loss: 0.0100 - accuracy: 1.
0000 - val_loss: 1.5922 - val_accuracy: 0.5000
Epoch 91/200
2/2 [==============================] - 0s 166ms/step - loss: 0.0173 - accuracy: 1.
0000 - val_loss: 1.3988 - val_accuracy: 0.4500
Epoch 92/200
2/2 [==============================] - 0s 172ms/step - loss: 0.0176 - accuracy: 1.
0000 - val_loss: 2.3366 - val_accuracy: 0.5500
Epoch 93/200
2/2 [==============================] - 0s 381ms/step - loss: 0.0226 - accuracy: 1.
0000 - val_loss: 1.6127 - val_accuracy: 0.6000
Epoch 94/200
2/2 [==============================] - 0s 183ms/step - loss: 0.0188 - accuracy: 1.
0000 - val_loss: 2.4432 - val_accuracy: 0.5000
Epoch 95/200
2/2 [==============================] - 0s 366ms/step - loss: 0.0082 - accuracy: 1.
0000 - val_loss: 1.2472 - val_accuracy: 0.4500
Epoch 96/200
2/2 [==============================] - 0s 167ms/step - loss: 0.0074 - accuracy: 1.
0000 - val_loss: 1.6641 - val_accuracy: 0.5000
Epoch 97/200
2/2 [==============================] - 0s 356ms/step - loss: 0.0258 - accuracy: 1.
0000 - val_loss: 1.8794 - val_accuracy: 0.4500
Epoch 98/200
2/2 [==============================] - 0s 350ms/step - loss: 0.0103 - accuracy: 1.
0000 - val_loss: 1.6185 - val_accuracy: 0.5000
Epoch 99/200
2/2 [==============================] - 0s 169ms/step - loss: 0.0074 - accuracy: 1.
0000 - val_loss: 1.6900 - val_accuracy: 0.5000
Epoch 100/200
2/2 [==============================] - 0s 167ms/step - loss: 0.0071 - accuracy: 1.
0000 - val_loss: 1.4471 - val_accuracy: 0.4500
Epoch 101/200
2/2 [==============================] - 0s 379ms/step - loss: 0.0117 - accuracy: 1.
0000 - val_loss: 1.3779 - val_accuracy: 0.4500
Epoch 102/200
2/2 [==============================] - 0s 170ms/step - loss: 0.0086 - accuracy: 1.
0000 - val_loss: 2.5250 - val_accuracy: 0.4500
Epoch 103/200
2/2 [==============================] - 0s 361ms/step - loss: 0.0117 - accuracy: 1.
0000 - val_loss: 1.6564 - val_accuracy: 0.4500
Epoch 104/200
2/2 [==============================] - 0s 360ms/step - loss: 0.0323 - accuracy: 1.
0000 - val_loss: 1.9594 - val_accuracy: 0.4500
Epoch 105/200
2/2 [==============================] - 0s 349ms/step - loss: 0.0267 - accuracy: 1.
0000 - val_loss: 1.2531 - val_accuracy: 0.5000
Epoch 106/200
2/2 [==============================] - 0s 166ms/step - loss: 0.0408 - accuracy: 1.
0000 - val_loss: 1.0532 - val_accuracy: 0.5000
Epoch 107/200
2/2 [==============================] - 0s 168ms/step - loss: 0.0126 - accuracy: 1.
```

```
0000 - val_loss: 1.0576 - val_accuracy: 0.5000
Epoch 108/200
2/2 [==============================] - 0s 174ms/step - loss: 0.0535 - accuracy: 0.
9750 - val_loss: 2.0351 - val_accuracy: 0.3500
Epoch 109/200
2/2 [==============================] - 0s 359ms/step - loss: 0.0090 - accuracy: 1.
0000 - val_loss: 1.7834 - val_accuracy: 0.3500
Epoch 110/200
2/2 [==============================] - 0s 356ms/step - loss: 0.0132 - accuracy: 1.
0000 - val_loss: 1.6962 - val_accuracy: 0.3000
Epoch 111/200
2/2 [==============================] - 0s 346ms/step - loss: 0.0488 - accuracy: 0.
9750 - val_loss: 1.9599 - val_accuracy: 0.3500
Epoch 112/200
2/2 [==============================] - 0s 167ms/step - loss: 0.0123 - accuracy: 1.
0000 - val_loss: 1.7990 - val_accuracy: 0.2500
Epoch 113/200
2/2 [==============================] - 0s 169ms/step - loss: 0.0109 - accuracy: 1.
0000 - val_loss: 1.7656 - val_accuracy: 0.3000
Epoch 114/200
2/2 [==============================] - 0s 165ms/step - loss: 0.0193 - accuracy: 1.
0000 - val_loss: 1.7173 - val_accuracy: 0.3000
Epoch 115/200
2/2 [==============================] - 0s 378ms/step - loss: 0.0679 - accuracy: 0.
9750 - val_loss: 1.8924 - val_accuracy: 0.4000
Epoch 116/200
2/2 [==============================] - 0s 166ms/step - loss: 0.0096 - accuracy: 1.
0000 - val_loss: 1.7928 - val_accuracy: 0.4500
Epoch 117/200
2/2 [==============================] - 0s 171ms/step - loss: 0.0236 - accuracy: 1.
0000 - val_loss: 2.0728 - val_accuracy: 0.4500
Epoch 118/200
2/2 [==============================] - 0s 346ms/step - loss: 0.0233 - accuracy: 1.
0000 - val_loss: 1.6017 - val_accuracy: 0.4500
Epoch 119/200
2/2 [==============================] - 0s 168ms/step - loss: 0.0171 - accuracy: 1.
0000 - val_loss: 1.2964 - val_accuracy: 0.5000
Epoch 120/200
2/2 [==============================] - 0s 163ms/step - loss: 0.0190 - accuracy: 1.
0000 - val_loss: 1.8980 - val_accuracy: 0.4000
Epoch 121/200
2/2 [==============================] - 0s 347ms/step - loss: 0.1152 - accuracy: 0.
9250 - val_loss: 1.3729 - val_accuracy: 0.4500
Epoch 122/200
2/2 [==============================] - 0s 171ms/step - loss: 0.0228 - accuracy: 1.
0000 - val_loss: 1.5913 - val_accuracy: 0.4000
Epoch 123/200
2/2 [==============================] - 0s 351ms/step - loss: 0.0229 - accuracy: 1.
0000 - val_loss: 1.5685 - val_accuracy: 0.4000
Epoch 124/200
2/2 [==============================] - 0s 361ms/step - loss: 0.0226 - accuracy: 1.
0000 - val_loss: 1.4641 - val_accuracy: 0.4000
Epoch 125/200
2/2 [==============================] - 0s 171ms/step - loss: 0.0114 - accuracy: 1.
0000 - val_loss: 1.3671 - val_accuracy: 0.4500
Epoch 126/200
2/2 [==============================] - 0s 347ms/step - loss: 0.0099 - accuracy: 1.
0000 - val_loss: 1.4092 - val_accuracy: 0.4500
Epoch 127/200
2/2 [==============================] - 0s 168ms/step - loss: 0.0110 - accuracy: 1.
0000 - val_loss: 1.4888 - val_accuracy: 0.4000
Epoch 128/200
2/2 [==============================] - 0s 170ms/step - loss: 0.0111 - accuracy: 1.
0000 - val_loss: 1.4459 - val_accuracy: 0.4500
```

```
Epoch 129/200
2/2 [==============================] - 0s 174ms/step - loss: 0.0215 - accuracy: 1.
0000 - val_loss: 1.4732 - val_accuracy: 0.4000
Epoch 130/200
2/2 [==============================] - 0s 160ms/step - loss: 0.0139 - accuracy: 1.
0000 - val_loss: 1.4173 - val_accuracy: 0.4000
Epoch 131/200
2/2 [==============================] - 0s 169ms/step - loss: 0.0334 - accuracy: 1.
0000 - val_loss: 1.3274 - val_accuracy: 0.5000
Epoch 132/200
2/2 [==============================] - 0s 167ms/step - loss: 0.0177 - accuracy: 1.
0000 - val_loss: 1.4717 - val_accuracy: 0.5000
Epoch 133/200
2/2 [==============================] - 0s 169ms/step - loss: 0.0263 - accuracy: 1.
0000 - val_loss: 1.3440 - val_accuracy: 0.4000
Epoch 134/200
2/2 [==============================] - 0s 354ms/step - loss: 0.0077 - accuracy: 1.
0000 - val_loss: 1.4001 - val_accuracy: 0.4000
Epoch 135/200
2/2 [==============================] - 0s 389ms/step - loss: 0.0276 - accuracy: 1.
0000 - val_loss: 1.4951 - val_accuracy: 0.4500
Epoch 136/200
2/2 [==============================] - 0s 177ms/step - loss: 0.0063 - accuracy: 1.
0000 - val_loss: 1.4520 - val_accuracy: 0.4500
Epoch 137/200
2/2 [==============================] - 0s 166ms/step - loss: 0.0039 - accuracy: 1.
0000 - val_loss: 1.4438 - val_accuracy: 0.4500
Epoch 138/200
2/2 [==============================] - 0s 369ms/step - loss: 0.0161 - accuracy: 1.
0000 - val_loss: 1.2920 - val_accuracy: 0.4500
Epoch 139/200
2/2 [==============================] - 0s 166ms/step - loss: 0.0181 - accuracy: 1.
0000 - val_loss: 1.2206 - val_accuracy: 0.4500
Epoch 140/200
2/2 [==============================] - 0s 167ms/step - loss: 0.0752 - accuracy: 0.
9750 - val_loss: 2.1110 - val_accuracy: 0.4000
Epoch 141/200
2/2 [==============================] - 0s 362ms/step - loss: 0.0210 - accuracy: 1.
0000 - val_loss: 2.0432 - val_accuracy: 0.5500
Epoch 142/200
2/2 [==============================] - 0s 347ms/step - loss: 0.0105 - accuracy: 1.
0000 - val_loss: 1.7050 - val_accuracy: 0.4000
Epoch 143/200
2/2 [==============================] - 0s 388ms/step - loss: 0.0159 - accuracy: 1.
0000 - val_loss: 1.7426 - val_accuracy: 0.4000
Epoch 144/200
2/2 [==============================] - 0s 338ms/step - loss: 0.0059 - accuracy: 1.
0000 - val_loss: 1.7546 - val_accuracy: 0.4000
Epoch 145/200
2/2 [==============================] - 0s 170ms/step - loss: 0.0074 - accuracy: 1.
0000 - val_loss: 1.8944 - val_accuracy: 0.3500
Epoch 146/200
2/2 [==============================] - 0s 161ms/step - loss: 0.0162 - accuracy: 1.
0000 - val_loss: 1.9694 - val_accuracy: 0.4000
Epoch 147/200
2/2 [==============================] - 0s 166ms/step - loss: 0.0123 - accuracy: 1.
0000 - val_loss: 1.9586 - val_accuracy: 0.4500
Epoch 148/200
2/2 [==============================] - 0s 173ms/step - loss: 0.0157 - accuracy: 1.
0000 - val_loss: 1.9719 - val_accuracy: 0.4000
Epoch 149/200
2/2 [==============================] - 0s 347ms/step - loss: 0.0103 - accuracy: 1.
0000 - val_loss: 2.0627 - val_accuracy: 0.4000
Epoch 150/200
```

```
2/2 [==============================] - 0s 361ms/step - loss: 0.0066 - accuracy: 1.
0000 - val_loss: 2.0335 - val_accuracy: 0.4000
Epoch 151/200
2/2 [==============================] - 0s 163ms/step - loss: 0.0160 - accuracy: 1.
0000 - val_loss: 2.0520 - val_accuracy: 0.4500
Epoch 152/200
2/2 [==============================] - 0s 350ms/step - loss: 0.0348 - accuracy: 1.
0000 - val_loss: 1.7758 - val_accuracy: 0.4000
Epoch 153/200
2/2 [==============================] - 0s 160ms/step - loss: 0.0094 - accuracy: 1.
0000 - val_loss: 1.7052 - val_accuracy: 0.4000
Epoch 154/200
2/2 [==============================] - 0s 169ms/step - loss: 0.0051 - accuracy: 1.
0000 - val_loss: 1.7356 - val_accuracy: 0.4000
Epoch 155/200
2/2 [==============================] - 0s 168ms/step - loss: 0.0112 - accuracy: 1.
0000 - val_loss: 1.9303 - val_accuracy: 0.3500
Epoch 156/200
2/2 [==============================] - 0s 163ms/step - loss: 0.0124 - accuracy: 1.
0000 - val_loss: 1.8441 - val_accuracy: 0.3500
Epoch 157/200
2/2 [==============================] - 0s 355ms/step - loss: 0.0064 - accuracy: 1.
0000 - val_loss: 1.9285 - val_accuracy: 0.4500
Epoch 158/200
2/2 [==============================] - 0s 341ms/step - loss: 0.0102 - accuracy: 1.
0000 - val_loss: 1.7157 - val_accuracy: 0.4000
Epoch 159/200
2/2 [==============================] - 1s 611ms/step - loss: 0.0061 - accuracy: 1.
0000 - val_loss: 1.7069 - val_accuracy: 0.4500
Epoch 160/200
2/2 [==============================] - 0s 170ms/step - loss: 0.0088 - accuracy: 1.
0000 - val_loss: 1.8899 - val_accuracy: 0.4500
Epoch 161/200
2/2 [==============================] - 1s 166ms/step - loss: 0.0065 - accuracy: 1.
0000 - val_loss: 1.5438 - val_accuracy: 0.3000
Epoch 162/200
2/2 [==============================] - 1s 631ms/step - loss: 0.0070 - accuracy: 1.
0000 - val_loss: 1.5461 - val_accuracy: 0.3500
Epoch 163/200
2/2 [==============================] - 0s 170ms/step - loss: 0.0067 - accuracy: 1.
0000 - val_loss: 1.7965 - val_accuracy: 0.4000
Epoch 164/200
2/2 [==============================] - 0s 352ms/step - loss: 0.0105 - accuracy: 1.
0000 - val_loss: 1.6793 - val_accuracy: 0.3500
Epoch 165/200
2/2 [==============================] - 0s 357ms/step - loss: 0.0148 - accuracy: 1.
0000 - val_loss: 1.6976 - val_accuracy: 0.4000
Epoch 166/200
2/2 [==============================] - 0s 341ms/step - loss: 0.0119 - accuracy: 1.
0000 - val_loss: 2.9507 - val_accuracy: 0.4500
Epoch 167/200
2/2 [==============================] - 0s 172ms/step - loss: 0.0385 - accuracy: 1.
0000 - val_loss: 4.1275 - val_accuracy: 0.3000
Epoch 168/200
2/2 [==============================] - 0s 368ms/step - loss: 0.0362 - accuracy: 0.
9750 - val_loss: 2.2239 - val_accuracy: 0.4000
Epoch 169/200
2/2 [==============================] - 0s 161ms/step - loss: 0.0300 - accuracy: 0.
9750 - val_loss: 1.1546 - val_accuracy: 0.5000
Epoch 170/200
2/2 [==============================] - 0s 353ms/step - loss: 0.0061 - accuracy: 1.
0000 - val_loss: 1.1347 - val_accuracy: 0.5500
Epoch 171/200
2/2 [==============================] - 0s 168ms/step - loss: 0.0063 - accuracy: 1.
```

```
0000 - val_loss: 0.9618 - val_accuracy: 0.4500
Epoch 172/200
2/2 [==============================] - 0s 164ms/step - loss: 0.0035 - accuracy: 1.
0000 - val_loss: 0.9572 - val_accuracy: 0.4500
Epoch 173/200
2/2 [==============================] - 0s 349ms/step - loss: 0.0183 - accuracy: 1.
0000 - val_loss: 0.9145 - val_accuracy: 0.4500
Epoch 174/200
2/2 [==============================] - 0s 348ms/step - loss: 0.0028 - accuracy: 1.
0000 - val_loss: 0.9013 - val_accuracy: 0.4500
Epoch 175/200
2/2 [==============================] - 0s 163ms/step - loss: 0.0379 - accuracy: 0.
9750 - val_loss: 1.0403 - val_accuracy: 0.4500
Epoch 176/200
2/2 [==============================] - 0s 353ms/step - loss: 0.0090 - accuracy: 1.
0000 - val_loss: 1.0402 - val_accuracy: 0.4500
Epoch 177/200
2/2 [==============================] - 0s 171ms/step - loss: 0.0054 - accuracy: 1.
0000 - val_loss: 1.0385 - val_accuracy: 0.4500
Epoch 178/200
2/2 [==============================] - 0s 351ms/step - loss: 0.0469 - accuracy: 0.
9750 - val_loss: 1.0831 - val_accuracy: 0.5500
Epoch 179/200
2/2 [==============================] - 0s 164ms/step - loss: 0.0243 - accuracy: 0.
9750 - val_loss: 1.0463 - val_accuracy: 0.4500
Epoch 180/200
2/2 [==============================] - 0s 165ms/step - loss: 0.0080 - accuracy: 1.
0000 - val_loss: 1.0216 - val_accuracy: 0.4500
Epoch 181/200
2/2 [==============================] - 0s 367ms/step - loss: 0.0030 - accuracy: 1.
0000 - val_loss: 1.0089 - val_accuracy: 0.5000
Epoch 182/200
2/2 [==============================] - 0s 368ms/step - loss: 0.0063 - accuracy: 1.
0000 - val_loss: 0.9628 - val_accuracy: 0.5000
Epoch 183/200
2/2 [==============================] - 0s 356ms/step - loss: 0.0287 - accuracy: 0.
9750 - val_loss: 0.9455 - val_accuracy: 0.5000
Epoch 184/200
2/2 [==============================] - 0s 355ms/step - loss: 0.0989 - accuracy: 0.
9250 - val_loss: 0.9614 - val_accuracy: 0.5000
Epoch 185/200
2/2 [==============================] - 0s 352ms/step - loss: 0.0139 - accuracy: 1.
0000 - val_loss: 0.9310 - val_accuracy: 0.5000
Epoch 186/200
2/2 [==============================] - 0s 361ms/step - loss: 0.0034 - accuracy: 1.
0000 - val_loss: 0.9062 - val_accuracy: 0.5000
Epoch 187/200
2/2 [==============================] - 0s 366ms/step - loss: 0.0063 - accuracy: 1.
0000 - val_loss: 0.8981 - val_accuracy: 0.5000
Epoch 188/200
2/2 [==============================] - 0s 169ms/step - loss: 0.0086 - accuracy: 1.
0000 - val_loss: 0.9006 - val_accuracy: 0.5000
Epoch 189/200
2/2 [==============================] - 0s 180ms/step - loss: 0.0136 - accuracy: 1.
0000 - val_loss: 0.9073 - val_accuracy: 0.5000
Epoch 190/200
2/2 [==============================] - 0s 350ms/step - loss: 0.0080 - accuracy: 1.
0000 - val_loss: 1.0335 - val_accuracy: 0.4000
Epoch 191/200
2/2 [==============================] - 0s 360ms/step - loss: 0.0042 - accuracy: 1.
0000 - val_loss: 0.9818 - val_accuracy: 0.4000
Epoch 192/200
2/2 [==============================] - 0s 358ms/step - loss: 0.0356 - accuracy: 0.
9750 - val_loss: 0.8645 - val_accuracy: 0.5000
```

```
Epoch 193/200
2/2 [==============================] - 0s 349ms/step - loss: 0.0105 - accuracy: 1.
0000 - val_loss: 0.8613 - val_accuracy: 0.5000
Epoch 194/200
2/2 [==============================] - 0s 356ms/step - loss: 0.0247 - accuracy: 0.
9750 - val_loss: 0.8604 - val_accuracy: 0.5500
Epoch 195/200
2/2 [==============================] - 0s 366ms/step - loss: 0.0059 - accuracy: 1.
0000 - val_loss: 0.8565 - val_accuracy: 0.5500
Epoch 196/200
2/2 [==============================] - 0s 168ms/step - loss: 0.0044 - accuracy: 1.
0000 - val_loss: 0.8863 - val_accuracy: 0.5000
Epoch 197/200
2/2 [==============================] - 0s 368ms/step - loss: 0.0142 - accuracy: 1.
0000 - val_loss: 1.0028 - val_accuracy: 0.5000
Epoch 198/200
2/2 [==============================] - 0s 168ms/step - loss: 0.0140 - accuracy: 1.
0000 - val_loss: 1.0251 - val_accuracy: 0.5000
Epoch 199/200
2/2 [==============================] - 0s 173ms/step - loss: 0.0210 - accuracy: 1.
0000 - val_loss: 0.9973 - val_accuracy: 0.4500
Epoch 200/200
2/2 [==============================] - 0s 355ms/step - loss: 0.1251 - accuracy: 0.
9500 - val_loss: 0.9060 - val_accuracy: 0.5500
```

In [12]:
```python
loss, accuracy = model.evaluate(test_images)
print("Accuracy of the model:", accuracy)
```

```
1/1 [==============================] - 0s 137ms/step - loss: 0.9060 - accuracy: 0.
5500
Accuracy of the model: 0.550000011920929
```

In [11]:
```python
from sklearn.metrics import confusion_matrix
import seaborn as sns

preds = model.predict(test_images)
pred_labels = np.argmax(preds, axis=1)
print("Actual labels: ", test_images.labels)
print("Predicted labels: ", pred_labels)
```

```
Actual labels:  [0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1]
Predicted labels:  [0 0 0 0 0 1 0 1 0 0 0 0 0 1 1 1 1 1 1 1 1]
```