```python
import os
import cv2
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import seaborn as sns
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import StratifiedShuffleSplit
from sklearn.metrics import classification_report
from sklearn.model_selection import train_test_split
from keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.applications.resnet50 import ResNet50
from tensorflow.keras.layers import Dense, GlobalAveragePooling2D
from tensorflow.keras.models import Model
from tensorflow.keras.optimizers import Adam
from tensorflow import keras
from tensorflow.keras import layers
import tensorflow as tf
from keras.utils import to_categorical
```

a. Take at least 100 images per class with at least 3 classes using your phone/camera. Display 5 examples from each class.

```python
# Function to combine images of different classes together and convert
them to pixels and store into a csv files
def create_csvImages_file(pixel=128):
    # Specify the path to the main folder containing the class folders
    main_folder_path = '/Users/manaagrawal/Downloads/dataset'   #
Update with your main folder path

    # Define a list of class names corresponding to the subfolder
names
    class_names = ['Flowers', 'Pebbles', 'Plants']  # Update with your
class names

    # Read image files from the class folders and resize to 64x64
    images = []
    labels = []
    for i, class_name in enumerate(class_names):
        class_folder_path = os.path.join(main_folder_path, class_name)
        for file in os.listdir(class_folder_path):
            if file.endswith('.jpeg'):  # Update with the file
extensions of your images
                image_path = os.path.join(class_folder_path, file)
                image = cv2.imread(image_path, cv2.COLOR_BGR2RGB)
                image = cv2.resize(image, (pixel, pixel))
                image = image.astype(np.uint8)
                images.append(image)
```

```python
                labels.append(i)  # Use the index of the class name as
the label

    # Convert the lists of images and labels to NumPy arrays
    images = np.array(images)
    labels = np.array(labels)

    # Convert images array to pixels and store in a CSV file
    pixels = images.reshape(images.shape[0], -1)
    df = pd.DataFrame(pixels)
    df['label'] = labels
    df.to_csv('/Users/manaagrawal/Downloads/dataset/dataset.csv',
index=False)

    return

# #Create the images file (pixels)
# create_csvImages_file()

# Import the CSV file and display the images
df = pd.read_csv('/Users/manaagrawal/Downloads/dataset/dataset.csv')
pixels = df.iloc[:, :-1].values
labels = df.iloc[:, -1].values
# Set the number of output classes
num_classes = 3
images = pixels.reshape(pixels.shape[0], 128, 128, 3)

def display_images(num_samples = 10, rows=2,columns=5):
    # Define a list of class names corresponding to the subfolder
names
    class_names = ['Flowers', 'Pebbles', 'Plants']  # Update with your
class names
    #num_samples = 10  # Number of samples to display
    random_indices = np.random.randint(0, len(images), num_samples)
    for i, idx in enumerate(random_indices):
        plt.subplot(rows, columns, i+1)
        # Convert image depth to 8-bit format
        image = cv2.normalize(images[idx], None, alpha=0, beta=255,
norm_type=cv2.NORM_MINMAX, dtype=cv2.CV_8U)
        plt.imshow(cv2.cvtColor(image, cv2.COLOR_BGR2RGB))
        plt.title('{}'.format(class_names[labels[idx]]))
        plt.axis('off')
    plt.tight_layout()
    plt.show()

    return

#Five images from each class
display_images(num_samples = 20, rows=4,columns=5)
```

b. Split the images into a training set, a validation set, and a test set.

```
X = pixels/255
y = to_categorical(labels, num_classes)

sss = StratifiedShuffleSplit(n_splits=1, test_size=1/7,
random_state=10)
for i, (train_index, test_index) in enumerate(sss.split(X, y)):
    X_train, X_val = X[train_index], X[test_index]
    y_train, y_val = y[train_index], y[test_index]

sss = StratifiedShuffleSplit(n_splits=1, test_size=1/6,
random_state=10)
for i, (train_index, test_index) in enumerate(sss.split(X_train,
y_train)):
    X_train, X_test = X[train_index], X[test_index]
    y_train, y_test = y[train_index], y[test_index]
```

Perfomed stratification so that the sets we obtain are balanced with data from all the classes

c. Build the input pipeline, including the appropriate preprocessing operations, and add data augmentation.

```python
# Reshape the data to match the format required by Keras
X_train = X_train.reshape(-1, 128, 128, 3)
X_val = X_val.reshape(-1, 128, 128, 3)
X_test = X_test.reshape(-1, 128, 128, 3)

# Define the data augmentation pipeline
datagen = ImageDataGenerator(
    rotation_range=10,
    zoom_range=0.1,
    width_shift_range=0.1,
    height_shift_range=0.1,
    horizontal_flip=True,
    vertical_flip=True
)

# Fit the data augmentation pipeline on the training data
datagen.fit(X_train)

# Define batch size
batch_size = 32

# Create training generators
# Fit the model on the augmented dataset
train_generator = datagen.flow(X_train, y_train,
batch_size=batch_size)
```

After reshaping the data, we build an input pipeline with data augmentation where we apply rotation, zoom and various other operations to add new images to the data since our dataset is very small.

d. Fine-tune a pretrained model of your choice on this dataset (the one you created in part c). Report classification accuracy and give a few examples of correct/incorrect classification (show a few images that were correctly/incorrectly classified).

```python
# set the random seed
np.random.seed(10)
tf.random.set_seed(10)

# Load the ResNet50 model pre-trained on ImageNet
base_model = ResNet50(weights='imagenet', include_top=False,
```

```python
        input_shape=(128, 128, 3))

# Freeze the weights of all layers in the pre-trained model except the
last few layers
for layer in base_model.layers[:-10]:
    layer.trainable = False

def train(epochs = 100,learning_rate=0.0001,base_model=base_model):

    # Add a new output layer to the model
    x = base_model.output
    x = GlobalAveragePooling2D()(x)
    predictions = Dense(num_classes, activation='softmax')(x)


    model = Model(inputs=base_model.input, outputs=predictions)

    # Compile the model
    model.compile(optimizer=Adam(learning_rate=learning_rate),
                  loss='categorical_crossentropy',
                  metrics=['categorical_accuracy'])


    steps_per_epoch = len(train_generator)
    validation_steps = len(y_val)

    model.fit(train_generator,
              steps_per_epoch=steps_per_epoch,
              epochs=epochs,
              validation_data=[X_val,y_val],
              validation_steps=validation_steps)

    # Evaluate the model on the test set
    test_loss, test_acc = model.evaluate(X_test,y_test, verbose=1)
    print('Test accuracy:', test_acc)
    return model

pretrained_model = train()

Epoch 1/100
8/8 [==============================] - 5s 484ms/step - loss: 0.8575 -
categorical_accuracy: 0.6327 - val_loss: 1.1064 -
val_categorical_accuracy: 0.3478
Epoch 2/100
8/8 [==============================] - 3s 486ms/step - loss: 0.6444 -
categorical_accuracy: 0.7257 - val_loss: 1.1029 -
val_categorical_accuracy: 0.3478
Epoch 3/100
8/8 [==============================] - 4s 445ms/step - loss: 0.5538 -
categorical_accuracy: 0.7743 - val_loss: 1.1023 -
```

```
val_categorical_accuracy: 0.3478
Epoch 4/100
8/8 [==============================] - 4s 445ms/step - loss: 0.5189 -
categorical_accuracy: 0.8053 - val_loss: 1.1054 -
val_categorical_accuracy: 0.4565
Epoch 5/100
8/8 [==============================] - 4s 445ms/step - loss: 0.4534 -
categorical_accuracy: 0.8274 - val_loss: 1.1207 -
val_categorical_accuracy: 0.4565
Epoch 6/100
8/8 [==============================] - 4s 445ms/step - loss: 0.4573 -
categorical_accuracy: 0.8230 - val_loss: 1.1339 -
val_categorical_accuracy: 0.4565
Epoch 7/100
8/8 [==============================] - 3s 443ms/step - loss: 0.3508 -
categorical_accuracy: 0.8584 - val_loss: 1.1911 -
val_categorical_accuracy: 0.3043
Epoch 8/100
8/8 [==============================] - 3s 439ms/step - loss: 0.4119 -
categorical_accuracy: 0.8496 - val_loss: 1.2630 -
val_categorical_accuracy: 0.3043
Epoch 9/100
8/8 [==============================] - 4s 519ms/step - loss: 0.3532 -
categorical_accuracy: 0.8496 - val_loss: 1.4486 -
val_categorical_accuracy: 0.3043
Epoch 10/100
8/8 [==============================] - 4s 473ms/step - loss: 0.3343 -
categorical_accuracy: 0.8584 - val_loss: 1.4128 -
val_categorical_accuracy: 0.3043
Epoch 11/100
8/8 [==============================] - 4s 443ms/step - loss: 0.3790 -
categorical_accuracy: 0.8584 - val_loss: 1.4236 -
val_categorical_accuracy: 0.3043
Epoch 12/100
8/8 [==============================] - 3s 439ms/step - loss: 0.2796 -
categorical_accuracy: 0.8850 - val_loss: 1.5240 -
val_categorical_accuracy: 0.3043
Epoch 13/100
8/8 [==============================] - 4s 474ms/step - loss: 0.3085 -
categorical_accuracy: 0.8938 - val_loss: 1.7599 -
val_categorical_accuracy: 0.3043
Epoch 14/100
8/8 [==============================] - 4s 463ms/step - loss: 0.3817 -
categorical_accuracy: 0.8363 - val_loss: 1.7936 -
val_categorical_accuracy: 0.3043
Epoch 15/100
8/8 [==============================] - 3s 443ms/step - loss: 0.3133 -
categorical_accuracy: 0.8894 - val_loss: 1.8995 -
val_categorical_accuracy: 0.3043
Epoch 16/100
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8/8 [==============================] - 3s 442ms/step - loss: 0.3153 -
categorical_accuracy: 0.8673 - val_loss: 1.8421 -
val_categorical_accuracy: 0.3043
Epoch 17/100
8/8 [==============================] - 4s 445ms/step - loss: 0.3631 -
categorical_accuracy: 0.8496 - val_loss: 2.0054 -
val_categorical_accuracy: 0.3043
Epoch 18/100
8/8 [==============================] - 4s 469ms/step - loss: 0.2589 -
categorical_accuracy: 0.9071 - val_loss: 2.1783 -
val_categorical_accuracy: 0.3043
Epoch 19/100
8/8 [==============================] - 4s 454ms/step - loss: 0.2922 -
categorical_accuracy: 0.8894 - val_loss: 2.2664 -
val_categorical_accuracy: 0.3043
Epoch 20/100
8/8 [==============================] - 4s 449ms/step - loss: 0.3222 -
categorical_accuracy: 0.8805 - val_loss: 2.1910 -
val_categorical_accuracy: 0.3043
Epoch 21/100
8/8 [==============================] - 4s 445ms/step - loss: 0.2706 -
categorical_accuracy: 0.8894 - val_loss: 2.0923 -
val_categorical_accuracy: 0.3043
Epoch 22/100
8/8 [==============================] - 4s 456ms/step - loss: 0.2419 -
categorical_accuracy: 0.9115 - val_loss: 2.3322 -
val_categorical_accuracy: 0.3043
Epoch 23/100
8/8 [==============================] - 4s 459ms/step - loss: 0.2501 -
categorical_accuracy: 0.9248 - val_loss: 2.8906 -
val_categorical_accuracy: 0.3043
Epoch 24/100
8/8 [==============================] - 4s 460ms/step - loss: 0.2237 -
categorical_accuracy: 0.9027 - val_loss: 3.2473 -
val_categorical_accuracy: 0.3043
Epoch 25/100
8/8 [==============================] - 4s 456ms/step - loss: 0.2269 -
categorical_accuracy: 0.9071 - val_loss: 3.3294 -
val_categorical_accuracy: 0.3043
Epoch 26/100
8/8 [==============================] - 4s 451ms/step - loss: 0.1897 -
categorical_accuracy: 0.9381 - val_loss: 3.8057 -
val_categorical_accuracy: 0.3043
Epoch 27/100
8/8 [==============================] - 4s 471ms/step - loss: 0.2384 -
categorical_accuracy: 0.9027 - val_loss: 4.3868 -
val_categorical_accuracy: 0.3043
Epoch 28/100
8/8 [==============================] - 4s 452ms/step - loss: 0.2041 -
categorical_accuracy: 0.9558 - val_loss: 4.5500 -
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val_categorical_accuracy: 0.3043
Epoch 29/100
8/8 [==============================] - 4s 453ms/step - loss: 0.2836 -
categorical_accuracy: 0.8717 - val_loss: 4.8989 -
val_categorical_accuracy: 0.3043
Epoch 30/100
8/8 [==============================] - 4s 459ms/step - loss: 0.3380 -
categorical_accuracy: 0.8496 - val_loss: 5.0192 -
val_categorical_accuracy: 0.3043
Epoch 31/100
8/8 [==============================] - 4s 553ms/step - loss: 0.2951 -
categorical_accuracy: 0.8805 - val_loss: 4.6222 -
val_categorical_accuracy: 0.3043
Epoch 32/100
8/8 [==============================] - 5s 626ms/step - loss: 0.2778 -
categorical_accuracy: 0.9027 - val_loss: 3.9966 -
val_categorical_accuracy: 0.3043
Epoch 33/100
8/8 [==============================] - 5s 704ms/step - loss: 0.2859 -
categorical_accuracy: 0.8717 - val_loss: 4.1294 -
val_categorical_accuracy: 0.3043
Epoch 34/100
8/8 [==============================] - 6s 776ms/step - loss: 0.2717 -
categorical_accuracy: 0.9027 - val_loss: 4.9585 -
val_categorical_accuracy: 0.3043
Epoch 35/100
8/8 [==============================] - 6s 746ms/step - loss: 0.2776 -
categorical_accuracy: 0.8938 - val_loss: 5.0417 -
val_categorical_accuracy: 0.3043
Epoch 36/100
8/8 [==============================] - 6s 785ms/step - loss: 0.2282 -
categorical_accuracy: 0.9159 - val_loss: 4.8608 -
val_categorical_accuracy: 0.3043
Epoch 37/100
8/8 [==============================] - 6s 809ms/step - loss: 0.2388 -
categorical_accuracy: 0.8982 - val_loss: 4.2096 -
val_categorical_accuracy: 0.3261
Epoch 38/100
8/8 [==============================] - 6s 746ms/step - loss: 0.2062 -
categorical_accuracy: 0.9248 - val_loss: 4.2426 -
val_categorical_accuracy: 0.3261
Epoch 39/100
8/8 [==============================] - 6s 739ms/step - loss: 0.1762 -
categorical_accuracy: 0.9646 - val_loss: 4.4123 -
val_categorical_accuracy: 0.3261
Epoch 40/100
8/8 [==============================] - 6s 762ms/step - loss: 0.2327 -
categorical_accuracy: 0.9204 - val_loss: 4.0567 -
val_categorical_accuracy: 0.3261
Epoch 41/100
```

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8/8 [==============================] - 6s 730ms/step - loss: 0.1865 -
categorical_accuracy: 0.9381 - val_loss: 3.4534 -
val_categorical_accuracy: 0.3478
Epoch 42/100
8/8 [==============================] - 6s 753ms/step - loss: 0.2331 -
categorical_accuracy: 0.9027 - val_loss: 3.0502 -
val_categorical_accuracy: 0.3696
Epoch 43/100
8/8 [==============================] - 6s 732ms/step - loss: 0.2442 -
categorical_accuracy: 0.9204 - val_loss: 3.2519 -
val_categorical_accuracy: 0.3696
Epoch 44/100
8/8 [==============================] - 6s 716ms/step - loss: 0.2152 -
categorical_accuracy: 0.9204 - val_loss: 2.8098 -
val_categorical_accuracy: 0.3913
Epoch 45/100
8/8 [==============================] - 6s 753ms/step - loss: 0.2404 -
categorical_accuracy: 0.9027 - val_loss: 3.0378 -
val_categorical_accuracy: 0.3696
Epoch 46/100
8/8 [==============================] - 6s 812ms/step - loss: 0.2237 -
categorical_accuracy: 0.9248 - val_loss: 2.9586 -
val_categorical_accuracy: 0.3478
Epoch 47/100
8/8 [==============================] - 6s 727ms/step - loss: 0.1902 -
categorical_accuracy: 0.9292 - val_loss: 2.6664 -
val_categorical_accuracy: 0.3696
Epoch 48/100
8/8 [==============================] - 6s 754ms/step - loss: 0.2158 -
categorical_accuracy: 0.9336 - val_loss: 3.0468 -
val_categorical_accuracy: 0.3696
Epoch 49/100
8/8 [==============================] - 6s 726ms/step - loss: 0.2147 -
categorical_accuracy: 0.9292 - val_loss: 2.5354 -
val_categorical_accuracy: 0.4565
Epoch 50/100
8/8 [==============================] - 6s 722ms/step - loss: 0.1750 -
categorical_accuracy: 0.9292 - val_loss: 2.1098 -
val_categorical_accuracy: 0.4565
Epoch 51/100
8/8 [==============================] - 6s 746ms/step - loss: 0.1785 -
categorical_accuracy: 0.9248 - val_loss: 1.5394 -
val_categorical_accuracy: 0.5217
Epoch 52/100
8/8 [==============================] - 6s 816ms/step - loss: 0.2436 -
categorical_accuracy: 0.8982 - val_loss: 1.6965 -
val_categorical_accuracy: 0.5000
Epoch 53/100
8/8 [==============================] - 6s 721ms/step - loss: 0.1951 -
categorical_accuracy: 0.9159 - val_loss: 1.5295 -
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val_categorical_accuracy: 0.5217
Epoch 54/100
8/8 [==============================] - 6s 742ms/step - loss: 0.1866 -
categorical_accuracy: 0.9292 - val_loss: 1.2802 -
val_categorical_accuracy: 0.5652
Epoch 55/100
8/8 [==============================] - 6s 713ms/step - loss: 0.2337 -
categorical_accuracy: 0.9027 - val_loss: 1.0107 -
val_categorical_accuracy: 0.6087
Epoch 56/100
8/8 [==============================] - 6s 746ms/step - loss: 0.2220 -
categorical_accuracy: 0.9027 - val_loss: 1.2188 -
val_categorical_accuracy: 0.6087
Epoch 57/100
8/8 [==============================] - 6s 731ms/step - loss: 0.2240 -
categorical_accuracy: 0.9115 - val_loss: 1.3483 -
val_categorical_accuracy: 0.5870
Epoch 58/100
8/8 [==============================] - 6s 719ms/step - loss: 0.2344 -
categorical_accuracy: 0.8982 - val_loss: 3.1961 -
val_categorical_accuracy: 0.3696
Epoch 59/100
8/8 [==============================] - 6s 754ms/step - loss: 0.2857 -
categorical_accuracy: 0.8628 - val_loss: 2.0311 -
val_categorical_accuracy: 0.4783
Epoch 60/100
8/8 [==============================] - 6s 726ms/step - loss: 0.1602 -
categorical_accuracy: 0.9336 - val_loss: 0.7921 -
val_categorical_accuracy: 0.6739
Epoch 61/100
8/8 [==============================] - 6s 718ms/step - loss: 0.1481 -
categorical_accuracy: 0.9425 - val_loss: 0.6392 -
val_categorical_accuracy: 0.7609
Epoch 62/100
8/8 [==============================] - 6s 780ms/step - loss: 0.1974 -
categorical_accuracy: 0.9248 - val_loss: 0.7706 -
val_categorical_accuracy: 0.7174
Epoch 63/100
8/8 [==============================] - 6s 723ms/step - loss: 0.1680 -
categorical_accuracy: 0.9469 - val_loss: 0.5916 -
val_categorical_accuracy: 0.7609
Epoch 64/100
8/8 [==============================] - 6s 723ms/step - loss: 0.2499 -
categorical_accuracy: 0.9071 - val_loss: 0.2775 -
val_categorical_accuracy: 0.8478
Epoch 65/100
8/8 [==============================] - 6s 744ms/step - loss: 0.1789 -
categorical_accuracy: 0.9381 - val_loss: 0.4185 -
val_categorical_accuracy: 0.8043
Epoch 66/100
```

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8/8 [==============================] - 6s 717ms/step - loss: 0.1899 -
categorical_accuracy: 0.9381 - val_loss: 0.4652 -
val_categorical_accuracy: 0.8043
Epoch 67/100
8/8 [==============================] - 6s 752ms/step - loss: 0.1703 -
categorical_accuracy: 0.9204 - val_loss: 0.3378 -
val_categorical_accuracy: 0.8478
Epoch 68/100
8/8 [==============================] - 6s 734ms/step - loss: 0.1697 -
categorical_accuracy: 0.9425 - val_loss: 0.5154 -
val_categorical_accuracy: 0.8043
Epoch 69/100
8/8 [==============================] - 6s 719ms/step - loss: 0.1964 -
categorical_accuracy: 0.9381 - val_loss: 0.4648 -
val_categorical_accuracy: 0.8043
Epoch 70/100
8/8 [==============================] - 6s 752ms/step - loss: 0.1830 -
categorical_accuracy: 0.9336 - val_loss: 0.1881 -
val_categorical_accuracy: 0.8913
Epoch 71/100
8/8 [==============================] - 6s 740ms/step - loss: 0.1557 -
categorical_accuracy: 0.9381 - val_loss: 0.1961 -
val_categorical_accuracy: 0.8913
Epoch 72/100
8/8 [==============================] - 6s 802ms/step - loss: 0.1700 -
categorical_accuracy: 0.9425 - val_loss: 0.4459 -
val_categorical_accuracy: 0.8261
Epoch 73/100
8/8 [==============================] - 6s 819ms/step - loss: 0.2325 -
categorical_accuracy: 0.9115 - val_loss: 0.6007 -
val_categorical_accuracy: 0.8043
Epoch 74/100
8/8 [==============================] - 6s 730ms/step - loss: 0.1772 -
categorical_accuracy: 0.9336 - val_loss: 0.7352 -
val_categorical_accuracy: 0.7609
Epoch 75/100
8/8 [==============================] - 6s 725ms/step - loss: 0.1459 -
categorical_accuracy: 0.9425 - val_loss: 0.6028 -
val_categorical_accuracy: 0.8261
Epoch 76/100
8/8 [==============================] - 6s 745ms/step - loss: 0.1454 -
categorical_accuracy: 0.9336 - val_loss: 0.3081 -
val_categorical_accuracy: 0.8478
Epoch 77/100
8/8 [==============================] - 6s 733ms/step - loss: 0.1234 -
categorical_accuracy: 0.9602 - val_loss: 0.1750 -
val_categorical_accuracy: 0.9130
Epoch 78/100
8/8 [==============================] - 6s 760ms/step - loss: 0.1523 -
categorical_accuracy: 0.9336 - val_loss: 0.2382 -
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val_categorical_accuracy: 0.8478
Epoch 79/100
8/8 [==============================] - 6s 735ms/step - loss: 0.2197 -
categorical_accuracy: 0.9115 - val_loss: 0.4086 -
val_categorical_accuracy: 0.8261
Epoch 80/100
8/8 [==============================] - 6s 726ms/step - loss: 0.1545 -
categorical_accuracy: 0.9425 - val_loss: 0.3676 -
val_categorical_accuracy: 0.8043
Epoch 81/100
8/8 [==============================] - 6s 753ms/step - loss: 0.1643 -
categorical_accuracy: 0.9336 - val_loss: 0.7332 -
val_categorical_accuracy: 0.7174
Epoch 82/100
8/8 [==============================] - 6s 720ms/step - loss: 0.1448 -
categorical_accuracy: 0.9602 - val_loss: 1.0793 -
val_categorical_accuracy: 0.6739
Epoch 83/100
8/8 [==============================] - 6s 718ms/step - loss: 0.1906 -
categorical_accuracy: 0.9292 - val_loss: 0.2717 -
val_categorical_accuracy: 0.8913
Epoch 84/100
8/8 [==============================] - 6s 748ms/step - loss: 0.2563 -
categorical_accuracy: 0.8850 - val_loss: 0.2012 -
val_categorical_accuracy: 0.8913
Epoch 85/100
8/8 [==============================] - 6s 719ms/step - loss: 0.2474 -
categorical_accuracy: 0.8938 - val_loss: 0.1623 -
val_categorical_accuracy: 0.9565
Epoch 86/100
8/8 [==============================] - 6s 713ms/step - loss: 0.1919 -
categorical_accuracy: 0.9292 - val_loss: 0.1629 -
val_categorical_accuracy: 0.9348
Epoch 87/100
8/8 [==============================] - 6s 773ms/step - loss: 0.2091 -
categorical_accuracy: 0.9115 - val_loss: 0.1189 -
val_categorical_accuracy: 0.9348
Epoch 88/100
8/8 [==============================] - 6s 804ms/step - loss: 0.1830 -
categorical_accuracy: 0.9159 - val_loss: 0.1582 -
val_categorical_accuracy: 0.9130
Epoch 89/100
8/8 [==============================] - 6s 734ms/step - loss: 0.1882 -
categorical_accuracy: 0.9469 - val_loss: 0.3613 -
val_categorical_accuracy: 0.8478
Epoch 90/100
8/8 [==============================] - 6s 734ms/step - loss: 0.0920 -
categorical_accuracy: 0.9735 - val_loss: 0.3928 -
val_categorical_accuracy: 0.8043
Epoch 91/100
```

```
8/8 [==============================] - 6s 720ms/step - loss: 0.2506 -
categorical_accuracy: 0.8938 - val_loss: 0.5348 -
val_categorical_accuracy: 0.7826
Epoch 92/100
8/8 [==============================] - 6s 752ms/step - loss: 0.1548 -
categorical_accuracy: 0.9292 - val_loss: 0.1551 -
val_categorical_accuracy: 0.9130
Epoch 93/100
8/8 [==============================] - 6s 812ms/step - loss: 0.1770 -
categorical_accuracy: 0.9027 - val_loss: 0.1224 -
val_categorical_accuracy: 0.9348
Epoch 94/100
8/8 [==============================] - 6s 717ms/step - loss: 0.1803 -
categorical_accuracy: 0.9248 - val_loss: 0.6029 -
val_categorical_accuracy: 0.8043
Epoch 95/100
8/8 [==============================] - 6s 745ms/step - loss: 0.1724 -
categorical_accuracy: 0.9071 - val_loss: 0.2437 -
val_categorical_accuracy: 0.8913
Epoch 96/100
8/8 [==============================] - 6s 709ms/step - loss: 0.1375 -
categorical_accuracy: 0.9381 - val_loss: 0.1250 -
val_categorical_accuracy: 0.9130
Epoch 97/100
8/8 [==============================] - 6s 718ms/step - loss: 0.2569 -
categorical_accuracy: 0.8938 - val_loss: 0.1814 -
val_categorical_accuracy: 0.8913
Epoch 98/100
8/8 [==============================] - 6s 753ms/step - loss: 0.1597 -
categorical_accuracy: 0.9292 - val_loss: 0.0804 -
val_categorical_accuracy: 1.0000
Epoch 99/100
8/8 [==============================] - 6s 738ms/step - loss: 0.2009 -
categorical_accuracy: 0.9248 - val_loss: 0.2791 -
val_categorical_accuracy: 0.8478
Epoch 100/100
8/8 [==============================] - 6s 760ms/step - loss: 0.2105 -
categorical_accuracy: 0.9336 - val_loss: 0.5362 -
val_categorical_accuracy: 0.7391
2/2 [==============================] - 1s 236ms/step - loss: 0.5184 -
categorical_accuracy: 0.8696
Test accuracy: 0.8695651888847351
```

I used ResNet50 model since it is a popular choice for image classification. I also froze some of the base layers since the weights at that level detects common features and do not need much adjustment and its a good way to apply transfer learning. In the output layer, I use softmax to obtain probabilities as this is a categorical classification. Finally I compile the model with metrics and loss functions also categorical as the output is one hot-encoded labels. Finally I train the model with epochs and different learning rates. I chose the model that best fits with the help of test loss and test accuracy.

Will hypertune learning rates to find the optimal model.

```
lr = [0.001,0.01,0.00001]
for l in lr:
    pretrained_model = train(learning_rate=l)
```

```
Epoch 1/100
8/8 [==============================] - 5s 507ms/step - loss: 0.6986 -
categorical_accuracy: 0.6858 - val_loss: 2.7568 -
val_categorical_accuracy: 0.6304
Epoch 2/100
8/8 [==============================] - 4s 462ms/step - loss: 0.4869 -
categorical_accuracy: 0.8142 - val_loss: 18.1015 -
val_categorical_accuracy: 0.3478
Epoch 3/100
8/8 [==============================] - 4s 469ms/step - loss: 0.5136 -
categorical_accuracy: 0.7743 - val_loss: 10.7391 -
val_categorical_accuracy: 0.3696
Epoch 4/100
8/8 [==============================] - 4s 540ms/step - loss: 0.4656 -
categorical_accuracy: 0.7876 - val_loss: 10.9010 -
val_categorical_accuracy: 0.4783
Epoch 5/100
8/8 [==============================] - 4s 471ms/step - loss: 0.4454 -
categorical_accuracy: 0.8009 - val_loss: 14.0861 -
val_categorical_accuracy: 0.5870
Epoch 6/100
8/8 [==============================] - 4s 475ms/step - loss: 0.3579 -
categorical_accuracy: 0.8673 - val_loss: 9.2487 -
val_categorical_accuracy: 0.6087
Epoch 7/100
8/8 [==============================] - 4s 473ms/step - loss: 0.3845 -
categorical_accuracy: 0.8451 - val_loss: 9.0574 -
val_categorical_accuracy: 0.5000
Epoch 8/100
8/8 [==============================] - 4s 491ms/step - loss: 0.3414 -
categorical_accuracy: 0.8407 - val_loss: 2.1536 -
val_categorical_accuracy: 0.7174
Epoch 9/100
8/8 [==============================] - 4s 467ms/step - loss: 0.2089 -
categorical_accuracy: 0.9204 - val_loss: 0.2869 -
val_categorical_accuracy: 0.9130
```

```
Epoch 10/100
8/8 [==============================] - 4s 518ms/step - loss: 0.3354 -
categorical_accuracy: 0.8628 - val_loss: 4.0510 -
val_categorical_accuracy: 0.6522
Epoch 11/100
8/8 [==============================] - 4s 473ms/step - loss: 0.2685 -
categorical_accuracy: 0.8938 - val_loss: 1.6966 -
val_categorical_accuracy: 0.7391
Epoch 12/100
8/8 [==============================] - 4s 486ms/step - loss: 0.3644 -
categorical_accuracy: 0.8451 - val_loss: 8.4842 -
val_categorical_accuracy: 0.5000
Epoch 13/100
8/8 [==============================] - 4s 473ms/step - loss: 0.5048 -
categorical_accuracy: 0.8274 - val_loss: 16.9391 -
val_categorical_accuracy: 0.3261
Epoch 14/100
8/8 [==============================] - 4s 471ms/step - loss: 0.3442 -
categorical_accuracy: 0.8451 - val_loss: 25.2549 -
val_categorical_accuracy: 0.3261
Epoch 15/100
8/8 [==============================] - 4s 473ms/step - loss: 0.3660 -
categorical_accuracy: 0.8319 - val_loss: 13.5902 -
val_categorical_accuracy: 0.3478
Epoch 16/100
8/8 [==============================] - 4s 478ms/step - loss: 0.2647 -
categorical_accuracy: 0.9071 - val_loss: 8.8684 -
val_categorical_accuracy: 0.3696
Epoch 17/100
8/8 [==============================] - 4s 538ms/step - loss: 0.3022 -
categorical_accuracy: 0.8850 - val_loss: 15.9500 -
val_categorical_accuracy: 0.3478
Epoch 18/100
8/8 [==============================] - 4s 479ms/step - loss: 0.2442 -
categorical_accuracy: 0.9027 - val_loss: 9.4737 -
val_categorical_accuracy: 0.3696
Epoch 19/100
8/8 [==============================] - 4s 478ms/step - loss: 0.1951 -
categorical_accuracy: 0.9115 - val_loss: 5.4939 -
val_categorical_accuracy: 0.4783
Epoch 20/100
8/8 [==============================] - 4s 521ms/step - loss: 0.2882 -
categorical_accuracy: 0.8850 - val_loss: 8.7113 -
val_categorical_accuracy: 0.3696
Epoch 21/100
8/8 [==============================] - 4s 490ms/step - loss: 0.2775 -
categorical_accuracy: 0.8761 - val_loss: 8.6312 -
val_categorical_accuracy: 0.4130
Epoch 22/100
8/8 [==============================] - 4s 476ms/step - loss: 0.3667 -
```

```
categorical_accuracy: 0.8142 - val_loss: 15.5232 -
val_categorical_accuracy: 0.3261
Epoch 23/100
8/8 [==============================] - 4s 476ms/step - loss: 0.4377 -
categorical_accuracy: 0.8009 - val_loss: 11.6232 -
val_categorical_accuracy: 0.3261
Epoch 24/100
8/8 [==============================] - 4s 506ms/step - loss: 0.3555 -
categorical_accuracy: 0.8540 - val_loss: 3.0019 -
val_categorical_accuracy: 0.5870
Epoch 25/100
8/8 [==============================] - 4s 552ms/step - loss: 0.2974 -
categorical_accuracy: 0.8805 - val_loss: 2.1128 -
val_categorical_accuracy: 0.6957
Epoch 26/100
8/8 [==============================] - 4s 516ms/step - loss: 0.2755 -
categorical_accuracy: 0.8938 - val_loss: 0.6824 -
val_categorical_accuracy: 0.8261
Epoch 27/100
8/8 [==============================] - 4s 487ms/step - loss: 0.2206 -
categorical_accuracy: 0.9248 - val_loss: 2.5597 -
val_categorical_accuracy: 0.5000
Epoch 28/100
8/8 [==============================] - 4s 478ms/step - loss: 0.2910 -
categorical_accuracy: 0.9159 - val_loss: 0.3705 -
val_categorical_accuracy: 0.8478
Epoch 29/100
8/8 [==============================] - 4s 493ms/step - loss: 0.2644 -
categorical_accuracy: 0.9071 - val_loss: 0.2275 -
val_categorical_accuracy: 0.8478
Epoch 30/100
8/8 [==============================] - 4s 475ms/step - loss: 0.4386 -
categorical_accuracy: 0.8009 - val_loss: 0.3846 -
val_categorical_accuracy: 0.8043
Epoch 31/100
8/8 [==============================] - 4s 476ms/step - loss: 0.4289 -
categorical_accuracy: 0.8363 - val_loss: 2.0594 -
val_categorical_accuracy: 0.6304
Epoch 32/100
8/8 [==============================] - 4s 478ms/step - loss: 0.2927 -
categorical_accuracy: 0.8717 - val_loss: 0.3679 -
val_categorical_accuracy: 0.9130
Epoch 33/100
8/8 [==============================] - 4s 497ms/step - loss: 0.2676 -
categorical_accuracy: 0.9071 - val_loss: 0.4253 -
val_categorical_accuracy: 0.8478
Epoch 34/100
8/8 [==============================] - 4s 478ms/step - loss: 0.3051 -
categorical_accuracy: 0.8761 - val_loss: 0.6948 -
val_categorical_accuracy: 0.7174
```

```
Epoch 35/100
8/8 [==============================] - 4s 478ms/step - loss: 0.2417 -
categorical_accuracy: 0.8938 - val_loss: 1.2593 -
val_categorical_accuracy: 0.6957
Epoch 36/100
8/8 [==============================] - 4s 479ms/step - loss: 0.2066 -
categorical_accuracy: 0.9204 - val_loss: 0.7266 -
val_categorical_accuracy: 0.7609
Epoch 37/100
8/8 [==============================] - 4s 491ms/step - loss: 0.3282 -
categorical_accuracy: 0.8584 - val_loss: 1.2203 -
val_categorical_accuracy: 0.7391
Epoch 38/100
8/8 [==============================] - 4s 477ms/step - loss: 0.4017 -
categorical_accuracy: 0.8230 - val_loss: 1.9364 -
val_categorical_accuracy: 0.6739
Epoch 39/100
8/8 [==============================] - 4s 479ms/step - loss: 0.2577 -
categorical_accuracy: 0.8938 - val_loss: 1.3805 -
val_categorical_accuracy: 0.6957
Epoch 40/100
8/8 [==============================] - 4s 482ms/step - loss: 0.3100 -
categorical_accuracy: 0.8673 - val_loss: 0.6382 -
val_categorical_accuracy: 0.7826
Epoch 41/100
8/8 [==============================] - 4s 481ms/step - loss: 0.2607 -
categorical_accuracy: 0.8761 - val_loss: 0.1552 -
val_categorical_accuracy: 0.9130
Epoch 42/100
8/8 [==============================] - 4s 499ms/step - loss: 0.2700 -
categorical_accuracy: 0.9071 - val_loss: 1.5050 -
val_categorical_accuracy: 0.6739
Epoch 43/100
8/8 [==============================] - 4s 482ms/step - loss: 0.1779 -
categorical_accuracy: 0.9469 - val_loss: 0.7130 -
val_categorical_accuracy: 0.7826
Epoch 44/100
8/8 [==============================] - 4s 476ms/step - loss: 0.2109 -
categorical_accuracy: 0.9159 - val_loss: 0.4985 -
val_categorical_accuracy: 0.8043
Epoch 45/100
8/8 [==============================] - 4s 483ms/step - loss: 0.2571 -
categorical_accuracy: 0.8850 - val_loss: 2.3021 -
val_categorical_accuracy: 0.5435
Epoch 46/100
8/8 [==============================] - 4s 498ms/step - loss: 0.3121 -
categorical_accuracy: 0.8938 - val_loss: 2.9650 -
val_categorical_accuracy: 0.6522
Epoch 47/100
8/8 [==============================] - 4s 485ms/step - loss: 0.3376 -
```

```
categorical_accuracy: 0.8451 - val_loss: 0.9738 -
val_categorical_accuracy: 0.8043
Epoch 48/100
8/8 [==============================] - 4s 483ms/step - loss: 0.2277 -
categorical_accuracy: 0.9115 - val_loss: 1.2770 -
val_categorical_accuracy: 0.6957
Epoch 49/100
8/8 [==============================] - 4s 485ms/step - loss: 0.2960 -
categorical_accuracy: 0.8673 - val_loss: 1.4096 -
val_categorical_accuracy: 0.6739
Epoch 50/100
8/8 [==============================] - 4s 500ms/step - loss: 0.1816 -
categorical_accuracy: 0.9204 - val_loss: 1.0192 -
val_categorical_accuracy: 0.7174
Epoch 51/100
8/8 [==============================] - 4s 483ms/step - loss: 0.1675 -
categorical_accuracy: 0.9425 - val_loss: 0.9848 -
val_categorical_accuracy: 0.7609
Epoch 52/100
8/8 [==============================] - 4s 485ms/step - loss: 0.1758 -
categorical_accuracy: 0.9292 - val_loss: 0.2682 -
val_categorical_accuracy: 0.8913
Epoch 53/100
8/8 [==============================] - 4s 487ms/step - loss: 0.2249 -
categorical_accuracy: 0.9204 - val_loss: 0.1319 -
val_categorical_accuracy: 0.9348
Epoch 54/100
8/8 [==============================] - 4s 547ms/step - loss: 0.1553 -
categorical_accuracy: 0.9425 - val_loss: 0.3034 -
val_categorical_accuracy: 0.8913
Epoch 55/100
8/8 [==============================] - 4s 509ms/step - loss: 0.2440 -
categorical_accuracy: 0.9115 - val_loss: 0.5325 -
val_categorical_accuracy: 0.8261
Epoch 56/100
8/8 [==============================] - 4s 515ms/step - loss: 0.1773 -
categorical_accuracy: 0.9248 - val_loss: 0.6605 -
val_categorical_accuracy: 0.8261
Epoch 57/100
8/8 [==============================] - 4s 484ms/step - loss: 0.2596 -
categorical_accuracy: 0.8805 - val_loss: 0.9692 -
val_categorical_accuracy: 0.7174
Epoch 58/100
8/8 [==============================] - 4s 556ms/step - loss: 0.2814 -
categorical_accuracy: 0.8805 - val_loss: 0.8852 -
val_categorical_accuracy: 0.7174
Epoch 59/100
8/8 [==============================] - 4s 514ms/step - loss: 0.2754 -
categorical_accuracy: 0.8805 - val_loss: 0.2477 -
val_categorical_accuracy: 0.8696
```

```
Epoch 60/100
8/8 [==============================] - 4s 487ms/step - loss: 0.1892 -
categorical_accuracy: 0.9071 - val_loss: 0.1593 -
val_categorical_accuracy: 0.9130
Epoch 61/100
8/8 [==============================] - 4s 487ms/step - loss: 0.1590 -
categorical_accuracy: 0.9159 - val_loss: 0.2172 -
val_categorical_accuracy: 0.8913
Epoch 62/100
8/8 [==============================] - 4s 500ms/step - loss: 0.1830 -
categorical_accuracy: 0.9204 - val_loss: 0.3363 -
val_categorical_accuracy: 0.8478
Epoch 63/100
8/8 [==============================] - 4s 480ms/step - loss: 0.3854 -
categorical_accuracy: 0.8363 - val_loss: 1.4171 -
val_categorical_accuracy: 0.6739
Epoch 64/100
8/8 [==============================] - 4s 554ms/step - loss: 0.3621 -
categorical_accuracy: 0.8584 - val_loss: 0.5156 -
val_categorical_accuracy: 0.7609
Epoch 65/100
8/8 [==============================] - 4s 510ms/step - loss: 0.2977 -
categorical_accuracy: 0.8761 - val_loss: 2.1060 -
val_categorical_accuracy: 0.5000
Epoch 66/100
8/8 [==============================] - 4s 503ms/step - loss: 0.2519 -
categorical_accuracy: 0.8938 - val_loss: 1.0116 -
val_categorical_accuracy: 0.6522
Epoch 67/100
8/8 [==============================] - 4s 486ms/step - loss: 0.3225 -
categorical_accuracy: 0.8717 - val_loss: 0.9088 -
val_categorical_accuracy: 0.7391
Epoch 68/100
8/8 [==============================] - 4s 489ms/step - loss: 0.1889 -
categorical_accuracy: 0.9115 - val_loss: 0.5210 -
val_categorical_accuracy: 0.8261
Epoch 69/100
8/8 [==============================] - 4s 487ms/step - loss: 0.2083 -
categorical_accuracy: 0.9115 - val_loss: 1.4553 -
val_categorical_accuracy: 0.5217
Epoch 70/100
8/8 [==============================] - 4s 557ms/step - loss: 0.1701 -
categorical_accuracy: 0.9381 - val_loss: 1.3669 -
val_categorical_accuracy: 0.5870
Epoch 71/100
8/8 [==============================] - 4s 488ms/step - loss: 0.1709 -
categorical_accuracy: 0.9381 - val_loss: 0.5828 -
val_categorical_accuracy: 0.7826
Epoch 72/100
8/8 [==============================] - 4s 488ms/step - loss: 0.1770 -
```

```
categorical_accuracy: 0.9469 - val_loss: 0.5917 -
val_categorical_accuracy: 0.7826
Epoch 73/100
8/8 [==============================] - 4s 492ms/step - loss: 0.2791 -
categorical_accuracy: 0.8805 - val_loss: 1.0460 -
val_categorical_accuracy: 0.7609
Epoch 74/100
8/8 [==============================] - 4s 504ms/step - loss: 0.2872 -
categorical_accuracy: 0.8805 - val_loss: 1.3470 -
val_categorical_accuracy: 0.6522
Epoch 75/100
8/8 [==============================] - 4s 489ms/step - loss: 0.2308 -
categorical_accuracy: 0.9159 - val_loss: 0.4783 -
val_categorical_accuracy: 0.8261
Epoch 76/100
8/8 [==============================] - 4s 487ms/step - loss: 0.2150 -
categorical_accuracy: 0.9159 - val_loss: 0.5644 -
val_categorical_accuracy: 0.8261
Epoch 77/100
8/8 [==============================] - 4s 492ms/step - loss: 0.2004 -
categorical_accuracy: 0.9248 - val_loss: 0.5684 -
val_categorical_accuracy: 0.8043
Epoch 78/100
8/8 [==============================] - 4s 499ms/step - loss: 0.1585 -
categorical_accuracy: 0.9469 - val_loss: 0.7844 -
val_categorical_accuracy: 0.7609
Epoch 79/100
8/8 [==============================] - 4s 518ms/step - loss: 0.2751 -
categorical_accuracy: 0.8805 - val_loss: 0.5237 -
val_categorical_accuracy: 0.8043
Epoch 80/100
8/8 [==============================] - 4s 503ms/step - loss: 0.1902 -
categorical_accuracy: 0.9071 - val_loss: 0.3067 -
val_categorical_accuracy: 0.9348
Epoch 81/100
8/8 [==============================] - 4s 531ms/step - loss: 0.2316 -
categorical_accuracy: 0.9115 - val_loss: 2.6761 -
val_categorical_accuracy: 0.5870
Epoch 82/100
8/8 [==============================] - 4s 529ms/step - loss: 0.2844 -
categorical_accuracy: 0.8982 - val_loss: 1.7088 -
val_categorical_accuracy: 0.7391
Epoch 83/100
8/8 [==============================] - 4s 511ms/step - loss: 0.2894 -
categorical_accuracy: 0.8938 - val_loss: 1.5066 -
val_categorical_accuracy: 0.6739
Epoch 84/100
8/8 [==============================] - 4s 567ms/step - loss: 0.2897 -
categorical_accuracy: 0.8850 - val_loss: 3.1505 -
val_categorical_accuracy: 0.4348
```

```
Epoch 85/100
8/8 [==============================] - 4s 515ms/step - loss: 0.2767 -
categorical_accuracy: 0.8894 - val_loss: 2.3308 -
val_categorical_accuracy: 0.6304
Epoch 86/100
8/8 [==============================] - 4s 595ms/step - loss: 0.2710 -
categorical_accuracy: 0.9027 - val_loss: 1.0908 -
val_categorical_accuracy: 0.6739
Epoch 87/100
8/8 [==============================] - 4s 516ms/step - loss: 0.1845 -
categorical_accuracy: 0.9204 - val_loss: 0.2163 -
val_categorical_accuracy: 0.8696
Epoch 88/100
8/8 [==============================] - 4s 519ms/step - loss: 0.2642 -
categorical_accuracy: 0.8938 - val_loss: 0.1269 -
val_categorical_accuracy: 0.9130
Epoch 89/100
8/8 [==============================] - 4s 522ms/step - loss: 0.1500 -
categorical_accuracy: 0.9425 - val_loss: 0.2160 -
val_categorical_accuracy: 0.9130
Epoch 90/100
8/8 [==============================] - 4s 547ms/step - loss: 0.1816 -
categorical_accuracy: 0.9336 - val_loss: 0.4731 -
val_categorical_accuracy: 0.8261
Epoch 91/100
8/8 [==============================] - 4s 525ms/step - loss: 0.1402 -
categorical_accuracy: 0.9558 - val_loss: 0.1453 -
val_categorical_accuracy: 0.9130
Epoch 92/100
8/8 [==============================] - 4s 525ms/step - loss: 0.1258 -
categorical_accuracy: 0.9292 - val_loss: 0.3151 -
val_categorical_accuracy: 0.8913
Epoch 93/100
8/8 [==============================] - 4s 527ms/step - loss: 0.2178 -
categorical_accuracy: 0.9115 - val_loss: 0.3395 -
val_categorical_accuracy: 0.8043
Epoch 94/100
8/8 [==============================] - 4s 543ms/step - loss: 0.2074 -
categorical_accuracy: 0.9248 - val_loss: 0.6595 -
val_categorical_accuracy: 0.7609
Epoch 95/100
8/8 [==============================] - 4s 521ms/step - loss: 0.1417 -
categorical_accuracy: 0.9602 - val_loss: 0.5937 -
val_categorical_accuracy: 0.7391
Epoch 96/100
8/8 [==============================] - 4s 526ms/step - loss: 0.2642 -
categorical_accuracy: 0.9071 - val_loss: 1.2351 -
val_categorical_accuracy: 0.5435
Epoch 97/100
8/8 [==============================] - 4s 527ms/step - loss: 0.2521 -
```

```
categorical_accuracy: 0.8982 - val_loss: 0.4351 -
val_categorical_accuracy: 0.8261
Epoch 98/100
8/8 [==============================] - 4s 547ms/step - loss: 0.2153 -
categorical_accuracy: 0.9027 - val_loss: 0.8357 -
val_categorical_accuracy: 0.7609
Epoch 99/100
8/8 [==============================] - 4s 523ms/step - loss: 0.1575 -
categorical_accuracy: 0.9381 - val_loss: 0.4102 -
val_categorical_accuracy: 0.8478
Epoch 100/100
8/8 [==============================] - 4s 525ms/step - loss: 0.2018 -
categorical_accuracy: 0.9381 - val_loss: 0.6599 -
val_categorical_accuracy: 0.7391
2/2 [==============================] - 1s 171ms/step - loss: 0.6787 -
categorical_accuracy: 0.8043
Test accuracy: 0.804347813129425
Epoch 1/100
8/8 [==============================] - 5s 653ms/step - loss: 1.7600 -
categorical_accuracy: 0.5398 - val_loss: 234.4596 -
val_categorical_accuracy: 0.3913
Epoch 2/100
8/8 [==============================] - 4s 518ms/step - loss: 0.7107 -
categorical_accuracy: 0.6991 - val_loss: 1084.2758 -
val_categorical_accuracy: 0.3043
Epoch 3/100
8/8 [==============================] - 4s 520ms/step - loss: 0.7009 -
categorical_accuracy: 0.6858 - val_loss: 1362.9122 -
val_categorical_accuracy: 0.3043
Epoch 4/100
8/8 [==============================] - 4s 521ms/step - loss: 0.5032 -
categorical_accuracy: 0.7965 - val_loss: 1219.7864 -
val_categorical_accuracy: 0.3043
Epoch 5/100
8/8 [==============================] - 4s 541ms/step - loss: 0.5834 -
categorical_accuracy: 0.7611 - val_loss: 645.0430 -
val_categorical_accuracy: 0.3043
Epoch 6/100
8/8 [==============================] - 4s 522ms/step - loss: 0.6917 -
categorical_accuracy: 0.7611 - val_loss: 51.1351 -
val_categorical_accuracy: 0.5000
Epoch 7/100
8/8 [==============================] - 4s 523ms/step - loss: 1.0387 -
categorical_accuracy: 0.6062 - val_loss: 32.2759 -
val_categorical_accuracy: 0.5217
Epoch 8/100
8/8 [==============================] - 4s 523ms/step - loss: 0.6839 -
categorical_accuracy: 0.7168 - val_loss: 76.6587 -
val_categorical_accuracy: 0.3478
Epoch 9/100
```

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8/8 [==============================] - 4s 541ms/step - loss: 0.5382 -
categorical_accuracy: 0.7522 - val_loss: 59.3934 -
val_categorical_accuracy: 0.3696
Epoch 10/100
8/8 [==============================] - 4s 519ms/step - loss: 0.4667 -
categorical_accuracy: 0.7699 - val_loss: 73.4009 -
val_categorical_accuracy: 0.3043
Epoch 11/100
8/8 [==============================] - 4s 525ms/step - loss: 0.7538 -
categorical_accuracy: 0.7832 - val_loss: 72.7377 -
val_categorical_accuracy: 0.3261
Epoch 12/100
8/8 [==============================] - 5s 620ms/step - loss: 0.4042 -
categorical_accuracy: 0.8407 - val_loss: 62.8811 -
val_categorical_accuracy: 0.3696
Epoch 13/100
8/8 [==============================] - 4s 547ms/step - loss: 0.5831 -
categorical_accuracy: 0.7788 - val_loss: 85.0563 -
val_categorical_accuracy: 0.3043
Epoch 14/100
8/8 [==============================] - 4s 521ms/step - loss: 0.3694 -
categorical_accuracy: 0.8407 - val_loss: 35.5171 -
val_categorical_accuracy: 0.3696
Epoch 15/100
8/8 [==============================] - 4s 517ms/step - loss: 0.3692 -
categorical_accuracy: 0.8717 - val_loss: 18.0458 -
val_categorical_accuracy: 0.5217
Epoch 16/100
8/8 [==============================] - 4s 591ms/step - loss: 0.3574 -
categorical_accuracy: 0.8628 - val_loss: 11.5940 -
val_categorical_accuracy: 0.5217
Epoch 17/100
8/8 [==============================] - 4s 523ms/step - loss: 0.3847 -
categorical_accuracy: 0.8186 - val_loss: 11.1357 -
val_categorical_accuracy: 0.4130
Epoch 18/100
8/8 [==============================] - 4s 531ms/step - loss: 0.3575 -
categorical_accuracy: 0.8540 - val_loss: 10.1797 -
val_categorical_accuracy: 0.5000
Epoch 19/100
8/8 [==============================] - 4s 522ms/step - loss: 0.6109 -
categorical_accuracy: 0.7788 - val_loss: 11.7629 -
val_categorical_accuracy: 0.5870
Epoch 20/100
8/8 [==============================] - 4s 552ms/step - loss: 0.6430 -
categorical_accuracy: 0.7478 - val_loss: 68.5083 -
val_categorical_accuracy: 0.3043
Epoch 21/100
8/8 [==============================] - 4s 529ms/step - loss: 0.6930 -
categorical_accuracy: 0.7124 - val_loss: 69.0976 -
```

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val_categorical_accuracy: 0.3043
Epoch 22/100
8/8 [==============================] - 4s 525ms/step - loss: 0.5087 -
categorical_accuracy: 0.7832 - val_loss: 32.8477 -
val_categorical_accuracy: 0.5217
Epoch 23/100
8/8 [==============================] - 4s 526ms/step - loss: 0.3916 -
categorical_accuracy: 0.8319 - val_loss: 26.4050 -
val_categorical_accuracy: 0.5435
Epoch 24/100
8/8 [==============================] - 4s 551ms/step - loss: 0.4056 -
categorical_accuracy: 0.8363 - val_loss: 15.8387 -
val_categorical_accuracy: 0.5870
Epoch 25/100
8/8 [==============================] - 4s 584ms/step - loss: 0.4294 -
categorical_accuracy: 0.8230 - val_loss: 20.8178 -
val_categorical_accuracy: 0.4130
Epoch 26/100
8/8 [==============================] - 4s 534ms/step - loss: 0.3043 -
categorical_accuracy: 0.8673 - val_loss: 9.9462 -
val_categorical_accuracy: 0.5435
Epoch 27/100
8/8 [==============================] - 4s 525ms/step - loss: 0.5329 -
categorical_accuracy: 0.8009 - val_loss: 8.0294 -
val_categorical_accuracy: 0.5435
Epoch 28/100
8/8 [==============================] - 4s 548ms/step - loss: 0.5212 -
categorical_accuracy: 0.7611 - val_loss: 2.0741 -
val_categorical_accuracy: 0.6739
Epoch 29/100
8/8 [==============================] - 4s 526ms/step - loss: 0.7445 -
categorical_accuracy: 0.7522 - val_loss: 3.8770 -
val_categorical_accuracy: 0.5652
Epoch 30/100
8/8 [==============================] - 4s 526ms/step - loss: 0.3752 -
categorical_accuracy: 0.8451 - val_loss: 1.4066 -
val_categorical_accuracy: 0.6957
Epoch 31/100
8/8 [==============================] - 4s 573ms/step - loss: 0.8317 -
categorical_accuracy: 0.6991 - val_loss: 6.2835 -
val_categorical_accuracy: 0.4130
Epoch 32/100
8/8 [==============================] - 4s 536ms/step - loss: 0.5053 -
categorical_accuracy: 0.7876 - val_loss: 1.9703 -
val_categorical_accuracy: 0.6739
Epoch 33/100
8/8 [==============================] - 4s 521ms/step - loss: 0.3809 -
categorical_accuracy: 0.8717 - val_loss: 3.2083 -
val_categorical_accuracy: 0.6087
Epoch 34/100
```

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8/8 [==============================] - 4s 518ms/step - loss: 0.3122 -
categorical_accuracy: 0.8982 - val_loss: 2.5272 -
val_categorical_accuracy: 0.7174
Epoch 35/100
8/8 [==============================] - 4s 520ms/step - loss: 0.3355 -
categorical_accuracy: 0.8717 - val_loss: 1.4838 -
val_categorical_accuracy: 0.6739
Epoch 36/100
8/8 [==============================] - 4s 523ms/step - loss: 0.3308 -
categorical_accuracy: 0.8496 - val_loss: 0.2804 -
val_categorical_accuracy: 0.9130
Epoch 37/100
8/8 [==============================] - 4s 515ms/step - loss: 0.3630 -
categorical_accuracy: 0.8628 - val_loss: 0.6792 -
val_categorical_accuracy: 0.8043
Epoch 38/100
8/8 [==============================] - 4s 515ms/step - loss: 0.4177 -
categorical_accuracy: 0.8186 - val_loss: 0.5895 -
val_categorical_accuracy: 0.8913
Epoch 39/100
8/8 [==============================] - 4s 523ms/step - loss: 0.3794 -
categorical_accuracy: 0.8363 - val_loss: 0.3136 -
val_categorical_accuracy: 0.8913
Epoch 40/100
8/8 [==============================] - 4s 516ms/step - loss: 0.4913 -
categorical_accuracy: 0.7832 - val_loss: 0.4138 -
val_categorical_accuracy: 0.8478
Epoch 41/100
8/8 [==============================] - 4s 517ms/step - loss: 0.3131 -
categorical_accuracy: 0.8407 - val_loss: 0.3429 -
val_categorical_accuracy: 0.8261
Epoch 42/100
8/8 [==============================] - 4s 515ms/step - loss: 0.2608 -
categorical_accuracy: 0.8938 - val_loss: 1.6280 -
val_categorical_accuracy: 0.6522
Epoch 43/100
8/8 [==============================] - 4s 527ms/step - loss: 0.4795 -
categorical_accuracy: 0.8053 - val_loss: 0.6034 -
val_categorical_accuracy: 0.8478
Epoch 44/100
8/8 [==============================] - 5s 577ms/step - loss: 0.3557 -
categorical_accuracy: 0.8628 - val_loss: 4.1897 -
val_categorical_accuracy: 0.5435
Epoch 45/100
8/8 [==============================] - 4s 569ms/step - loss: 0.3282 -
categorical_accuracy: 0.8805 - val_loss: 3.1052 -
val_categorical_accuracy: 0.4783
Epoch 46/100
8/8 [==============================] - 57s 8s/step - loss: 0.3195 -
categorical_accuracy: 0.8584 - val_loss: 1.9681 -
```

```
val_categorical_accuracy: 0.6304
Epoch 47/100
8/8 [==============================] - 4s 457ms/step - loss: 0.2933 -
categorical_accuracy: 0.8673 - val_loss: 1.9528 -
val_categorical_accuracy: 0.6087
Epoch 48/100
8/8 [==============================] - 76s 556ms/step - loss: 0.4546 -
categorical_accuracy: 0.7832 - val_loss: 0.3795 -
val_categorical_accuracy: 0.8913
Epoch 49/100
8/8 [==============================] - 4s 481ms/step - loss: 0.5838 -
categorical_accuracy: 0.7965 - val_loss: 0.7143 -
val_categorical_accuracy: 0.8043
Epoch 50/100
8/8 [==============================] - 4s 530ms/step - loss: 0.5021 -
categorical_accuracy: 0.7743 - val_loss: 1.8074 -
val_categorical_accuracy: 0.7391
Epoch 51/100
8/8 [==============================] - 4s 491ms/step - loss: 0.2640 -
categorical_accuracy: 0.8894 - val_loss: 0.5696 -
val_categorical_accuracy: 0.8696
Epoch 52/100
8/8 [==============================] - 4s 459ms/step - loss: 0.2538 -
categorical_accuracy: 0.9071 - val_loss: 0.6101 -
val_categorical_accuracy: 0.8043
Epoch 53/100
8/8 [==============================] - 4s 522ms/step - loss: 0.2765 -
categorical_accuracy: 0.8761 - val_loss: 1.5320 -
val_categorical_accuracy: 0.7391
Epoch 54/100
8/8 [==============================] - 4s 482ms/step - loss: 0.3396 -
categorical_accuracy: 0.8717 - val_loss: 1.9617 -
val_categorical_accuracy: 0.7174
Epoch 55/100
8/8 [==============================] - 4s 470ms/step - loss: 0.3080 -
categorical_accuracy: 0.9115 - val_loss: 2.1461 -
val_categorical_accuracy: 0.6957
Epoch 56/100
8/8 [==============================] - 4s 462ms/step - loss: 0.2680 -
categorical_accuracy: 0.8894 - val_loss: 2.8495 -
val_categorical_accuracy: 0.6304
Epoch 57/100
8/8 [==============================] - 4s 513ms/step - loss: 0.3185 -
categorical_accuracy: 0.8628 - val_loss: 1.4693 -
val_categorical_accuracy: 0.6304
Epoch 58/100
8/8 [==============================] - 4s 466ms/step - loss: 0.2969 -
categorical_accuracy: 0.8761 - val_loss: 1.1343 -
val_categorical_accuracy: 0.7391
Epoch 59/100
```

```
8/8 [==============================] - 4s 486ms/step - loss: 0.2561 -
categorical_accuracy: 0.9115 - val_loss: 1.9502 -
val_categorical_accuracy: 0.6522
Epoch 60/100
8/8 [==============================] - 4s 524ms/step - loss: 0.1977 -
categorical_accuracy: 0.9204 - val_loss: 0.2866 -
val_categorical_accuracy: 0.8696
Epoch 61/100
8/8 [==============================] - 4s 473ms/step - loss: 0.2778 -
categorical_accuracy: 0.8938 - val_loss: 0.1316 -
val_categorical_accuracy: 0.9565
Epoch 62/100
8/8 [==============================] - 4s 468ms/step - loss: 0.4524 -
categorical_accuracy: 0.8274 - val_loss: 0.2488 -
val_categorical_accuracy: 0.9130
Epoch 63/100
8/8 [==============================] - 4s 462ms/step - loss: 0.2955 -
categorical_accuracy: 0.9071 - val_loss: 3.2347 -
val_categorical_accuracy: 0.6304
Epoch 64/100
8/8 [==============================] - 4s 489ms/step - loss: 0.2799 -
categorical_accuracy: 0.8850 - val_loss: 2.0024 -
val_categorical_accuracy: 0.5217
Epoch 65/100
8/8 [==============================] - 4s 521ms/step - loss: 0.4240 -
categorical_accuracy: 0.8319 - val_loss: 3.2057 -
val_categorical_accuracy: 0.4348
Epoch 66/100
8/8 [==============================] - 4s 468ms/step - loss: 0.2740 -
categorical_accuracy: 0.8938 - val_loss: 0.7786 -
val_categorical_accuracy: 0.8261
Epoch 67/100
8/8 [==============================] - 4s 522ms/step - loss: 0.3054 -
categorical_accuracy: 0.8894 - val_loss: 0.3797 -
val_categorical_accuracy: 0.8696
Epoch 68/100
8/8 [==============================] - 4s 485ms/step - loss: 0.1820 -
categorical_accuracy: 0.9336 - val_loss: 0.9234 -
val_categorical_accuracy: 0.8043
Epoch 69/100
8/8 [==============================] - 4s 519ms/step - loss: 0.2544 -
categorical_accuracy: 0.9204 - val_loss: 3.5538 -
val_categorical_accuracy: 0.6522
Epoch 70/100
8/8 [==============================] - 4s 477ms/step - loss: 0.2216 -
categorical_accuracy: 0.9027 - val_loss: 2.8729 -
val_categorical_accuracy: 0.5652
Epoch 71/100
8/8 [==============================] - 4s 477ms/step - loss: 0.2942 -
categorical_accuracy: 0.8850 - val_loss: 1.7711 -
```

```
val_categorical_accuracy: 0.6304
Epoch 72/100
8/8 [==============================] - 4s 491ms/step - loss: 0.2534 -
categorical_accuracy: 0.9027 - val_loss: 0.6831 -
val_categorical_accuracy: 0.7391
Epoch 73/100
8/8 [==============================] - 4s 477ms/step - loss: 0.2407 -
categorical_accuracy: 0.9204 - val_loss: 0.3652 -
val_categorical_accuracy: 0.8696
Epoch 74/100
8/8 [==============================] - 4s 529ms/step - loss: 0.3706 -
categorical_accuracy: 0.8628 - val_loss: 0.9239 -
val_categorical_accuracy: 0.7391
Epoch 75/100
8/8 [==============================] - 4s 473ms/step - loss: 0.1933 -
categorical_accuracy: 0.9292 - val_loss: 2.2718 -
val_categorical_accuracy: 0.6957
Epoch 76/100
8/8 [==============================] - 4s 550ms/step - loss: 0.3080 -
categorical_accuracy: 0.8584 - val_loss: 2.2315 -
val_categorical_accuracy: 0.5217
Epoch 77/100
8/8 [==============================] - 4s 490ms/step - loss: 0.2734 -
categorical_accuracy: 0.8850 - val_loss: 0.4696 -
val_categorical_accuracy: 0.8696
Epoch 78/100
8/8 [==============================] - 4s 484ms/step - loss: 0.3327 -
categorical_accuracy: 0.8628 - val_loss: 0.6869 -
val_categorical_accuracy: 0.8261
Epoch 79/100
8/8 [==============================] - 4s 489ms/step - loss: 0.3090 -
categorical_accuracy: 0.8628 - val_loss: 2.3888 -
val_categorical_accuracy: 0.5870
Epoch 80/100
8/8 [==============================] - 4s 528ms/step - loss: 0.4996 -
categorical_accuracy: 0.8142 - val_loss: 2.3105 -
val_categorical_accuracy: 0.6304
Epoch 81/100
8/8 [==============================] - 4s 507ms/step - loss: 0.3443 -
categorical_accuracy: 0.8496 - val_loss: 0.2367 -
val_categorical_accuracy: 0.9348
Epoch 82/100
8/8 [==============================] - 4s 483ms/step - loss: 0.2244 -
categorical_accuracy: 0.8982 - val_loss: 0.3999 -
val_categorical_accuracy: 0.8043
Epoch 83/100
8/8 [==============================] - 4s 528ms/step - loss: 0.3580 -
categorical_accuracy: 0.8584 - val_loss: 2.1073 -
val_categorical_accuracy: 0.6087
Epoch 84/100
```

```
8/8 [==============================] - 4s 484ms/step - loss: 0.2239 -
categorical_accuracy: 0.9204 - val_loss: 1.1917 -
val_categorical_accuracy: 0.6957
Epoch 85/100
8/8 [==============================] - 4s 502ms/step - loss: 0.3302 -
categorical_accuracy: 0.8673 - val_loss: 1.6297 -
val_categorical_accuracy: 0.6304
Epoch 86/100
8/8 [==============================] - 4s 477ms/step - loss: 0.3305 -
categorical_accuracy: 0.8584 - val_loss: 0.2209 -
val_categorical_accuracy: 0.8696
Epoch 87/100
8/8 [==============================] - 4s 480ms/step - loss: 0.2725 -
categorical_accuracy: 0.8894 - val_loss: 1.4696 -
val_categorical_accuracy: 0.5652
Epoch 88/100
8/8 [==============================] - 4s 482ms/step - loss: 0.2532 -
categorical_accuracy: 0.8850 - val_loss: 0.4158 -
val_categorical_accuracy: 0.8261
Epoch 89/100
8/8 [==============================] - 4s 497ms/step - loss: 0.3003 -
categorical_accuracy: 0.8894 - val_loss: 0.4670 -
val_categorical_accuracy: 0.8261
Epoch 90/100
8/8 [==============================] - 4s 481ms/step - loss: 0.2788 -
categorical_accuracy: 0.8850 - val_loss: 0.4860 -
val_categorical_accuracy: 0.7609
Epoch 91/100
8/8 [==============================] - 4s 486ms/step - loss: 0.2510 -
categorical_accuracy: 0.8850 - val_loss: 0.3923 -
val_categorical_accuracy: 0.8043
Epoch 92/100
8/8 [==============================] - 4s 538ms/step - loss: 0.2843 -
categorical_accuracy: 0.8982 - val_loss: 0.1598 -
val_categorical_accuracy: 0.9565
Epoch 93/100
8/8 [==============================] - 4s 506ms/step - loss: 0.2946 -
categorical_accuracy: 0.8717 - val_loss: 1.3644 -
val_categorical_accuracy: 0.6739
Epoch 94/100
8/8 [==============================] - 4s 512ms/step - loss: 0.2408 -
categorical_accuracy: 0.8982 - val_loss: 1.3250 -
val_categorical_accuracy: 0.6957
Epoch 95/100
8/8 [==============================] - 4s 527ms/step - loss: 0.2017 -
categorical_accuracy: 0.9071 - val_loss: 0.2784 -
val_categorical_accuracy: 0.8913
Epoch 96/100
8/8 [==============================] - 4s 543ms/step - loss: 0.3520 -
categorical_accuracy: 0.8584 - val_loss: 0.6675 -
```

```
val_categorical_accuracy: 0.8043
Epoch 97/100
8/8 [==============================] - 5s 601ms/step - loss: 0.2783 -
categorical_accuracy: 0.8805 - val_loss: 0.2451 -
val_categorical_accuracy: 0.9348
Epoch 98/100
8/8 [==============================] - 4s 531ms/step - loss: 0.2667 -
categorical_accuracy: 0.9071 - val_loss: 1.3605 -
val_categorical_accuracy: 0.6739
Epoch 99/100
8/8 [==============================] - 4s 541ms/step - loss: 0.3537 -
categorical_accuracy: 0.8584 - val_loss: 0.6438 -
val_categorical_accuracy: 0.8261
Epoch 100/100
8/8 [==============================] - 4s 509ms/step - loss: 0.2112 -
categorical_accuracy: 0.9159 - val_loss: 0.2723 -
val_categorical_accuracy: 0.9130
2/2 [==============================] - 1s 165ms/step - loss: 0.5076 -
categorical_accuracy: 0.8043
Test accuracy: 0.804347813129425
Epoch 1/100
8/8 [==============================] - 5s 606ms/step - loss: 1.1111 -
categorical_accuracy: 0.3938 - val_loss: 1.0998 -
val_categorical_accuracy: 0.3478
Epoch 2/100
8/8 [==============================] - 4s 525ms/step - loss: 1.1058 -
categorical_accuracy: 0.3938 - val_loss: 1.0993 -
val_categorical_accuracy: 0.3478
Epoch 3/100
8/8 [==============================] - 4s 557ms/step - loss: 1.1006 -
categorical_accuracy: 0.3938 - val_loss: 1.0977 -
val_categorical_accuracy: 0.3478
Epoch 4/100
8/8 [==============================] - 4s 562ms/step - loss: 1.0990 -
categorical_accuracy: 0.3938 - val_loss: 1.0952 -
val_categorical_accuracy: 0.3478
Epoch 5/100
8/8 [==============================] - 4s 542ms/step - loss: 1.0912 -
categorical_accuracy: 0.3938 - val_loss: 1.0925 -
val_categorical_accuracy: 0.3478
Epoch 6/100
8/8 [==============================] - 4s 548ms/step - loss: 1.0911 -
categorical_accuracy: 0.3938 - val_loss: 1.0896 -
val_categorical_accuracy: 0.3478
Epoch 7/100
8/8 [==============================] - 4s 552ms/step - loss: 1.0872 -
categorical_accuracy: 0.3938 - val_loss: 1.0867 -
val_categorical_accuracy: 0.3478
Epoch 8/100
8/8 [==============================] - 4s 631ms/step - loss: 1.0842 -
```

```
categorical_accuracy: 0.3938 - val_loss: 1.0839 -
val_categorical_accuracy: 0.3478
Epoch 9/100
8/8 [==============================] - 4s 608ms/step - loss: 1.0797 -
categorical_accuracy: 0.3938 - val_loss: 1.0807 -
val_categorical_accuracy: 0.3478
Epoch 10/100
8/8 [==============================] - 4s 559ms/step - loss: 1.0776 -
categorical_accuracy: 0.3938 - val_loss: 1.0774 -
val_categorical_accuracy: 0.3478
Epoch 11/100
8/8 [==============================] - 4s 568ms/step - loss: 1.0709 -
categorical_accuracy: 0.3938 - val_loss: 1.0743 -
val_categorical_accuracy: 0.3478
Epoch 12/100
8/8 [==============================] - 4s 556ms/step - loss: 1.0694 -
categorical_accuracy: 0.3938 - val_loss: 1.0710 -
val_categorical_accuracy: 0.3478
Epoch 13/100
8/8 [==============================] - 4s 554ms/step - loss: 1.0637 -
categorical_accuracy: 0.3938 - val_loss: 1.0677 -
val_categorical_accuracy: 0.3478
Epoch 14/100
8/8 [==============================] - 4s 554ms/step - loss: 1.0602 -
categorical_accuracy: 0.3938 - val_loss: 1.0643 -
val_categorical_accuracy: 0.3478
Epoch 15/100
8/8 [==============================] - 5s 584ms/step - loss: 1.0560 -
categorical_accuracy: 0.3938 - val_loss: 1.0612 -
val_categorical_accuracy: 0.3478
Epoch 16/100
8/8 [==============================] - 4s 559ms/step - loss: 1.0522 -
categorical_accuracy: 0.3938 - val_loss: 1.0580 -
val_categorical_accuracy: 0.3696
Epoch 17/100
8/8 [==============================] - 4s 562ms/step - loss: 1.0461 -
categorical_accuracy: 0.3982 - val_loss: 1.0546 -
val_categorical_accuracy: 0.3696
Epoch 18/100
8/8 [==============================] - 4s 617ms/step - loss: 1.0447 -
categorical_accuracy: 0.3982 - val_loss: 1.0516 -
val_categorical_accuracy: 0.3696
Epoch 19/100
8/8 [==============================] - 5s 578ms/step - loss: 1.0405 -
categorical_accuracy: 0.3982 - val_loss: 1.0484 -
val_categorical_accuracy: 0.3913
Epoch 20/100
8/8 [==============================] - 4s 571ms/step - loss: 1.0366 -
categorical_accuracy: 0.4027 - val_loss: 1.0455 -
val_categorical_accuracy: 0.3913
```

```
Epoch 21/100
8/8 [==============================] - 4s 561ms/step - loss: 1.0343 -
categorical_accuracy: 0.3982 - val_loss: 1.0419 -
val_categorical_accuracy: 0.3913
Epoch 22/100
8/8 [==============================] - 5s 575ms/step - loss: 1.0275 -
categorical_accuracy: 0.4027 - val_loss: 1.0389 -
val_categorical_accuracy: 0.3913
Epoch 23/100
8/8 [==============================] - 4s 617ms/step - loss: 1.0265 -
categorical_accuracy: 0.4027 - val_loss: 1.0358 -
val_categorical_accuracy: 0.3913
Epoch 24/100
8/8 [==============================] - 4s 559ms/step - loss: 1.0230 -
categorical_accuracy: 0.4071 - val_loss: 1.0329 -
val_categorical_accuracy: 0.3913
Epoch 25/100
8/8 [==============================] - 5s 602ms/step - loss: 1.0197 -
categorical_accuracy: 0.4159 - val_loss: 1.0292 -
val_categorical_accuracy: 0.3913
Epoch 26/100
8/8 [==============================] - 5s 575ms/step - loss: 1.0168 -
categorical_accuracy: 0.4336 - val_loss: 1.0256 -
val_categorical_accuracy: 0.3913
Epoch 27/100
8/8 [==============================] - 4s 554ms/step - loss: 1.0155 -
categorical_accuracy: 0.4204 - val_loss: 1.0226 -
val_categorical_accuracy: 0.3913
Epoch 28/100
8/8 [==============================] - 4s 560ms/step - loss: 1.0091 -
categorical_accuracy: 0.4292 - val_loss: 1.0197 -
val_categorical_accuracy: 0.4130
Epoch 29/100
8/8 [==============================] - 5s 583ms/step - loss: 1.0084 -
categorical_accuracy: 0.4513 - val_loss: 1.0160 -
val_categorical_accuracy: 0.4130
Epoch 30/100
8/8 [==============================] - 4s 563ms/step - loss: 1.0023 -
categorical_accuracy: 0.4646 - val_loss: 1.0124 -
val_categorical_accuracy: 0.4130
Epoch 31/100
8/8 [==============================] - 4s 557ms/step - loss: 0.9976 -
categorical_accuracy: 0.4779 - val_loss: 1.0086 -
val_categorical_accuracy: 0.4130
Epoch 32/100
8/8 [==============================] - 4s 550ms/step - loss: 0.9930 -
categorical_accuracy: 0.4646 - val_loss: 1.0053 -
val_categorical_accuracy: 0.4130
Epoch 33/100
8/8 [==============================] - 5s 690ms/step - loss: 0.9927 -
```

```
categorical_accuracy: 0.4912 - val_loss: 1.0023 -
val_categorical_accuracy: 0.4130
Epoch 34/100
8/8 [==============================] - 32s 4s/step - loss: 0.9883 -
categorical_accuracy: 0.4867 - val_loss: 0.9985 -
val_categorical_accuracy: 0.4130
Epoch 35/100
8/8 [==============================] - 4s 530ms/step - loss: 0.9852 -
categorical_accuracy: 0.5044 - val_loss: 0.9955 -
val_categorical_accuracy: 0.4130
Epoch 36/100
8/8 [==============================] - 26s 4s/step - loss: 0.9811 -
categorical_accuracy: 0.5133 - val_loss: 0.9922 -
val_categorical_accuracy: 0.4130
Epoch 37/100
8/8 [==============================] - 39s 5s/step - loss: 0.9870 -
categorical_accuracy: 0.5044 - val_loss: 0.9896 -
val_categorical_accuracy: 0.4130
Epoch 38/100
8/8 [==============================] - 4s 462ms/step - loss: 0.9760 -
categorical_accuracy: 0.5398 - val_loss: 0.9867 -
val_categorical_accuracy: 0.4130
Epoch 39/100
8/8 [==============================] - 4s 467ms/step - loss: 0.9755 -
categorical_accuracy: 0.5354 - val_loss: 0.9831 -
val_categorical_accuracy: 0.4348
Epoch 40/100
8/8 [==============================] - 4s 450ms/step - loss: 0.9723 -
categorical_accuracy: 0.5442 - val_loss: 0.9802 -
val_categorical_accuracy: 0.4348
Epoch 41/100
8/8 [==============================] - 4s 500ms/step - loss: 0.9684 -
categorical_accuracy: 0.5398 - val_loss: 0.9777 -
val_categorical_accuracy: 0.4565
Epoch 42/100
8/8 [==============================] - 4s 473ms/step - loss: 0.9626 -
categorical_accuracy: 0.5796 - val_loss: 0.9742 -
val_categorical_accuracy: 0.4565
Epoch 43/100
8/8 [==============================] - 4s 474ms/step - loss: 0.9538 -
categorical_accuracy: 0.5487 - val_loss: 0.9712 -
val_categorical_accuracy: 0.4565
Epoch 44/100
8/8 [==============================] - 4s 470ms/step - loss: 0.9503 -
categorical_accuracy: 0.5929 - val_loss: 0.9677 -
val_categorical_accuracy: 0.4565
Epoch 45/100
8/8 [==============================] - 4s 508ms/step - loss: 0.9554 -
categorical_accuracy: 0.5708 - val_loss: 0.9651 -
val_categorical_accuracy: 0.4565
```

```
Epoch 46/100
8/8 [==============================] - 4s 463ms/step - loss: 0.9466 -
categorical_accuracy: 0.6018 - val_loss: 0.9619 -
val_categorical_accuracy: 0.4565
Epoch 47/100
8/8 [==============================] - 4s 472ms/step - loss: 0.9450 -
categorical_accuracy: 0.5841 - val_loss: 0.9593 -
val_categorical_accuracy: 0.4565
Epoch 48/100
8/8 [==============================] - 4s 488ms/step - loss: 0.9414 -
categorical_accuracy: 0.6018 - val_loss: 0.9568 -
val_categorical_accuracy: 0.4565
Epoch 49/100
8/8 [==============================] - 4s 471ms/step - loss: 0.9377 -
categorical_accuracy: 0.6239 - val_loss: 0.9539 -
val_categorical_accuracy: 0.4565
Epoch 50/100
8/8 [==============================] - 4s 480ms/step - loss: 0.9376 -
categorical_accuracy: 0.6062 - val_loss: 0.9512 -
val_categorical_accuracy: 0.4565
Epoch 51/100
8/8 [==============================] - 4s 480ms/step - loss: 0.9288 -
categorical_accuracy: 0.6195 - val_loss: 0.9476 -
val_categorical_accuracy: 0.4565
Epoch 52/100
8/8 [==============================] - 4s 485ms/step - loss: 0.9277 -
categorical_accuracy: 0.6327 - val_loss: 0.9457 -
val_categorical_accuracy: 0.4565
Epoch 53/100
8/8 [==============================] - 4s 465ms/step - loss: 0.9324 -
categorical_accuracy: 0.6106 - val_loss: 0.9422 -
val_categorical_accuracy: 0.4783
Epoch 54/100
8/8 [==============================] - 4s 473ms/step - loss: 0.9268 -
categorical_accuracy: 0.6062 - val_loss: 0.9395 -
val_categorical_accuracy: 0.4783
Epoch 55/100
8/8 [==============================] - 4s 477ms/step - loss: 0.9203 -
categorical_accuracy: 0.6283 - val_loss: 0.9364 -
val_categorical_accuracy: 0.4783
Epoch 56/100
8/8 [==============================] - 4s 508ms/step - loss: 0.9161 -
categorical_accuracy: 0.6460 - val_loss: 0.9336 -
val_categorical_accuracy: 0.5000
Epoch 57/100
8/8 [==============================] - 4s 488ms/step - loss: 0.9187 -
categorical_accuracy: 0.6372 - val_loss: 0.9310 -
val_categorical_accuracy: 0.5000
Epoch 58/100
8/8 [==============================] - 4s 498ms/step - loss: 0.9047 -
```

```
categorical_accuracy: 0.6726 - val_loss: 0.9271 -
val_categorical_accuracy: 0.5000
Epoch 59/100
8/8 [==============================] - 4s 488ms/step - loss: 0.9088 -
categorical_accuracy: 0.6504 - val_loss: 0.9234 -
val_categorical_accuracy: 0.5217
Epoch 60/100
8/8 [==============================] - 4s 501ms/step - loss: 0.9005 -
categorical_accuracy: 0.6770 - val_loss: 0.9206 -
val_categorical_accuracy: 0.5435
Epoch 61/100
8/8 [==============================] - 4s 484ms/step - loss: 0.9048 -
categorical_accuracy: 0.6549 - val_loss: 0.9168 -
val_categorical_accuracy: 0.5435
Epoch 62/100
8/8 [==============================] - 4s 483ms/step - loss: 0.9047 -
categorical_accuracy: 0.6593 - val_loss: 0.9131 -
val_categorical_accuracy: 0.5435
Epoch 63/100
8/8 [==============================] - 4s 484ms/step - loss: 0.8933 -
categorical_accuracy: 0.6681 - val_loss: 0.9108 -
val_categorical_accuracy: 0.5435
Epoch 64/100
8/8 [==============================] - 4s 480ms/step - loss: 0.8886 -
categorical_accuracy: 0.6814 - val_loss: 0.9084 -
val_categorical_accuracy: 0.5435
Epoch 65/100
8/8 [==============================] - 4s 488ms/step - loss: 0.8848 -
categorical_accuracy: 0.6947 - val_loss: 0.9050 -
val_categorical_accuracy: 0.5435
Epoch 66/100
8/8 [==============================] - 4s 496ms/step - loss: 0.8921 -
categorical_accuracy: 0.6681 - val_loss: 0.9014 -
val_categorical_accuracy: 0.5435
Epoch 67/100
8/8 [==============================] - 4s 494ms/step - loss: 0.8777 -
categorical_accuracy: 0.6903 - val_loss: 0.8999 -
val_categorical_accuracy: 0.5435
Epoch 68/100
8/8 [==============================] - 4s 492ms/step - loss: 0.8755 -
categorical_accuracy: 0.6726 - val_loss: 0.8972 -
val_categorical_accuracy: 0.5435
Epoch 69/100
8/8 [==============================] - 4s 515ms/step - loss: 0.8830 -
categorical_accuracy: 0.6681 - val_loss: 0.8939 -
val_categorical_accuracy: 0.5435
Epoch 70/100
8/8 [==============================] - 4s 500ms/step - loss: 0.8703 -
categorical_accuracy: 0.6991 - val_loss: 0.8920 -
val_categorical_accuracy: 0.5652
```

```
Epoch 71/100
8/8 [==============================] - 4s 564ms/step - loss: 0.8691 -
categorical_accuracy: 0.6947 - val_loss: 0.8891 -
val_categorical_accuracy: 0.5652
Epoch 72/100
8/8 [==============================] - 4s 509ms/step - loss: 0.8650 -
categorical_accuracy: 0.6991 - val_loss: 0.8867 -
val_categorical_accuracy: 0.5652
Epoch 73/100
8/8 [==============================] - 5s 623ms/step - loss: 0.8689 -
categorical_accuracy: 0.7080 - val_loss: 0.8829 -
val_categorical_accuracy: 0.5652
Epoch 74/100
8/8 [==============================] - 7s 946ms/step - loss: 0.8629 -
categorical_accuracy: 0.7257 - val_loss: 0.8803 -
val_categorical_accuracy: 0.5652
Epoch 75/100
8/8 [==============================] - 4s 495ms/step - loss: 0.8495 -
categorical_accuracy: 0.7257 - val_loss: 0.8783 -
val_categorical_accuracy: 0.5652
Epoch 76/100
8/8 [==============================] - 4s 587ms/step - loss: 0.8606 -
categorical_accuracy: 0.7212 - val_loss: 0.8738 -
val_categorical_accuracy: 0.5652
Epoch 77/100
8/8 [==============================] - 4s 477ms/step - loss: 0.8505 -
categorical_accuracy: 0.7345 - val_loss: 0.8701 -
val_categorical_accuracy: 0.5870
Epoch 78/100
8/8 [==============================] - 4s 477ms/step - loss: 0.8542 -
categorical_accuracy: 0.7035 - val_loss: 0.8669 -
val_categorical_accuracy: 0.6087
Epoch 79/100
8/8 [==============================] - 4s 484ms/step - loss: 0.8482 -
categorical_accuracy: 0.6858 - val_loss: 0.8642 -
val_categorical_accuracy: 0.6087
Epoch 80/100
8/8 [==============================] - 4s 483ms/step - loss: 0.8487 -
categorical_accuracy: 0.7345 - val_loss: 0.8625 -
val_categorical_accuracy: 0.6087
Epoch 81/100
8/8 [==============================] - 4s 526ms/step - loss: 0.8427 -
categorical_accuracy: 0.7478 - val_loss: 0.8604 -
val_categorical_accuracy: 0.6087
Epoch 82/100
8/8 [==============================] - 4s 485ms/step - loss: 0.8345 -
categorical_accuracy: 0.7389 - val_loss: 0.8586 -
val_categorical_accuracy: 0.6087
Epoch 83/100
8/8 [==============================] - 4s 491ms/step - loss: 0.8386 -
```

```
categorical_accuracy: 0.7345 - val_loss: 0.8563 -
val_categorical_accuracy: 0.6087
Epoch 84/100
8/8 [==============================] - 4s 485ms/step - loss: 0.8302 -
categorical_accuracy: 0.7478 - val_loss: 0.8542 -
val_categorical_accuracy: 0.6087
Epoch 85/100
8/8 [==============================] - 4s 503ms/step - loss: 0.8311 -
categorical_accuracy: 0.7611 - val_loss: 0.8499 -
val_categorical_accuracy: 0.6087
Epoch 86/100
8/8 [==============================] - 4s 478ms/step - loss: 0.8257 -
categorical_accuracy: 0.7743 - val_loss: 0.8485 -
val_categorical_accuracy: 0.6304
Epoch 87/100
8/8 [==============================] - 4s 505ms/step - loss: 0.8290 -
categorical_accuracy: 0.7478 - val_loss: 0.8444 -
val_categorical_accuracy: 0.6304
Epoch 88/100
8/8 [==============================] - 4s 561ms/step - loss: 0.8151 -
categorical_accuracy: 0.7876 - val_loss: 0.8411 -
val_categorical_accuracy: 0.6304
Epoch 89/100
8/8 [==============================] - 4s 583ms/step - loss: 0.8231 -
categorical_accuracy: 0.7478 - val_loss: 0.8376 -
val_categorical_accuracy: 0.6304
Epoch 90/100
8/8 [==============================] - 4s 498ms/step - loss: 0.8257 -
categorical_accuracy: 0.7522 - val_loss: 0.8344 -
val_categorical_accuracy: 0.6304
Epoch 91/100
8/8 [==============================] - 4s 519ms/step - loss: 0.8065 -
categorical_accuracy: 0.7832 - val_loss: 0.8313 -
val_categorical_accuracy: 0.6304
Epoch 92/100
8/8 [==============================] - 4s 515ms/step - loss: 0.8120 -
categorical_accuracy: 0.7876 - val_loss: 0.8294 -
val_categorical_accuracy: 0.6522
Epoch 93/100
8/8 [==============================] - 4s 566ms/step - loss: 0.8067 -
categorical_accuracy: 0.7876 - val_loss: 0.8261 -
val_categorical_accuracy: 0.6522
Epoch 94/100
8/8 [==============================] - 4s 564ms/step - loss: 0.8044 -
categorical_accuracy: 0.7832 - val_loss: 0.8257 -
val_categorical_accuracy: 0.6522
Epoch 95/100
8/8 [==============================] - 5s 581ms/step - loss: 0.7948 -
categorical_accuracy: 0.7965 - val_loss: 0.8225 -
val_categorical_accuracy: 0.6522
```

```
Epoch 96/100
8/8 [==============================] - 5s 613ms/step - loss: 0.7898 -
categorical_accuracy: 0.7965 - val_loss: 0.8194 -
val_categorical_accuracy: 0.6522
Epoch 97/100
8/8 [==============================] - 4s 568ms/step - loss: 0.7880 -
categorical_accuracy: 0.8097 - val_loss: 0.8176 -
val_categorical_accuracy: 0.6522
Epoch 98/100
8/8 [==============================] - 4s 634ms/step - loss: 0.7942 -
categorical_accuracy: 0.7743 - val_loss: 0.8149 -
val_categorical_accuracy: 0.6522
Epoch 99/100
8/8 [==============================] - 5s 589ms/step - loss: 0.7845 -
categorical_accuracy: 0.7920 - val_loss: 0.8120 -
val_categorical_accuracy: 0.6522
Epoch 100/100
8/8 [==============================] - 5s 607ms/step - loss: 0.7808 -
categorical_accuracy: 0.8319 - val_loss: 0.8076 -
val_categorical_accuracy: 0.6522
2/2 [==============================] - 1s 194ms/step - loss: 0.7153 -
categorical_accuracy: 0.8043
Test accuracy: 0.804347813129425

pretrained_model = train(learning_rate=0.0001)

Epoch 1/100
8/8 [==============================] - 5s 543ms/step - loss: 1.2943 -
categorical_accuracy: 0.3540 - val_loss: 1.3173 -
val_categorical_accuracy: 0.3043
Epoch 2/100
8/8 [==============================] - 4s 515ms/step - loss: 1.2376 -
categorical_accuracy: 0.3540 - val_loss: 1.2607 -
val_categorical_accuracy: 0.3043
Epoch 3/100
8/8 [==============================] - 4s 557ms/step - loss: 1.1822 -
categorical_accuracy: 0.3540 - val_loss: 1.2088 -
val_categorical_accuracy: 0.3043
Epoch 4/100
8/8 [==============================] - 4s 549ms/step - loss: 1.1405 -
categorical_accuracy: 0.3540 - val_loss: 1.1590 -
val_categorical_accuracy: 0.3043
Epoch 5/100
8/8 [==============================] - 4s 557ms/step - loss: 1.0930 -
categorical_accuracy: 0.3540 - val_loss: 1.1156 -
val_categorical_accuracy: 0.3043
Epoch 6/100
8/8 [==============================] - 5s 592ms/step - loss: 1.0527 -
categorical_accuracy: 0.3628 - val_loss: 1.0730 -
val_categorical_accuracy: 0.3043
Epoch 7/100
```

```
8/8 [==============================] - 5s 590ms/step - loss: 1.0190 -
categorical_accuracy: 0.3805 - val_loss: 1.0330 -
val_categorical_accuracy: 0.3043
Epoch 8/100
8/8 [==============================] - 5s 577ms/step - loss: 0.9834 -
categorical_accuracy: 0.3894 - val_loss: 0.9926 -
val_categorical_accuracy: 0.3261
Epoch 9/100
8/8 [==============================] - 5s 593ms/step - loss: 0.9418 -
categorical_accuracy: 0.4159 - val_loss: 0.9554 -
val_categorical_accuracy: 0.3478
Epoch 10/100
8/8 [==============================] - 5s 597ms/step - loss: 0.9055 -
categorical_accuracy: 0.5088 - val_loss: 0.9219 -
val_categorical_accuracy: 0.4565
Epoch 11/100
8/8 [==============================] - 4s 567ms/step - loss: 0.8717 -
categorical_accuracy: 0.5929 - val_loss: 0.8908 -
val_categorical_accuracy: 0.5652
Epoch 12/100
8/8 [==============================] - 4s 563ms/step - loss: 0.8369 -
categorical_accuracy: 0.6637 - val_loss: 0.8614 -
val_categorical_accuracy: 0.6739
Epoch 13/100
8/8 [==============================] - 5s 599ms/step - loss: 0.8063 -
categorical_accuracy: 0.7389 - val_loss: 0.8340 -
val_categorical_accuracy: 0.6957
Epoch 14/100
8/8 [==============================] - 5s 574ms/step - loss: 0.7831 -
categorical_accuracy: 0.7522 - val_loss: 0.8083 -
val_categorical_accuracy: 0.7826
Epoch 15/100
8/8 [==============================] - 5s 580ms/step - loss: 0.7538 -
categorical_accuracy: 0.7832 - val_loss: 0.7832 -
val_categorical_accuracy: 0.8261
Epoch 16/100
8/8 [==============================] - 5s 593ms/step - loss: 0.7443 -
categorical_accuracy: 0.7743 - val_loss: 0.7607 -
val_categorical_accuracy: 0.8261
Epoch 17/100
8/8 [==============================] - 5s 650ms/step - loss: 0.6916 -
categorical_accuracy: 0.8451 - val_loss: 0.7366 -
val_categorical_accuracy: 0.8478
Epoch 18/100
8/8 [==============================] - 5s 585ms/step - loss: 0.6827 -
categorical_accuracy: 0.8319 - val_loss: 0.7124 -
val_categorical_accuracy: 0.8478
Epoch 19/100
8/8 [==============================] - 4s 561ms/step - loss: 0.6507 -
categorical_accuracy: 0.8717 - val_loss: 0.6904 -
```

val_categorical_accuracy: 0.8478
Epoch 20/100
8/8 [==============================] - 5s 587ms/step - loss: 0.6234 -
categorical_accuracy: 0.8761 - val_loss: 0.6698 -
val_categorical_accuracy: 0.8478
Epoch 21/100
8/8 [==============================] - 4s 562ms/step - loss: 0.6158 -
categorical_accuracy: 0.8761 - val_loss: 0.6489 -
val_categorical_accuracy: 0.8478
Epoch 22/100
8/8 [==============================] - 4s 619ms/step - loss: 0.5838 -
categorical_accuracy: 0.8850 - val_loss: 0.6305 -
val_categorical_accuracy: 0.8913
Epoch 23/100
8/8 [==============================] - 4s 626ms/step - loss: 0.5642 -
categorical_accuracy: 0.9204 - val_loss: 0.6144 -
val_categorical_accuracy: 0.8696
Epoch 24/100
8/8 [==============================] - 5s 577ms/step - loss: 0.5704 -
categorical_accuracy: 0.8673 - val_loss: 0.5968 -
val_categorical_accuracy: 0.8913
Epoch 25/100
8/8 [==============================] - 4s 557ms/step - loss: 0.5187 -
categorical_accuracy: 0.9248 - val_loss: 0.5777 -
val_categorical_accuracy: 0.8913
Epoch 26/100
8/8 [==============================] - 4s 560ms/step - loss: 0.5119 -
categorical_accuracy: 0.8938 - val_loss: 0.5562 -
val_categorical_accuracy: 0.8913
Epoch 27/100
8/8 [==============================] - 5s 578ms/step - loss: 0.4994 -
categorical_accuracy: 0.9115 - val_loss: 0.5359 -
val_categorical_accuracy: 0.9130
Epoch 28/100
8/8 [==============================] - 4s 563ms/step - loss: 0.4968 -
categorical_accuracy: 0.8673 - val_loss: 0.5172 -
val_categorical_accuracy: 0.9130
Epoch 29/100
8/8 [==============================] - 4s 622ms/step - loss: 0.4576 -
categorical_accuracy: 0.9027 - val_loss: 0.5010 -
val_categorical_accuracy: 0.9130
Epoch 30/100
8/8 [==============================] - 4s 566ms/step - loss: 0.4230 -
categorical_accuracy: 0.9336 - val_loss: 0.4849 -
val_categorical_accuracy: 0.9130
Epoch 31/100
8/8 [==============================] - 5s 585ms/step - loss: 0.4192 -
categorical_accuracy: 0.9248 - val_loss: 0.4692 -
val_categorical_accuracy: 0.9130
Epoch 32/100

```
8/8 [==============================] - 4s 618ms/step - loss: 0.4206 -
categorical_accuracy: 0.9159 - val_loss: 0.4552 -
val_categorical_accuracy: 0.9130
Epoch 33/100
8/8 [==============================] - 4s 562ms/step - loss: 0.3989 -
categorical_accuracy: 0.9027 - val_loss: 0.4407 -
val_categorical_accuracy: 0.9130
Epoch 34/100
8/8 [==============================] - 4s 621ms/step - loss: 0.3958 -
categorical_accuracy: 0.8982 - val_loss: 0.4294 -
val_categorical_accuracy: 0.9130
Epoch 35/100
8/8 [==============================] - 5s 574ms/step - loss: 0.3830 -
categorical_accuracy: 0.9159 - val_loss: 0.4146 -
val_categorical_accuracy: 0.9348
Epoch 36/100
8/8 [==============================] - 5s 588ms/step - loss: 0.3467 -
categorical_accuracy: 0.9248 - val_loss: 0.4016 -
val_categorical_accuracy: 0.9348
Epoch 37/100
8/8 [==============================] - 5s 621ms/step - loss: 0.3521 -
categorical_accuracy: 0.9115 - val_loss: 0.3875 -
val_categorical_accuracy: 0.9348
Epoch 38/100
8/8 [==============================] - 5s 646ms/step - loss: 0.3210 -
categorical_accuracy: 0.9336 - val_loss: 0.3727 -
val_categorical_accuracy: 0.9348
Epoch 39/100
8/8 [==============================] - 5s 587ms/step - loss: 0.3289 -
categorical_accuracy: 0.9159 - val_loss: 0.3622 -
val_categorical_accuracy: 0.9348
Epoch 40/100
8/8 [==============================] - 5s 692ms/step - loss: 0.3482 -
categorical_accuracy: 0.9071 - val_loss: 0.3493 -
val_categorical_accuracy: 0.9565
Epoch 41/100
8/8 [==============================] - 5s 672ms/step - loss: 0.3411 -
categorical_accuracy: 0.9115 - val_loss: 0.3407 -
val_categorical_accuracy: 0.9565
Epoch 42/100
8/8 [==============================] - 4s 566ms/step - loss: 0.3010 -
categorical_accuracy: 0.9381 - val_loss: 0.3350 -
val_categorical_accuracy: 0.9565
Epoch 43/100
8/8 [==============================] - 4s 569ms/step - loss: 0.3130 -
categorical_accuracy: 0.9115 - val_loss: 0.3301 -
val_categorical_accuracy: 0.9348
Epoch 44/100
8/8 [==============================] - 4s 568ms/step - loss: 0.3138 -
categorical_accuracy: 0.9336 - val_loss: 0.3307 -
```

```
val_categorical_accuracy: 0.9348
Epoch 45/100
8/8 [==============================] - 5s 606ms/step - loss: 0.2839 -
categorical_accuracy: 0.9336 - val_loss: 0.3252 -
val_categorical_accuracy: 0.9348
Epoch 46/100
8/8 [==============================] - 5s 578ms/step - loss: 0.3097 -
categorical_accuracy: 0.8982 - val_loss: 0.3121 -
val_categorical_accuracy: 0.9565
Epoch 47/100
8/8 [==============================] - 5s 580ms/step - loss: 0.2809 -
categorical_accuracy: 0.9115 - val_loss: 0.3000 -
val_categorical_accuracy: 0.9348
Epoch 48/100
8/8 [==============================] - 5s 597ms/step - loss: 0.2613 -
categorical_accuracy: 0.9381 - val_loss: 0.2948 -
val_categorical_accuracy: 0.9565
Epoch 49/100
8/8 [==============================] - 4s 620ms/step - loss: 0.2911 -
categorical_accuracy: 0.9115 - val_loss: 0.2920 -
val_categorical_accuracy: 0.9565
Epoch 50/100
8/8 [==============================] - 4s 567ms/step - loss: 0.2772 -
categorical_accuracy: 0.9336 - val_loss: 0.2918 -
val_categorical_accuracy: 0.9565
Epoch 51/100
8/8 [==============================] - 5s 577ms/step - loss: 0.2557 -
categorical_accuracy: 0.9381 - val_loss: 0.2830 -
val_categorical_accuracy: 0.9565
Epoch 52/100
8/8 [==============================] - 5s 595ms/step - loss: 0.2416 -
categorical_accuracy: 0.9292 - val_loss: 0.2756 -
val_categorical_accuracy: 0.9565
Epoch 53/100
8/8 [==============================] - 4s 571ms/step - loss: 0.2394 -
categorical_accuracy: 0.9381 - val_loss: 0.2748 -
val_categorical_accuracy: 0.9565
Epoch 54/100
8/8 [==============================] - 4s 564ms/step - loss: 0.2622 -
categorical_accuracy: 0.9204 - val_loss: 0.2687 -
val_categorical_accuracy: 0.9565
Epoch 55/100
8/8 [==============================] - 5s 596ms/step - loss: 0.2345 -
categorical_accuracy: 0.9469 - val_loss: 0.2609 -
val_categorical_accuracy: 0.9783
Epoch 56/100
8/8 [==============================] - 4s 563ms/step - loss: 0.2395 -
categorical_accuracy: 0.9292 - val_loss: 0.2591 -
val_categorical_accuracy: 0.9565
Epoch 57/100
```

```
8/8 [==============================] - 4s 560ms/step - loss: 0.2575 -
categorical_accuracy: 0.9248 - val_loss: 0.2598 -
val_categorical_accuracy: 0.9565
Epoch 58/100
8/8 [==============================] - 4s 616ms/step - loss: 0.2229 -
categorical_accuracy: 0.9292 - val_loss: 0.2634 -
val_categorical_accuracy: 0.9348
Epoch 59/100
8/8 [==============================] - 5s 642ms/step - loss: 0.2278 -
categorical_accuracy: 0.9425 - val_loss: 0.2570 -
val_categorical_accuracy: 0.9348
Epoch 60/100
8/8 [==============================] - 5s 576ms/step - loss: 0.2809 -
categorical_accuracy: 0.8761 - val_loss: 0.2534 -
val_categorical_accuracy: 0.9348
Epoch 61/100
8/8 [==============================] - 4s 563ms/step - loss: 0.2068 -
categorical_accuracy: 0.9425 - val_loss: 0.2476 -
val_categorical_accuracy: 0.9348
Epoch 62/100
8/8 [==============================] - 5s 577ms/step - loss: 0.2372 -
categorical_accuracy: 0.9381 - val_loss: 0.2483 -
val_categorical_accuracy: 0.9348
Epoch 63/100
8/8 [==============================] - 5s 568ms/step - loss: 0.2220 -
categorical_accuracy: 0.9469 - val_loss: 0.2486 -
val_categorical_accuracy: 0.9348
Epoch 64/100
8/8 [==============================] - 4s 562ms/step - loss: 0.2187 -
categorical_accuracy: 0.9381 - val_loss: 0.2531 -
val_categorical_accuracy: 0.9348
Epoch 65/100
8/8 [==============================] - 4s 565ms/step - loss: 0.2409 -
categorical_accuracy: 0.9469 - val_loss: 0.2475 -
val_categorical_accuracy: 0.9348
Epoch 66/100
8/8 [==============================] - 5s 586ms/step - loss: 0.1800 -
categorical_accuracy: 0.9469 - val_loss: 0.2483 -
val_categorical_accuracy: 0.9348
Epoch 67/100
8/8 [==============================] - 4s 555ms/step - loss: 0.2333 -
categorical_accuracy: 0.9425 - val_loss: 0.2446 -
val_categorical_accuracy: 0.9348
Epoch 68/100
8/8 [==============================] - 4s 564ms/step - loss: 0.2846 -
categorical_accuracy: 0.8938 - val_loss: 0.2311 -
val_categorical_accuracy: 0.9348
Epoch 69/100
8/8 [==============================] - 4s 555ms/step - loss: 0.2354 -
categorical_accuracy: 0.9159 - val_loss: 0.2151 -
```

```
val_categorical_accuracy: 0.9348
Epoch 70/100
8/8 [==============================] - 5s 576ms/step - loss: 0.2196 -
categorical_accuracy: 0.9469 - val_loss: 0.2064 -
val_categorical_accuracy: 0.9565
Epoch 71/100
8/8 [==============================] - 4s 565ms/step - loss: 0.1941 -
categorical_accuracy: 0.9558 - val_loss: 0.2012 -
val_categorical_accuracy: 0.9783
Epoch 72/100
8/8 [==============================] - 4s 551ms/step - loss: 0.2245 -
categorical_accuracy: 0.9336 - val_loss: 0.2030 -
val_categorical_accuracy: 0.9565
Epoch 73/100
8/8 [==============================] - 4s 565ms/step - loss: 0.2218 -
categorical_accuracy: 0.9204 - val_loss: 0.2040 -
val_categorical_accuracy: 0.9565
Epoch 74/100
8/8 [==============================] - 4s 534ms/step - loss: 0.2250 -
categorical_accuracy: 0.9159 - val_loss: 0.2086 -
val_categorical_accuracy: 0.9348
Epoch 75/100
8/8 [==============================] - 4s 531ms/step - loss: 0.2576 -
categorical_accuracy: 0.9159 - val_loss: 0.2182 -
val_categorical_accuracy: 0.9348
Epoch 76/100
8/8 [==============================] - 4s 530ms/step - loss: 0.2339 -
categorical_accuracy: 0.9204 - val_loss: 0.2197 -
val_categorical_accuracy: 0.9348
Epoch 77/100
8/8 [==============================] - 4s 600ms/step - loss: 0.2103 -
categorical_accuracy: 0.9425 - val_loss: 0.2262 -
val_categorical_accuracy: 0.9348
Epoch 78/100
8/8 [==============================] - 4s 539ms/step - loss: 0.2119 -
categorical_accuracy: 0.9381 - val_loss: 0.2299 -
val_categorical_accuracy: 0.9348
Epoch 79/100
8/8 [==============================] - 4s 527ms/step - loss: 0.2395 -
categorical_accuracy: 0.9248 - val_loss: 0.2214 -
val_categorical_accuracy: 0.9348
Epoch 80/100
8/8 [==============================] - 4s 547ms/step - loss: 0.2484 -
categorical_accuracy: 0.8938 - val_loss: 0.2167 -
val_categorical_accuracy: 0.9348
Epoch 81/100
8/8 [==============================] - 4s 561ms/step - loss: 0.1870 -
categorical_accuracy: 0.9602 - val_loss: 0.2099 -
val_categorical_accuracy: 0.9348
Epoch 82/100
```

```
8/8 [==============================] - 4s 521ms/step - loss: 0.2023 -
categorical_accuracy: 0.9336 - val_loss: 0.2088 -
val_categorical_accuracy: 0.9348
Epoch 83/100
8/8 [==============================] - 4s 521ms/step - loss: 0.1907 -
categorical_accuracy: 0.9336 - val_loss: 0.2077 -
val_categorical_accuracy: 0.9348
Epoch 84/100
8/8 [==============================] - 4s 520ms/step - loss: 0.2099 -
categorical_accuracy: 0.9381 - val_loss: 0.2130 -
val_categorical_accuracy: 0.9348
Epoch 85/100
8/8 [==============================] - 4s 628ms/step - loss: 0.1923 -
categorical_accuracy: 0.9602 - val_loss: 0.2205 -
val_categorical_accuracy: 0.9348
Epoch 86/100
8/8 [==============================] - 4s 518ms/step - loss: 0.1879 -
categorical_accuracy: 0.9469 - val_loss: 0.2282 -
val_categorical_accuracy: 0.9348
Epoch 87/100
8/8 [==============================] - 4s 514ms/step - loss: 0.1897 -
categorical_accuracy: 0.9425 - val_loss: 0.2341 -
val_categorical_accuracy: 0.9130
Epoch 88/100
8/8 [==============================] - 4s 571ms/step - loss: 0.2358 -
categorical_accuracy: 0.9159 - val_loss: 0.2314 -
val_categorical_accuracy: 0.9130
Epoch 89/100
8/8 [==============================] - 4s 570ms/step - loss: 0.1820 -
categorical_accuracy: 0.9381 - val_loss: 0.2347 -
val_categorical_accuracy: 0.9130
Epoch 90/100
8/8 [==============================] - 4s 506ms/step - loss: 0.1863 -
categorical_accuracy: 0.9469 - val_loss: 0.2335 -
val_categorical_accuracy: 0.9130
Epoch 91/100
8/8 [==============================] - 4s 505ms/step - loss: 0.1938 -
categorical_accuracy: 0.9425 - val_loss: 0.2394 -
val_categorical_accuracy: 0.9130
Epoch 92/100
8/8 [==============================] - 4s 511ms/step - loss: 0.1614 -
categorical_accuracy: 0.9690 - val_loss: 0.2452 -
val_categorical_accuracy: 0.9130
Epoch 93/100
8/8 [==============================] - 4s 495ms/step - loss: 0.2232 -
categorical_accuracy: 0.9071 - val_loss: 0.2508 -
val_categorical_accuracy: 0.8913
Epoch 94/100
8/8 [==============================] - 4s 488ms/step - loss: 0.1838 -
categorical_accuracy: 0.9292 - val_loss: 0.2522 -
```

```
val_categorical_accuracy: 0.8913
Epoch 95/100
8/8 [==============================] - 4s 491ms/step - loss: 0.1632 -
categorical_accuracy: 0.9602 - val_loss: 0.2586 -
val_categorical_accuracy: 0.8913
Epoch 96/100
8/8 [==============================] - 4s 489ms/step - loss: 0.2117 -
categorical_accuracy: 0.9469 - val_loss: 0.2668 -
val_categorical_accuracy: 0.8913
Epoch 97/100
8/8 [==============================] - 4s 554ms/step - loss: 0.2617 -
categorical_accuracy: 0.9159 - val_loss: 0.2564 -
val_categorical_accuracy: 0.8913
Epoch 98/100
8/8 [==============================] - 4s 486ms/step - loss: 0.1936 -
categorical_accuracy: 0.9292 - val_loss: 0.2569 -
val_categorical_accuracy: 0.8913
Epoch 99/100
8/8 [==============================] - 4s 534ms/step - loss: 0.2234 -
categorical_accuracy: 0.9071 - val_loss: 0.2541 -
val_categorical_accuracy: 0.8913
Epoch 100/100
8/8 [==============================] - 4s 484ms/step - loss: 0.1916 -
categorical_accuracy: 0.9292 - val_loss: 0.2473 -
val_categorical_accuracy: 0.8913
2/2 [==============================] - 1s 166ms/step - loss: 0.3220 -
categorical_accuracy: 0.8696
Test accuracy: 0.8695651888847351
```

After hypertuning the final model works best with learning rate as 0.0001 since the accuracy we get is around 87 percent

```
y_pred = pretrained_model.predict(X_test)

# Convert predicted probabilities to class labels
y_pred_labels = np.argmax(y_pred, axis=1)

y_test_labels = np.argmax(y_test, axis=1)

# Print classification report
print(classification_report(y_test_labels,
y_pred_labels,zero_division=1))

2/2 [==============================] - 1s 176ms/step
              precision    recall  f1-score   support

           0       0.94      0.80      0.86        20
           1       0.78      0.95      0.86        19
           2       1.00      0.86      0.92         7

    accuracy                           0.87        46
```

```
     macro avg          0.91          0.87          0.88              46
weighted avg            0.88          0.87          0.87              46
```

According to the classification report, the model has an overall accuracy of 0.87, which means that it correctly predicted the class label for 85% of the samples in the test set. The precision, recall, and F1-score for each class are also really good, indicating how well the model performs on each individual class.

```
cm = confusion_matrix(y_test_labels, y_pred_labels)
sns.heatmap(cm, annot=True, cmap="Blues")
```

```
<Axes: >
```
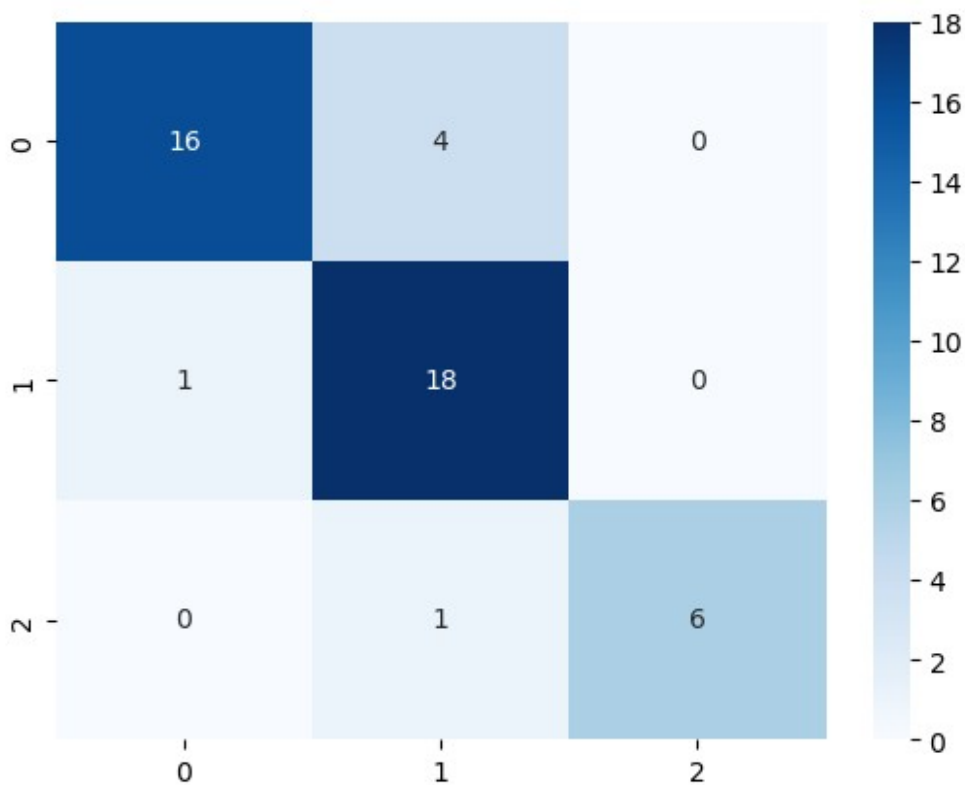


```python
def display(X_test,y_test, pred_labels, num_samples = 10,
rows=2,columns=5):
    # Define a list of class names corresponding to the subfolder
names
    class_names = ['Flowers', 'Pebbles', 'Plants']  # Update with your
class names
    #num_samples = 10  # Number of samples to display
    images = X_test
    labels = np.argmax(y_test, axis=1)
    # Find the indices where the predicted and true labels are
different
    diff_indices = np.where(pred_labels != labels)[0]
```

```python
    # Find the indices where the predicted and true labels are the
same
    same_indices = np.where(pred_labels == labels)[0]

    print("Incorrectly classified images")
    random_indices = np.random.choice(diff_indices,
size=min(num_samples,len(diff_indices)), replace=False)
    plt.figure(figsize=(8, 8))
    for i, idx in enumerate(random_indices):
        plt.subplot(rows, columns, i+1)
        # Convert image depth to 8-bit format
        image = cv2.normalize(images[idx], None, alpha=0, beta=255,
norm_type=cv2.NORM_MINMAX, dtype=cv2.CV_8U)
        plt.imshow(cv2.cvtColor(image, cv2.COLOR_BGR2RGB))
        plt.title('Actual-{} | Pred-
{}'.format(class_names[labels[idx]],
class_names[pred_labels[idx]]),fontdict={'fontsize': 8})
        plt.axis('off')
    plt.tight_layout()
    plt.show()

    print("\nCorrectly classified images")
    random_indices = np.random.choice(same_indices,
size=min(num_samples,len(same_indices)), replace=False)
    plt.figure(figsize=(8, 8))
    for i, idx in enumerate(random_indices):
        plt.subplot(rows, columns, i+1)
        # Convert image depth to 8-bit format
        image = cv2.normalize(images[idx], None, alpha=0, beta=255,
norm_type=cv2.NORM_MINMAX, dtype=cv2.CV_8U)
        plt.imshow(cv2.cvtColor(image, cv2.COLOR_BGR2RGB))
        plt.title('Actual-{} | Pred-
{}'.format(class_names[labels[idx]],
class_names[pred_labels[idx]]),fontdict={'fontsize': 8})
        plt.axis('off')
    plt.tight_layout()
    plt.show()

    return

display(X_test,y_test,y_pred_labels,num_samples=16,rows=4,columns=4)

Incorrectly classified images
```

Actual-Pebbles | Pred-Flowers   Actual-Flowers | Pred-Pebbles   Actual-Flowers | Pred-Pebbles   Actual-Plants | Pred-Pebbles

Actual-Flowers | Pred-Pebbles   Actual-Flowers | Pred-Pebbles
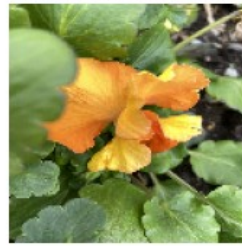
Correctly classified images

Actual-Pebbles | Pred-Pebbles   Actual-Flowers | Pred-Flowers   Actual-Flowers | Pred-Flowers   Actual-Pebbles | Pred-Pebbles

Actual-Flowers | Pred-Flowers   Actual-Flowers | Pred-Flowers   Actual-Pebbles | Pred-Pebbles   Actual-Pebbles | Pred-Pebbles

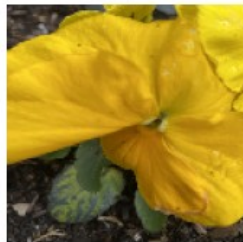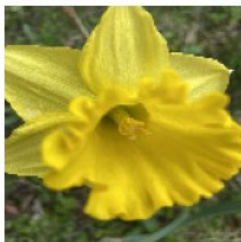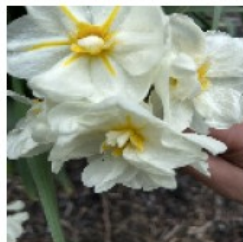Actual-Flowers | Pred-Flowers   Actual-Flowers | Pred-Flowers   Actual-Pebbles | Pred-Pebbles   Actual-Pebbles | Pred-Pebbles
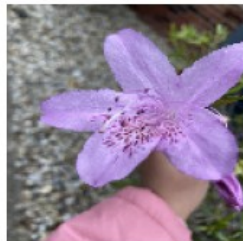
Actual-Flowers | Pred-Flowers   Actual-Flowers | Pred-Flowers   Actual-Pebbles | Pred-Pebbles   Actual-Pebbles | Pred-Pebbles

e. Train from scratch (without pretraining) a deep neural network that contains convolutional layers on this dataset (the one you created in part c). Report classification accuracy and give a few examples of correct/incorrect classification (show a few images that were correctly/incorrectly classified).

```
# Define the model architecture
my_model = keras.Sequential(
    [
        #This is the first convolutional layer of the network, with 32
filters of size 3x3. The activation function used is ReLU. The
input_shape parameter specifies the dimensions of the input images.
        layers.Conv2D(32, kernel_size=(3, 3), activation="relu",
```

```python
        input_shape=(128, 128, 3)),
            # This layer performs max pooling operation with a 2x2 pool
size, which helps to downsample the output of the previous layer.
        layers.MaxPooling2D(pool_size=(2, 2)),
            #This is the second convolutional layer of the network
        layers.Conv2D(64, kernel_size=(3, 3), activation="relu"),
            #This is another max pooling layer to further downsample the
output.
        layers.MaxPooling2D(pool_size=(2, 2)),
    ]
)
conv_model = train(base_model=my_model)
```

```
Epoch 1/100
8/8 [==============================] - 1s 107ms/step - loss: 1.1072 -
categorical_accuracy: 0.3540 - val_loss: 1.0975 -
val_categorical_accuracy: 0.3043
Epoch 2/100
8/8 [==============================] - 1s 113ms/step - loss: 1.0909 -
categorical_accuracy: 0.3540 - val_loss: 1.0911 -
val_categorical_accuracy: 0.3043
Epoch 3/100
8/8 [==============================] - 1s 99ms/step - loss: 1.0789 -
categorical_accuracy: 0.3496 - val_loss: 1.0808 -
val_categorical_accuracy: 0.3043
Epoch 4/100
8/8 [==============================] - 1s 103ms/step - loss: 1.0696 -
categorical_accuracy: 0.3938 - val_loss: 1.0710 -
val_categorical_accuracy: 0.4783
Epoch 5/100
8/8 [==============================] - 1s 106ms/step - loss: 1.0607 -
categorical_accuracy: 0.5000 - val_loss: 1.0591 -
val_categorical_accuracy: 0.4130
Epoch 6/100
8/8 [==============================] - 1s 100ms/step - loss: 1.0546 -
categorical_accuracy: 0.4381 - val_loss: 1.0495 -
val_categorical_accuracy: 0.3696
Epoch 7/100
8/8 [==============================] - 1s 99ms/step - loss: 1.0516 -
categorical_accuracy: 0.4292 - val_loss: 1.0451 -
val_categorical_accuracy: 0.3696
Epoch 8/100
8/8 [==============================] - 1s 99ms/step - loss: 1.0461 -
categorical_accuracy: 0.4381 - val_loss: 1.0436 -
val_categorical_accuracy: 0.3696
Epoch 9/100
8/8 [==============================] - 1s 103ms/step - loss: 1.0419 -
categorical_accuracy: 0.4558 - val_loss: 1.0369 -
val_categorical_accuracy: 0.4348
Epoch 10/100
```

```
8/8 [==============================] - 1s 120ms/step - loss: 1.0364 -
categorical_accuracy: 0.4735 - val_loss: 1.0247 -
val_categorical_accuracy: 0.4565
Epoch 11/100
8/8 [==============================] - 1s 110ms/step - loss: 1.0342 -
categorical_accuracy: 0.4779 - val_loss: 1.0151 -
val_categorical_accuracy: 0.4348
Epoch 12/100
8/8 [==============================] - 1s 114ms/step - loss: 1.0276 -
categorical_accuracy: 0.4735 - val_loss: 1.0136 -
val_categorical_accuracy: 0.4348
Epoch 13/100
8/8 [==============================] - 1s 134ms/step - loss: 1.0231 -
categorical_accuracy: 0.4735 - val_loss: 1.0047 -
val_categorical_accuracy: 0.4565
Epoch 14/100
8/8 [==============================] - 1s 124ms/step - loss: 1.0160 -
categorical_accuracy: 0.4779 - val_loss: 0.9926 -
val_categorical_accuracy: 0.4565
Epoch 15/100
8/8 [==============================] - 1s 146ms/step - loss: 1.0120 -
categorical_accuracy: 0.4867 - val_loss: 0.9832 -
val_categorical_accuracy: 0.5652
Epoch 16/100
8/8 [==============================] - 1s 134ms/step - loss: 1.0043 -
categorical_accuracy: 0.5000 - val_loss: 0.9727 -
val_categorical_accuracy: 0.5870
Epoch 17/100
8/8 [==============================] - 1s 145ms/step - loss: 1.0003 -
categorical_accuracy: 0.5044 - val_loss: 0.9590 -
val_categorical_accuracy: 0.6739
Epoch 18/100
8/8 [==============================] - 1s 144ms/step - loss: 0.9897 -
categorical_accuracy: 0.5044 - val_loss: 0.9464 -
val_categorical_accuracy: 0.6957
Epoch 19/100
8/8 [==============================] - 1s 142ms/step - loss: 0.9837 -
categorical_accuracy: 0.5133 - val_loss: 0.9387 -
val_categorical_accuracy: 0.6957
Epoch 20/100
8/8 [==============================] - 1s 159ms/step - loss: 0.9772 -
categorical_accuracy: 0.5221 - val_loss: 0.9244 -
val_categorical_accuracy: 0.7174
Epoch 21/100
8/8 [==============================] - 2s 178ms/step - loss: 0.9689 -
categorical_accuracy: 0.5354 - val_loss: 0.9171 -
val_categorical_accuracy: 0.7391
Epoch 22/100
8/8 [==============================] - 1s 158ms/step - loss: 0.9634 -
categorical_accuracy: 0.5664 - val_loss: 0.9093 -
```

```
val_categorical_accuracy: 0.7609
Epoch 23/100
8/8 [==============================] - 1s 165ms/step - loss: 0.9613 -
categorical_accuracy: 0.6062 - val_loss: 0.9029 -
val_categorical_accuracy: 0.8043
Epoch 24/100
8/8 [==============================] - 1s 167ms/step - loss: 0.9543 -
categorical_accuracy: 0.6416 - val_loss: 0.8917 -
val_categorical_accuracy: 0.7826
Epoch 25/100
8/8 [==============================] - 1s 189ms/step - loss: 0.9470 -
categorical_accuracy: 0.6018 - val_loss: 0.8886 -
val_categorical_accuracy: 0.8043
Epoch 26/100
8/8 [==============================] - 1s 167ms/step - loss: 0.9433 -
categorical_accuracy: 0.6018 - val_loss: 0.8791 -
val_categorical_accuracy: 0.8043
Epoch 27/100
8/8 [==============================] - 1s 167ms/step - loss: 0.9360 -
categorical_accuracy: 0.6195 - val_loss: 0.8709 -
val_categorical_accuracy: 0.8043
Epoch 28/100
8/8 [==============================] - 1s 165ms/step - loss: 0.9330 -
categorical_accuracy: 0.6239 - val_loss: 0.8722 -
val_categorical_accuracy: 0.7609
Epoch 29/100
8/8 [==============================] - 1s 163ms/step - loss: 0.9315 -
categorical_accuracy: 0.6150 - val_loss: 0.8583 -
val_categorical_accuracy: 0.8043
Epoch 30/100
8/8 [==============================] - 1s 163ms/step - loss: 0.9168 -
categorical_accuracy: 0.6504 - val_loss: 0.8447 -
val_categorical_accuracy: 0.7826
Epoch 31/100
8/8 [==============================] - 1s 170ms/step - loss: 0.9109 -
categorical_accuracy: 0.6327 - val_loss: 0.8357 -
val_categorical_accuracy: 0.7826
Epoch 32/100
8/8 [==============================] - 2s 188ms/step - loss: 0.9038 -
categorical_accuracy: 0.6150 - val_loss: 0.8299 -
val_categorical_accuracy: 0.7826
Epoch 33/100
8/8 [==============================] - 1s 167ms/step - loss: 0.8996 -
categorical_accuracy: 0.6504 - val_loss: 0.8253 -
val_categorical_accuracy: 0.8261
Epoch 34/100
8/8 [==============================] - 1s 162ms/step - loss: 0.8957 -
categorical_accuracy: 0.6814 - val_loss: 0.8192 -
val_categorical_accuracy: 0.8261
Epoch 35/100
```

```
8/8 [==============================] - 1s 199ms/step - loss: 0.8903 -
categorical_accuracy: 0.7080 - val_loss: 0.8128 -
val_categorical_accuracy: 0.8261
Epoch 36/100
8/8 [==============================] - 1s 170ms/step - loss: 0.8858 -
categorical_accuracy: 0.7168 - val_loss: 0.8050 -
val_categorical_accuracy: 0.8261
Epoch 37/100
8/8 [==============================] - 1s 167ms/step - loss: 0.8799 -
categorical_accuracy: 0.6814 - val_loss: 0.7975 -
val_categorical_accuracy: 0.8261
Epoch 38/100
8/8 [==============================] - 1s 162ms/step - loss: 0.8794 -
categorical_accuracy: 0.6637 - val_loss: 0.7909 -
val_categorical_accuracy: 0.8261
Epoch 39/100
8/8 [==============================] - 1s 168ms/step - loss: 0.8726 -
categorical_accuracy: 0.6549 - val_loss: 0.7857 -
val_categorical_accuracy: 0.8261
Epoch 40/100
8/8 [==============================] - 1s 172ms/step - loss: 0.8667 -
categorical_accuracy: 0.6726 - val_loss: 0.7761 -
val_categorical_accuracy: 0.8261
Epoch 41/100
8/8 [==============================] - 1s 164ms/step - loss: 0.8595 -
categorical_accuracy: 0.6504 - val_loss: 0.7696 -
val_categorical_accuracy: 0.8261
Epoch 42/100
8/8 [==============================] - 1s 192ms/step - loss: 0.8519 -
categorical_accuracy: 0.6991 - val_loss: 0.7665 -
val_categorical_accuracy: 0.8261
Epoch 43/100
8/8 [==============================] - 2s 190ms/step - loss: 0.8489 -
categorical_accuracy: 0.7168 - val_loss: 0.7632 -
val_categorical_accuracy: 0.8261
Epoch 44/100
8/8 [==============================] - 1s 167ms/step - loss: 0.8410 -
categorical_accuracy: 0.7080 - val_loss: 0.7509 -
val_categorical_accuracy: 0.8261
Epoch 45/100
8/8 [==============================] - 1s 166ms/step - loss: 0.8396 -
categorical_accuracy: 0.6460 - val_loss: 0.7452 -
val_categorical_accuracy: 0.8043
Epoch 46/100
8/8 [==============================] - 1s 164ms/step - loss: 0.8379 -
categorical_accuracy: 0.6372 - val_loss: 0.7373 -
val_categorical_accuracy: 0.8043
Epoch 47/100
8/8 [==============================] - 1s 164ms/step - loss: 0.8314 -
categorical_accuracy: 0.6460 - val_loss: 0.7327 -
```

```
val_categorical_accuracy: 0.8478
Epoch 48/100
8/8 [==============================] - 1s 167ms/step - loss: 0.8271 -
categorical_accuracy: 0.6681 - val_loss: 0.7272 -
val_categorical_accuracy: 0.8261
Epoch 49/100
8/8 [==============================] - 1s 164ms/step - loss: 0.8189 -
categorical_accuracy: 0.6726 - val_loss: 0.7226 -
val_categorical_accuracy: 0.8043
Epoch 50/100
8/8 [==============================] - 1s 168ms/step - loss: 0.8140 -
categorical_accuracy: 0.6770 - val_loss: 0.7156 -
val_categorical_accuracy: 0.8261
Epoch 51/100
8/8 [==============================] - 1s 175ms/step - loss: 0.8118 -
categorical_accuracy: 0.6593 - val_loss: 0.7081 -
val_categorical_accuracy: 0.8478
Epoch 52/100
8/8 [==============================] - 1s 167ms/step - loss: 0.8054 -
categorical_accuracy: 0.6637 - val_loss: 0.7027 -
val_categorical_accuracy: 0.8478
Epoch 53/100
8/8 [==============================] - 1s 189ms/step - loss: 0.8028 -
categorical_accuracy: 0.6681 - val_loss: 0.6980 -
val_categorical_accuracy: 0.8478
Epoch 54/100
8/8 [==============================] - 2s 187ms/step - loss: 0.7976 -
categorical_accuracy: 0.6858 - val_loss: 0.6938 -
val_categorical_accuracy: 0.8261
Epoch 55/100
8/8 [==============================] - 1s 203ms/step - loss: 0.7929 -
categorical_accuracy: 0.7168 - val_loss: 0.6965 -
val_categorical_accuracy: 0.8043
Epoch 56/100
8/8 [==============================] - 1s 169ms/step - loss: 0.7890 -
categorical_accuracy: 0.7168 - val_loss: 0.6868 -
val_categorical_accuracy: 0.8261
Epoch 57/100
8/8 [==============================] - 1s 165ms/step - loss: 0.7786 -
categorical_accuracy: 0.6858 - val_loss: 0.6784 -
val_categorical_accuracy: 0.8043
Epoch 58/100
8/8 [==============================] - 1s 167ms/step - loss: 0.7881 -
categorical_accuracy: 0.6150 - val_loss: 0.6698 -
val_categorical_accuracy: 0.8261
Epoch 59/100
8/8 [==============================] - 1s 162ms/step - loss: 0.7823 -
categorical_accuracy: 0.6239 - val_loss: 0.6640 -
val_categorical_accuracy: 0.8261
Epoch 60/100
```

```
8/8 [==============================] - 1s 167ms/step - loss: 0.7702 -
categorical_accuracy: 0.6770 - val_loss: 0.6678 -
val_categorical_accuracy: 0.8261
Epoch 61/100
8/8 [==============================] - 1s 171ms/step - loss: 0.7655 -
categorical_accuracy: 0.7345 - val_loss: 0.6750 -
val_categorical_accuracy: 0.8043
Epoch 62/100
8/8 [==============================] - 1s 173ms/step - loss: 0.7606 -
categorical_accuracy: 0.7743 - val_loss: 0.6569 -
val_categorical_accuracy: 0.8043
Epoch 63/100
8/8 [==============================] - 1s 171ms/step - loss: 0.7583 -
categorical_accuracy: 0.7080 - val_loss: 0.6487 -
val_categorical_accuracy: 0.8261
Epoch 64/100
8/8 [==============================] - 1s 165ms/step - loss: 0.7526 -
categorical_accuracy: 0.7655 - val_loss: 0.6646 -
val_categorical_accuracy: 0.7609
Epoch 65/100
8/8 [==============================] - 1s 202ms/step - loss: 0.7473 -
categorical_accuracy: 0.7876 - val_loss: 0.6493 -
val_categorical_accuracy: 0.8043
Epoch 66/100
8/8 [==============================] - 2s 177ms/step - loss: 0.7440 -
categorical_accuracy: 0.7434 - val_loss: 0.6295 -
val_categorical_accuracy: 0.8261
Epoch 67/100
8/8 [==============================] - 1s 167ms/step - loss: 0.7469 -
categorical_accuracy: 0.6770 - val_loss: 0.6177 -
val_categorical_accuracy: 0.8261
Epoch 68/100
8/8 [==============================] - 1s 171ms/step - loss: 0.7430 -
categorical_accuracy: 0.6504 - val_loss: 0.6152 -
val_categorical_accuracy: 0.8261
Epoch 69/100
8/8 [==============================] - 1s 162ms/step - loss: 0.7297 -
categorical_accuracy: 0.6947 - val_loss: 0.6141 -
val_categorical_accuracy: 0.8261
Epoch 70/100
8/8 [==============================] - 1s 170ms/step - loss: 0.7258 -
categorical_accuracy: 0.6991 - val_loss: 0.6101 -
val_categorical_accuracy: 0.8261
Epoch 71/100
8/8 [==============================] - 1s 167ms/step - loss: 0.7214 -
categorical_accuracy: 0.6947 - val_loss: 0.6080 -
val_categorical_accuracy: 0.8261
Epoch 72/100
8/8 [==============================] - 1s 163ms/step - loss: 0.7162 -
categorical_accuracy: 0.7257 - val_loss: 0.6025 -
```

val_categorical_accuracy: 0.8261
Epoch 73/100
8/8 [==============================] - 1s 162ms/step - loss: 0.7179 -
categorical_accuracy: 0.7611 - val_loss: 0.5961 -
val_categorical_accuracy: 0.8696
Epoch 74/100
8/8 [==============================] - 1s 172ms/step - loss: 0.7075 -
categorical_accuracy: 0.7611 - val_loss: 0.5967 -
val_categorical_accuracy: 0.8261
Epoch 75/100
8/8 [==============================] - 1s 166ms/step - loss: 0.7074 -
categorical_accuracy: 0.7124 - val_loss: 0.5840 -
val_categorical_accuracy: 0.8261
Epoch 76/100
8/8 [==============================] - 1s 174ms/step - loss: 0.7041 -
categorical_accuracy: 0.7124 - val_loss: 0.5856 -
val_categorical_accuracy: 0.8261
Epoch 77/100
8/8 [==============================] - 2s 213ms/step - loss: 0.6945 -
categorical_accuracy: 0.7566 - val_loss: 0.5901 -
val_categorical_accuracy: 0.8043
Epoch 78/100
8/8 [==============================] - 1s 170ms/step - loss: 0.6899 -
categorical_accuracy: 0.7876 - val_loss: 0.5966 -
val_categorical_accuracy: 0.8043
Epoch 79/100
8/8 [==============================] - 1s 163ms/step - loss: 0.6898 -
categorical_accuracy: 0.7788 - val_loss: 0.5917 -
val_categorical_accuracy: 0.8043
Epoch 80/100
8/8 [==============================] - 1s 164ms/step - loss: 0.6839 -
categorical_accuracy: 0.7965 - val_loss: 0.5971 -
val_categorical_accuracy: 0.8043
Epoch 81/100
8/8 [==============================] - 1s 173ms/step - loss: 0.6829 -
categorical_accuracy: 0.7832 - val_loss: 0.5656 -
val_categorical_accuracy: 0.8261
Epoch 82/100
8/8 [==============================] - 2s 211ms/step - loss: 0.6797 -
categorical_accuracy: 0.7743 - val_loss: 0.5548 -
val_categorical_accuracy: 0.8913
Epoch 83/100
8/8 [==============================] - 1s 173ms/step - loss: 0.6728 -
categorical_accuracy: 0.7788 - val_loss: 0.5597 -
val_categorical_accuracy: 0.8261
Epoch 84/100
8/8 [==============================] - 1s 164ms/step - loss: 0.6653 -
categorical_accuracy: 0.7920 - val_loss: 0.5844 -
val_categorical_accuracy: 0.8043
Epoch 85/100

```
8/8 [==============================] - 1s 164ms/step - loss: 0.6606 -
categorical_accuracy: 0.8142 - val_loss: 0.5617 -
val_categorical_accuracy: 0.8261
Epoch 86/100
8/8 [==============================] - 1s 165ms/step - loss: 0.6545 -
categorical_accuracy: 0.8053 - val_loss: 0.5450 -
val_categorical_accuracy: 0.8696
Epoch 87/100
8/8 [==============================] - 1s 196ms/step - loss: 0.6600 -
categorical_accuracy: 0.7699 - val_loss: 0.5437 -
val_categorical_accuracy: 0.8261
Epoch 88/100
8/8 [==============================] - 2s 187ms/step - loss: 0.6535 -
categorical_accuracy: 0.7655 - val_loss: 0.5409 -
val_categorical_accuracy: 0.8261
Epoch 89/100
8/8 [==============================] - 1s 166ms/step - loss: 0.6512 -
categorical_accuracy: 0.7788 - val_loss: 0.5351 -
val_categorical_accuracy: 0.8478
Epoch 90/100
8/8 [==============================] - 1s 166ms/step - loss: 0.6502 -
categorical_accuracy: 0.7611 - val_loss: 0.5377 -
val_categorical_accuracy: 0.8261
Epoch 91/100
8/8 [==============================] - 1s 162ms/step - loss: 0.6413 -
categorical_accuracy: 0.7920 - val_loss: 0.5427 -
val_categorical_accuracy: 0.8043
Epoch 92/100
8/8 [==============================] - 1s 165ms/step - loss: 0.6367 -
categorical_accuracy: 0.7965 - val_loss: 0.5268 -
val_categorical_accuracy: 0.8261
Epoch 93/100
8/8 [==============================] - 1s 164ms/step - loss: 0.6425 -
categorical_accuracy: 0.7743 - val_loss: 0.5143 -
val_categorical_accuracy: 0.8696
Epoch 94/100
8/8 [==============================] - 1s 190ms/step - loss: 0.6462 -
categorical_accuracy: 0.7611 - val_loss: 0.5146 -
val_categorical_accuracy: 0.8478
Epoch 95/100
8/8 [==============================] - 1s 165ms/step - loss: 0.6263 -
categorical_accuracy: 0.7876 - val_loss: 0.5654 -
val_categorical_accuracy: 0.7826
Epoch 96/100
8/8 [==============================] - 1s 166ms/step - loss: 0.6241 -
categorical_accuracy: 0.8673 - val_loss: 0.5426 -
val_categorical_accuracy: 0.8478
Epoch 97/100
8/8 [==============================] - 1s 164ms/step - loss: 0.6285 -
categorical_accuracy: 0.8363 - val_loss: 0.5153 -
```

```
val_categorical_accuracy: 0.8478
Epoch 98/100
8/8 [==============================] - 1s 167ms/step - loss: 0.6209 -
categorical_accuracy: 0.8230 - val_loss: 0.5392 -
val_categorical_accuracy: 0.8261
Epoch 99/100
8/8 [==============================] - 2s 187ms/step - loss: 0.6251 -
categorical_accuracy: 0.8230 - val_loss: 0.5835 -
val_categorical_accuracy: 0.6739
Epoch 100/100
8/8 [==============================] - 1s 162ms/step - loss: 0.6145 -
categorical_accuracy: 0.8496 - val_loss: 0.5317 -
val_categorical_accuracy: 0.8261
2/2 [==============================] - 0s 21ms/step - loss: 0.6900 -
categorical_accuracy: 0.6522
Test accuracy: 0.6521739363670349
```

The model consists of two convolutional layers, each followed by a max pooling layer. The layers.Conv2D layers are used to extract features from the input images by applying a set of filters to the input. The kernel_size parameter specifies the size of the filter, and the activation parameter specifies the activation function used to introduce non-linearity into the model. The layers.MaxPooling2D layers are used to downsample the feature maps and reduce the computational complexity of the model by reducing the spatial dimensions of the feature maps.

The output of the last max pooling layer is then passed to a GlobalAveragePooling2D layer, which computes the average value of each feature map across all spatial positions, resulting in a fixed-size vector. This operation reduces the number of parameters in the model and helps to prevent overfitting.

Finally, a Dense layer with softmax activation function is added as the output layer to generate the class probabilities for the input images.

Will hypertune learning rates to find the optimal model.
```python
lr = [0.001,0.01,0.00001]
for l in lr:
    conv_model = train(learning_rate=l,base_model=my_model)
```
```
Epoch 1/100
8/8 [==============================] - 1s 106ms/step - loss: 3.2756 -
categorical_accuracy: 0.3805 - val_loss: 2.4330 -
val_categorical_accuracy: 0.3696
Epoch 2/100
8/8 [==============================] - 1s 97ms/step - loss: 1.9701 -
categorical_accuracy: 0.3850 - val_loss: 1.4359 -
val_categorical_accuracy: 0.4565
Epoch 3/100
8/8 [==============================] - 1s 99ms/step - loss: 1.4014 -
categorical_accuracy: 0.4071 - val_loss: 0.9240 -
val_categorical_accuracy: 0.6087
```

```
Epoch 4/100
8/8 [==============================] - 1s 106ms/step - loss: 0.9400 -
categorical_accuracy: 0.6106 - val_loss: 0.6994 -
val_categorical_accuracy: 0.7391
Epoch 5/100
8/8 [==============================] - 1s 102ms/step - loss: 0.7540 -
categorical_accuracy: 0.7168 - val_loss: 0.5953 -
val_categorical_accuracy: 0.7391
Epoch 6/100
8/8 [==============================] - 1s 98ms/step - loss: 0.6818 -
categorical_accuracy: 0.6681 - val_loss: 0.5354 -
val_categorical_accuracy: 0.8261
Epoch 7/100
8/8 [==============================] - 1s 100ms/step - loss: 0.6172 -
categorical_accuracy: 0.7832 - val_loss: 0.4748 -
val_categorical_accuracy: 0.9130
Epoch 8/100
8/8 [==============================] - 1s 113ms/step - loss: 0.5766 -
categorical_accuracy: 0.8274 - val_loss: 0.4503 -
val_categorical_accuracy: 0.9130
Epoch 9/100
8/8 [==============================] - 1s 99ms/step - loss: 0.5417 -
categorical_accuracy: 0.8628 - val_loss: 0.4429 -
val_categorical_accuracy: 0.8696
Epoch 10/100
8/8 [==============================] - 1s 99ms/step - loss: 0.5220 -
categorical_accuracy: 0.9513 - val_loss: 0.4027 -
val_categorical_accuracy: 0.9348
Epoch 11/100
8/8 [==============================] - 1s 97ms/step - loss: 0.4754 -
categorical_accuracy: 0.9248 - val_loss: 0.3500 -
val_categorical_accuracy: 0.9348
Epoch 12/100
8/8 [==============================] - 1s 96ms/step - loss: 0.4513 -
categorical_accuracy: 0.8850 - val_loss: 0.3367 -
val_categorical_accuracy: 0.9348
Epoch 13/100
8/8 [==============================] - 1s 91ms/step - loss: 0.4170 -
categorical_accuracy: 0.9115 - val_loss: 0.3070 -
val_categorical_accuracy: 0.9565
Epoch 14/100
8/8 [==============================] - 1s 91ms/step - loss: 0.4293 -
categorical_accuracy: 0.9071 - val_loss: 0.2660 -
val_categorical_accuracy: 0.9783
Epoch 15/100
8/8 [==============================] - 1s 97ms/step - loss: 0.3970 -
categorical_accuracy: 0.9159 - val_loss: 0.3036 -
val_categorical_accuracy: 0.9348
Epoch 16/100
8/8 [==============================] - 1s 96ms/step - loss: 0.3551 -
```

```
categorical_accuracy: 0.9071 - val_loss: 0.2944 -
val_categorical_accuracy: 0.9348
Epoch 17/100
8/8 [==============================] - 1s 97ms/step - loss: 0.3388 -
categorical_accuracy: 0.9248 - val_loss: 0.2337 -
val_categorical_accuracy: 0.9783
Epoch 18/100
8/8 [==============================] - 1s 97ms/step - loss: 0.3165 -
categorical_accuracy: 0.9425 - val_loss: 0.2932 -
val_categorical_accuracy: 0.9348
Epoch 19/100
8/8 [==============================] - 1s 110ms/step - loss: 0.3191 -
categorical_accuracy: 0.9513 - val_loss: 0.2611 -
val_categorical_accuracy: 0.9348
Epoch 20/100
8/8 [==============================] - 1s 98ms/step - loss: 0.2800 -
categorical_accuracy: 0.9602 - val_loss: 0.2159 -
val_categorical_accuracy: 0.9348
Epoch 21/100
8/8 [==============================] - 1s 97ms/step - loss: 0.2592 -
categorical_accuracy: 0.9381 - val_loss: 0.1979 -
val_categorical_accuracy: 0.9348
Epoch 22/100
8/8 [==============================] - 1s 97ms/step - loss: 0.2550 -
categorical_accuracy: 0.9469 - val_loss: 0.2000 -
val_categorical_accuracy: 0.9565
Epoch 23/100
8/8 [==============================] - 1s 97ms/step - loss: 0.2345 -
categorical_accuracy: 0.9513 - val_loss: 0.2471 -
val_categorical_accuracy: 0.9130
Epoch 24/100
8/8 [==============================] - 1s 110ms/step - loss: 0.2347 -
categorical_accuracy: 0.9381 - val_loss: 0.2084 -
val_categorical_accuracy: 0.9348
Epoch 25/100
8/8 [==============================] - 1s 97ms/step - loss: 0.2214 -
categorical_accuracy: 0.9513 - val_loss: 0.1608 -
val_categorical_accuracy: 0.9565
Epoch 26/100
8/8 [==============================] - 1s 97ms/step - loss: 0.2252 -
categorical_accuracy: 0.9336 - val_loss: 0.2232 -
val_categorical_accuracy: 0.9348
Epoch 27/100
8/8 [==============================] - 1s 107ms/step - loss: 0.1954 -
categorical_accuracy: 0.9602 - val_loss: 0.2111 -
val_categorical_accuracy: 0.9348
Epoch 28/100
8/8 [==============================] - 1s 98ms/step - loss: 0.2089 -
categorical_accuracy: 0.9292 - val_loss: 0.1714 -
val_categorical_accuracy: 0.9348
```

```
Epoch 29/100
8/8 [==============================] - 1s 96ms/step - loss: 0.2061 -
categorical_accuracy: 0.9248 - val_loss: 0.1745 -
val_categorical_accuracy: 0.9565
Epoch 30/100
8/8 [==============================] - 1s 93ms/step - loss: 0.1812 -
categorical_accuracy: 0.9690 - val_loss: 0.2062 -
val_categorical_accuracy: 0.9348
Epoch 31/100
8/8 [==============================] - 1s 97ms/step - loss: 0.2255 -
categorical_accuracy: 0.9558 - val_loss: 0.1749 -
val_categorical_accuracy: 0.9565
Epoch 32/100
8/8 [==============================] - 1s 92ms/step - loss: 0.1843 -
categorical_accuracy: 0.9646 - val_loss: 0.2881 -
val_categorical_accuracy: 0.8913
Epoch 33/100
8/8 [==============================] - 1s 110ms/step - loss: 0.2237 -
categorical_accuracy: 0.9336 - val_loss: 0.2178 -
val_categorical_accuracy: 0.9348
Epoch 34/100
8/8 [==============================] - 1s 98ms/step - loss: 0.1851 -
categorical_accuracy: 0.9381 - val_loss: 0.1377 -
val_categorical_accuracy: 0.9565
Epoch 35/100
8/8 [==============================] - 1s 110ms/step - loss: 0.1626 -
categorical_accuracy: 0.9469 - val_loss: 0.2189 -
val_categorical_accuracy: 0.9130
Epoch 36/100
8/8 [==============================] - 1s 110ms/step - loss: 0.1550 -
categorical_accuracy: 0.9558 - val_loss: 0.2532 -
val_categorical_accuracy: 0.9130
Epoch 37/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1551 -
categorical_accuracy: 0.9690 - val_loss: 0.1924 -
val_categorical_accuracy: 0.9348
Epoch 38/100
8/8 [==============================] - 1s 98ms/step - loss: 0.1492 -
categorical_accuracy: 0.9690 - val_loss: 0.1985 -
val_categorical_accuracy: 0.9348
Epoch 39/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1449 -
categorical_accuracy: 0.9646 - val_loss: 0.2223 -
val_categorical_accuracy: 0.9130
Epoch 40/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1426 -
categorical_accuracy: 0.9602 - val_loss: 0.2010 -
val_categorical_accuracy: 0.9348
Epoch 41/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1398 -
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categorical_accuracy: 0.9646 - val_loss: 0.1463 -
val_categorical_accuracy: 0.9348
Epoch 42/100
8/8 [==============================] - 1s 92ms/step - loss: 0.1407 -
categorical_accuracy: 0.9646 - val_loss: 0.2552 -
val_categorical_accuracy: 0.8913
Epoch 43/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1658 -
categorical_accuracy: 0.9690 - val_loss: 0.1430 -
val_categorical_accuracy: 0.9565
Epoch 44/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1435 -
categorical_accuracy: 0.9690 - val_loss: 0.1954 -
val_categorical_accuracy: 0.9130
Epoch 45/100
8/8 [==============================] - 1s 110ms/step - loss: 0.1450 -
categorical_accuracy: 0.9425 - val_loss: 0.1914 -
val_categorical_accuracy: 0.9348
Epoch 46/100
8/8 [==============================] - 1s 99ms/step - loss: 0.1403 -
categorical_accuracy: 0.9735 - val_loss: 0.1720 -
val_categorical_accuracy: 0.9348
Epoch 47/100
8/8 [==============================] - 1s 105ms/step - loss: 0.1219 -
categorical_accuracy: 0.9735 - val_loss: 0.3024 -
val_categorical_accuracy: 0.8913
Epoch 48/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1364 -
categorical_accuracy: 0.9690 - val_loss: 0.1817 -
val_categorical_accuracy: 0.9348
Epoch 49/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1330 -
categorical_accuracy: 0.9690 - val_loss: 0.1514 -
val_categorical_accuracy: 0.9348
Epoch 50/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1205 -
categorical_accuracy: 0.9602 - val_loss: 0.2669 -
val_categorical_accuracy: 0.9130
Epoch 51/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1158 -
categorical_accuracy: 0.9779 - val_loss: 0.2241 -
val_categorical_accuracy: 0.9348
Epoch 52/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1206 -
categorical_accuracy: 0.9735 - val_loss: 0.1915 -
val_categorical_accuracy: 0.9348
Epoch 53/100
8/8 [==============================] - 1s 96ms/step - loss: 0.0942 -
categorical_accuracy: 0.9779 - val_loss: 0.1791 -
val_categorical_accuracy: 0.9348
```

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Epoch 54/100
8/8 [==============================] - 1s 101ms/step - loss: 0.1073 -
categorical_accuracy: 0.9690 - val_loss: 0.1741 -
val_categorical_accuracy: 0.9348
Epoch 55/100
8/8 [==============================] - 1s 100ms/step - loss: 0.1062 -
categorical_accuracy: 0.9735 - val_loss: 0.1993 -
val_categorical_accuracy: 0.9348
Epoch 56/100
8/8 [==============================] - 1s 110ms/step - loss: 0.1128 -
categorical_accuracy: 0.9690 - val_loss: 0.2290 -
val_categorical_accuracy: 0.9130
Epoch 57/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0984 -
categorical_accuracy: 0.9646 - val_loss: 0.1515 -
val_categorical_accuracy: 0.9565
Epoch 58/100
8/8 [==============================] - 1s 107ms/step - loss: 0.1130 -
categorical_accuracy: 0.9602 - val_loss: 0.2326 -
val_categorical_accuracy: 0.8913
Epoch 59/100
8/8 [==============================] - 1s 97ms/step - loss: 0.0968 -
categorical_accuracy: 0.9735 - val_loss: 0.1288 -
val_categorical_accuracy: 0.9565
Epoch 60/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1194 -
categorical_accuracy: 0.9690 - val_loss: 0.1811 -
val_categorical_accuracy: 0.9348
Epoch 61/100
8/8 [==============================] - 1s 98ms/step - loss: 0.1071 -
categorical_accuracy: 0.9690 - val_loss: 0.2788 -
val_categorical_accuracy: 0.8913
Epoch 62/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0988 -
categorical_accuracy: 0.9735 - val_loss: 0.1736 -
val_categorical_accuracy: 0.9348
Epoch 63/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0865 -
categorical_accuracy: 0.9779 - val_loss: 0.3103 -
val_categorical_accuracy: 0.8913
Epoch 64/100
8/8 [==============================] - 1s 97ms/step - loss: 0.0993 -
categorical_accuracy: 0.9735 - val_loss: 0.2037 -
val_categorical_accuracy: 0.9348
Epoch 65/100
8/8 [==============================] - 1s 110ms/step - loss: 0.0864 -
categorical_accuracy: 0.9823 - val_loss: 0.1642 -
val_categorical_accuracy: 0.9348
Epoch 66/100
8/8 [==============================] - 1s 110ms/step - loss: 0.0827 -
```

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categorical_accuracy: 0.9735 - val_loss: 0.1915 -
val_categorical_accuracy: 0.9348
Epoch 67/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1359 -
categorical_accuracy: 0.9558 - val_loss: 0.2422 -
val_categorical_accuracy: 0.9130
Epoch 68/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1329 -
categorical_accuracy: 0.9602 - val_loss: 0.1955 -
val_categorical_accuracy: 0.9348
Epoch 69/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1049 -
categorical_accuracy: 0.9646 - val_loss: 0.1263 -
val_categorical_accuracy: 0.9348
Epoch 70/100
8/8 [==============================] - 1s 98ms/step - loss: 0.1013 -
categorical_accuracy: 0.9690 - val_loss: 0.3119 -
val_categorical_accuracy: 0.8913
Epoch 71/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0939 -
categorical_accuracy: 0.9779 - val_loss: 0.1778 -
val_categorical_accuracy: 0.9348
Epoch 72/100
8/8 [==============================] - 1s 92ms/step - loss: 0.1003 -
categorical_accuracy: 0.9690 - val_loss: 0.1580 -
val_categorical_accuracy: 0.9348
Epoch 73/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0842 -
categorical_accuracy: 0.9779 - val_loss: 0.2475 -
val_categorical_accuracy: 0.8913
Epoch 74/100
8/8 [==============================] - 1s 97ms/step - loss: 0.0983 -
categorical_accuracy: 0.9735 - val_loss: 0.2428 -
val_categorical_accuracy: 0.8913
Epoch 75/100
8/8 [==============================] - 1s 98ms/step - loss: 0.1338 -
categorical_accuracy: 0.9469 - val_loss: 0.1117 -
val_categorical_accuracy: 0.9565
Epoch 76/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1340 -
categorical_accuracy: 0.9425 - val_loss: 0.2170 -
val_categorical_accuracy: 0.8913
Epoch 77/100
8/8 [==============================] - 1s 98ms/step - loss: 0.1108 -
categorical_accuracy: 0.9646 - val_loss: 0.3580 -
val_categorical_accuracy: 0.8913
Epoch 78/100
8/8 [==============================] - 1s 97ms/step - loss: 0.0926 -
categorical_accuracy: 0.9779 - val_loss: 0.1525 -
val_categorical_accuracy: 0.9348
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Epoch 79/100
8/8 [==============================] - 1s 97ms/step - loss: 0.0999 -
categorical_accuracy: 0.9646 - val_loss: 0.1424 -
val_categorical_accuracy: 0.9348
Epoch 80/100
8/8 [==============================] - 1s 97ms/step - loss: 0.0891 -
categorical_accuracy: 0.9602 - val_loss: 0.2760 -
val_categorical_accuracy: 0.8913
Epoch 81/100
8/8 [==============================] - 1s 97ms/step - loss: 0.0877 -
categorical_accuracy: 0.9646 - val_loss: 0.1757 -
val_categorical_accuracy: 0.9348
Epoch 82/100
8/8 [==============================] - 1s 93ms/step - loss: 0.0836 -
categorical_accuracy: 0.9779 - val_loss: 0.1837 -
val_categorical_accuracy: 0.9348
Epoch 83/100
8/8 [==============================] - 1s 93ms/step - loss: 0.0813 -
categorical_accuracy: 0.9779 - val_loss: 0.2574 -
val_categorical_accuracy: 0.8913
Epoch 84/100
8/8 [==============================] - 1s 111ms/step - loss: 0.0808 -
categorical_accuracy: 0.9735 - val_loss: 0.2324 -
val_categorical_accuracy: 0.8913
Epoch 85/100
8/8 [==============================] - 1s 108ms/step - loss: 0.0797 -
categorical_accuracy: 0.9735 - val_loss: 0.2916 -
val_categorical_accuracy: 0.8913
Epoch 86/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0930 -
categorical_accuracy: 0.9735 - val_loss: 0.1200 -
val_categorical_accuracy: 0.9565
Epoch 87/100
8/8 [==============================] - 1s 98ms/step - loss: 0.1001 -
categorical_accuracy: 0.9602 - val_loss: 0.2334 -
val_categorical_accuracy: 0.9130
Epoch 88/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0986 -
categorical_accuracy: 0.9602 - val_loss: 0.3192 -
val_categorical_accuracy: 0.8913
Epoch 89/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0704 -
categorical_accuracy: 0.9867 - val_loss: 0.1481 -
val_categorical_accuracy: 0.9348
Epoch 90/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0718 -
categorical_accuracy: 0.9867 - val_loss: 0.1858 -
val_categorical_accuracy: 0.9348
Epoch 91/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0745 -
```

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categorical_accuracy: 0.9735 - val_loss: 0.2638 -
val_categorical_accuracy: 0.8913
Epoch 92/100
8/8 [==============================] - 1s 112ms/step - loss: 0.0839 -
categorical_accuracy: 0.9779 - val_loss: 0.2898 -
val_categorical_accuracy: 0.8913
Epoch 93/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0876 -
categorical_accuracy: 0.9735 - val_loss: 0.2511 -
val_categorical_accuracy: 0.8913
Epoch 94/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0730 -
categorical_accuracy: 0.9779 - val_loss: 0.2323 -
val_categorical_accuracy: 0.8913
Epoch 95/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0757 -
categorical_accuracy: 0.9779 - val_loss: 0.2906 -
val_categorical_accuracy: 0.8913
Epoch 96/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0779 -
categorical_accuracy: 0.9779 - val_loss: 0.1859 -
val_categorical_accuracy: 0.9348
Epoch 97/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0876 -
categorical_accuracy: 0.9602 - val_loss: 0.1263 -
val_categorical_accuracy: 0.9348
Epoch 98/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0765 -
categorical_accuracy: 0.9779 - val_loss: 0.3546 -
val_categorical_accuracy: 0.8913
Epoch 99/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0804 -
categorical_accuracy: 0.9690 - val_loss: 0.1694 -
val_categorical_accuracy: 0.9348
Epoch 100/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0681 -
categorical_accuracy: 0.9779 - val_loss: 0.1832 -
val_categorical_accuracy: 0.9348
2/2 [==============================] - 0s 13ms/step - loss: 0.3372 -
categorical_accuracy: 0.8913
Test accuracy: 0.8913043737411499
Epoch 1/100
8/8 [==============================] - 1s 105ms/step - loss: 2.7588 -
categorical_accuracy: 0.2965 - val_loss: 0.8378 -
val_categorical_accuracy: 0.6087
Epoch 2/100
8/8 [==============================] - 1s 97ms/step - loss: 0.8807 -
categorical_accuracy: 0.6150 - val_loss: 0.6486 -
val_categorical_accuracy: 0.8696
Epoch 3/100
```

```
8/8 [==============================] - 1s 110ms/step - loss: 0.7384 -
categorical_accuracy: 0.6549 - val_loss: 0.4657 -
val_categorical_accuracy: 0.8913
Epoch 4/100
8/8 [==============================] - 1s 111ms/step - loss: 0.5765 -
categorical_accuracy: 0.8319 - val_loss: 0.2708 -
val_categorical_accuracy: 0.9348
Epoch 5/100
8/8 [==============================] - 1s 96ms/step - loss: 0.3062 -
categorical_accuracy: 0.8717 - val_loss: 0.5253 -
val_categorical_accuracy: 0.8261
Epoch 6/100
8/8 [==============================] - 1s 113ms/step - loss: 0.2326 -
categorical_accuracy: 0.9027 - val_loss: 0.5898 -
val_categorical_accuracy: 0.8043
Epoch 7/100
8/8 [==============================] - 1s 97ms/step - loss: 0.2043 -
categorical_accuracy: 0.9248 - val_loss: 0.1344 -
val_categorical_accuracy: 0.9130
Epoch 8/100
8/8 [==============================] - 1s 98ms/step - loss: 0.1900 -
categorical_accuracy: 0.9292 - val_loss: 0.1919 -
val_categorical_accuracy: 0.9348
Epoch 9/100
8/8 [==============================] - 1s 97ms/step - loss: 0.2648 -
categorical_accuracy: 0.8850 - val_loss: 0.7512 -
val_categorical_accuracy: 0.7391
Epoch 10/100
8/8 [==============================] - 1s 98ms/step - loss: 0.2413 -
categorical_accuracy: 0.9071 - val_loss: 0.4787 -
val_categorical_accuracy: 0.8043
Epoch 11/100
8/8 [==============================] - 1s 93ms/step - loss: 0.1804 -
categorical_accuracy: 0.9336 - val_loss: 0.2643 -
val_categorical_accuracy: 0.8696
Epoch 12/100
8/8 [==============================] - 1s 96ms/step - loss: 0.1698 -
categorical_accuracy: 0.9292 - val_loss: 0.2531 -
val_categorical_accuracy: 0.8696
Epoch 13/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1794 -
categorical_accuracy: 0.9336 - val_loss: 0.2186 -
val_categorical_accuracy: 0.9348
Epoch 14/100
8/8 [==============================] - 1s 97ms/step - loss: 0.2054 -
categorical_accuracy: 0.9159 - val_loss: 0.5889 -
val_categorical_accuracy: 0.8043
Epoch 15/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1746 -
categorical_accuracy: 0.9248 - val_loss: 0.8878 -
```

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val_categorical_accuracy: 0.7174
Epoch 16/100
8/8 [==============================] - 1s 92ms/step - loss: 0.2437 -
categorical_accuracy: 0.9204 - val_loss: 0.0609 -
val_categorical_accuracy: 0.9783
Epoch 17/100
8/8 [==============================] - 1s 110ms/step - loss: 0.1831 -
categorical_accuracy: 0.9513 - val_loss: 0.4852 -
val_categorical_accuracy: 0.7826
Epoch 18/100
8/8 [==============================] - 1s 98ms/step - loss: 0.2623 -
categorical_accuracy: 0.9071 - val_loss: 0.1490 -
val_categorical_accuracy: 0.9565
Epoch 19/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1885 -
categorical_accuracy: 0.9425 - val_loss: 0.1848 -
val_categorical_accuracy: 0.9130
Epoch 20/100
8/8 [==============================] - 1s 110ms/step - loss: 0.1586 -
categorical_accuracy: 0.9381 - val_loss: 0.1890 -
val_categorical_accuracy: 0.8913
Epoch 21/100
8/8 [==============================] - 1s 98ms/step - loss: 0.1325 -
categorical_accuracy: 0.9602 - val_loss: 0.1583 -
val_categorical_accuracy: 0.9348
Epoch 22/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1050 -
categorical_accuracy: 0.9646 - val_loss: 0.2586 -
val_categorical_accuracy: 0.9130
Epoch 23/100
8/8 [==============================] - 1s 104ms/step - loss: 0.1144 -
categorical_accuracy: 0.9646 - val_loss: 0.1549 -
val_categorical_accuracy: 0.9130
Epoch 24/100
8/8 [==============================] - 1s 102ms/step - loss: 0.0897 -
categorical_accuracy: 0.9646 - val_loss: 0.3151 -
val_categorical_accuracy: 0.8696
Epoch 25/100
8/8 [==============================] - 1s 96ms/step - loss: 0.1280 -
categorical_accuracy: 0.9425 - val_loss: 0.2401 -
val_categorical_accuracy: 0.8913
Epoch 26/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1276 -
categorical_accuracy: 0.9690 - val_loss: 0.1349 -
val_categorical_accuracy: 0.9565
Epoch 27/100
8/8 [==============================] - 1s 97ms/step - loss: 0.1383 -
categorical_accuracy: 0.9469 - val_loss: 0.4179 -
val_categorical_accuracy: 0.8913
Epoch 28/100
```

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8/8 [==============================] - 1s 97ms/step - loss: 0.0982 -
categorical_accuracy: 0.9558 - val_loss: 0.1530 -
val_categorical_accuracy: 0.9348
Epoch 29/100
8/8 [==============================] - 1s 98ms/step - loss: 0.1029 -
categorical_accuracy: 0.9690 - val_loss: 0.1923 -
val_categorical_accuracy: 0.9348
Epoch 30/100
8/8 [==============================] - 1s 93ms/step - loss: 0.0911 -
categorical_accuracy: 0.9690 - val_loss: 0.2395 -
val_categorical_accuracy: 0.9130
Epoch 31/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0948 -
categorical_accuracy: 0.9602 - val_loss: 0.3082 -
val_categorical_accuracy: 0.8913
Epoch 32/100
8/8 [==============================] - 1s 113ms/step - loss: 0.2451 -
categorical_accuracy: 0.9248 - val_loss: 0.0405 -
val_categorical_accuracy: 0.9783
Epoch 33/100
8/8 [==============================] - 1s 98ms/step - loss: 0.2763 -
categorical_accuracy: 0.8982 - val_loss: 0.7213 -
val_categorical_accuracy: 0.7609
Epoch 34/100
8/8 [==============================] - 1s 99ms/step - loss: 0.1383 -
categorical_accuracy: 0.9558 - val_loss: 0.0970 -
val_categorical_accuracy: 0.9565
Epoch 35/100
8/8 [==============================] - 1s 99ms/step - loss: 0.1002 -
categorical_accuracy: 0.9735 - val_loss: 0.1464 -
val_categorical_accuracy: 0.9348
Epoch 36/100
8/8 [==============================] - 1s 112ms/step - loss: 0.0838 -
categorical_accuracy: 0.9779 - val_loss: 0.2496 -
val_categorical_accuracy: 0.9130
Epoch 37/100
8/8 [==============================] - 1s 93ms/step - loss: 0.0694 -
categorical_accuracy: 0.9735 - val_loss: 0.1422 -
val_categorical_accuracy: 0.9348
Epoch 38/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0712 -
categorical_accuracy: 0.9779 - val_loss: 0.2338 -
val_categorical_accuracy: 0.9130
Epoch 39/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0752 -
categorical_accuracy: 0.9690 - val_loss: 0.1173 -
val_categorical_accuracy: 0.9348
Epoch 40/100
8/8 [==============================] - 1s 98ms/step - loss: 0.1337 -
categorical_accuracy: 0.9381 - val_loss: 0.2243 -
```

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val_categorical_accuracy: 0.9348
Epoch 41/100
8/8 [==============================] - 1s 98ms/step - loss: 0.1340 -
categorical_accuracy: 0.9425 - val_loss: 0.1729 -
val_categorical_accuracy: 0.9565
Epoch 42/100
8/8 [==============================] - 1s 105ms/step - loss: 0.1195 -
categorical_accuracy: 0.9513 - val_loss: 0.3724 -
val_categorical_accuracy: 0.8913
Epoch 43/100
8/8 [==============================] - 1s 119ms/step - loss: 0.1769 -
categorical_accuracy: 0.9513 - val_loss: 0.2689 -
val_categorical_accuracy: 0.8913
Epoch 44/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0846 -
categorical_accuracy: 0.9646 - val_loss: 0.2096 -
val_categorical_accuracy: 0.9348
Epoch 45/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0682 -
categorical_accuracy: 0.9823 - val_loss: 0.2220 -
val_categorical_accuracy: 0.9348
Epoch 46/100
8/8 [==============================] - 1s 102ms/step - loss: 0.0813 -
categorical_accuracy: 0.9735 - val_loss: 0.1734 -
val_categorical_accuracy: 0.9348
Epoch 47/100
8/8 [==============================] - 1s 112ms/step - loss: 0.3252 -
categorical_accuracy: 0.8761 - val_loss: 0.2328 -
val_categorical_accuracy: 0.9130
Epoch 48/100
8/8 [==============================] - 1s 100ms/step - loss: 0.2235 -
categorical_accuracy: 0.9248 - val_loss: 0.4482 -
val_categorical_accuracy: 0.8696
Epoch 49/100
8/8 [==============================] - 1s 94ms/step - loss: 0.1821 -
categorical_accuracy: 0.9336 - val_loss: 0.3423 -
val_categorical_accuracy: 0.8696
Epoch 50/100
8/8 [==============================] - 1s 100ms/step - loss: 0.1426 -
categorical_accuracy: 0.9336 - val_loss: 0.2720 -
val_categorical_accuracy: 0.8913
Epoch 51/100
8/8 [==============================] - 1s 100ms/step - loss: 0.1090 -
categorical_accuracy: 0.9558 - val_loss: 0.3270 -
val_categorical_accuracy: 0.8913
Epoch 52/100
8/8 [==============================] - 1s 99ms/step - loss: 0.1000 -
categorical_accuracy: 0.9646 - val_loss: 0.2207 -
val_categorical_accuracy: 0.9348
Epoch 53/100
```

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8/8 [==============================] - 1s 100ms/step - loss: 0.1131 -
categorical_accuracy: 0.9602 - val_loss: 0.1146 -
val_categorical_accuracy: 0.9348
Epoch 54/100
8/8 [==============================] - 1s 121ms/step - loss: 0.0954 -
categorical_accuracy: 0.9646 - val_loss: 0.3155 -
val_categorical_accuracy: 0.8913
Epoch 55/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0798 -
categorical_accuracy: 0.9690 - val_loss: 0.2541 -
val_categorical_accuracy: 0.8913
Epoch 56/100
8/8 [==============================] - 1s 95ms/step - loss: 0.0688 -
categorical_accuracy: 0.9779 - val_loss: 0.2855 -
val_categorical_accuracy: 0.8913
Epoch 57/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0591 -
categorical_accuracy: 0.9735 - val_loss: 0.2321 -
val_categorical_accuracy: 0.8913
Epoch 58/100
8/8 [==============================] - 1s 106ms/step - loss: 0.0630 -
categorical_accuracy: 0.9690 - val_loss: 0.2124 -
val_categorical_accuracy: 0.8913
Epoch 59/100
8/8 [==============================] - 1s 102ms/step - loss: 0.0802 -
categorical_accuracy: 0.9690 - val_loss: 0.3135 -
val_categorical_accuracy: 0.8913
Epoch 60/100
8/8 [==============================] - 1s 116ms/step - loss: 0.0706 -
categorical_accuracy: 0.9779 - val_loss: 0.1948 -
val_categorical_accuracy: 0.9348
Epoch 61/100
8/8 [==============================] - 1s 109ms/step - loss: 0.0571 -
categorical_accuracy: 0.9735 - val_loss: 0.1634 -
val_categorical_accuracy: 0.9348
Epoch 62/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0703 -
categorical_accuracy: 0.9735 - val_loss: 0.1756 -
val_categorical_accuracy: 0.9565
Epoch 63/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0571 -
categorical_accuracy: 0.9779 - val_loss: 0.3280 -
val_categorical_accuracy: 0.9130
Epoch 64/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0565 -
categorical_accuracy: 0.9779 - val_loss: 0.2660 -
val_categorical_accuracy: 0.9130
Epoch 65/100
8/8 [==============================] - 1s 107ms/step - loss: 0.0576 -
categorical_accuracy: 0.9823 - val_loss: 0.2089 -
```

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val_categorical_accuracy: 0.9348
Epoch 66/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0731 -
categorical_accuracy: 0.9602 - val_loss: 0.2362 -
val_categorical_accuracy: 0.9130
Epoch 67/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0537 -
categorical_accuracy: 0.9779 - val_loss: 0.1802 -
val_categorical_accuracy: 0.9348
Epoch 68/100
8/8 [==============================] - 1s 95ms/step - loss: 0.0539 -
categorical_accuracy: 0.9735 - val_loss: 0.3218 -
val_categorical_accuracy: 0.8913
Epoch 69/100
8/8 [==============================] - 1s 115ms/step - loss: 0.0468 -
categorical_accuracy: 0.9912 - val_loss: 0.1694 -
val_categorical_accuracy: 0.9348
Epoch 70/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0504 -
categorical_accuracy: 0.9867 - val_loss: 0.3610 -
val_categorical_accuracy: 0.8913
Epoch 71/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0531 -
categorical_accuracy: 0.9735 - val_loss: 0.1854 -
val_categorical_accuracy: 0.9130
Epoch 72/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0577 -
categorical_accuracy: 0.9867 - val_loss: 0.2482 -
val_categorical_accuracy: 0.9130
Epoch 73/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0868 -
categorical_accuracy: 0.9779 - val_loss: 0.2624 -
val_categorical_accuracy: 0.9130
Epoch 74/100
8/8 [==============================] - 1s 113ms/step - loss: 0.0492 -
categorical_accuracy: 0.9912 - val_loss: 0.1565 -
val_categorical_accuracy: 0.9565
Epoch 75/100
8/8 [==============================] - 1s 113ms/step - loss: 0.1988 -
categorical_accuracy: 0.9381 - val_loss: 1.0886 -
val_categorical_accuracy: 0.7174
Epoch 76/100
8/8 [==============================] - 1s 99ms/step - loss: 0.1440 -
categorical_accuracy: 0.9381 - val_loss: 0.0458 -
val_categorical_accuracy: 0.9783
Epoch 77/100
8/8 [==============================] - 1s 100ms/step - loss: 0.2231 -
categorical_accuracy: 0.9292 - val_loss: 0.2084 -
val_categorical_accuracy: 0.8913
Epoch 78/100
```

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8/8 [==============================] - 1s 99ms/step - loss: 0.1692 -
categorical_accuracy: 0.9602 - val_loss: 0.0982 -
val_categorical_accuracy: 0.9783
Epoch 79/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0737 -
categorical_accuracy: 0.9646 - val_loss: 0.3009 -
val_categorical_accuracy: 0.9348
Epoch 80/100
8/8 [==============================] - 1s 110ms/step - loss: 0.2076 -
categorical_accuracy: 0.9204 - val_loss: 0.1908 -
val_categorical_accuracy: 0.9348
Epoch 81/100
8/8 [==============================] - 1s 117ms/step - loss: 0.2006 -
categorical_accuracy: 0.9292 - val_loss: 0.0862 -
val_categorical_accuracy: 0.9565
Epoch 82/100
8/8 [==============================] - 1s 99ms/step - loss: 0.1745 -
categorical_accuracy: 0.9558 - val_loss: 0.3435 -
val_categorical_accuracy: 0.8913
Epoch 83/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0705 -
categorical_accuracy: 0.9823 - val_loss: 0.2421 -
val_categorical_accuracy: 0.9348
Epoch 84/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0702 -
categorical_accuracy: 0.9779 - val_loss: 0.0898 -
val_categorical_accuracy: 0.9348
Epoch 85/100
8/8 [==============================] - 1s 95ms/step - loss: 0.0746 -
categorical_accuracy: 0.9779 - val_loss: 0.2148 -
val_categorical_accuracy: 0.9348
Epoch 86/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0529 -
categorical_accuracy: 0.9823 - val_loss: 0.2370 -
val_categorical_accuracy: 0.9348
Epoch 87/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0555 -
categorical_accuracy: 0.9779 - val_loss: 0.1585 -
val_categorical_accuracy: 0.9348
Epoch 88/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0505 -
categorical_accuracy: 0.9823 - val_loss: 0.1600 -
val_categorical_accuracy: 0.9348
Epoch 89/100
8/8 [==============================] - 1s 101ms/step - loss: 0.0693 -
categorical_accuracy: 0.9735 - val_loss: 0.2422 -
val_categorical_accuracy: 0.9130
Epoch 90/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0437 -
categorical_accuracy: 0.9779 - val_loss: 0.1154 -
```

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val_categorical_accuracy: 0.9348
Epoch 91/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0409 -
categorical_accuracy: 0.9912 - val_loss: 0.2280 -
val_categorical_accuracy: 0.9130
Epoch 92/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0395 -
categorical_accuracy: 0.9912 - val_loss: 0.2136 -
val_categorical_accuracy: 0.9130
Epoch 93/100
8/8 [==============================] - 1s 101ms/step - loss: 0.0378 -
categorical_accuracy: 0.9867 - val_loss: 0.1381 -
val_categorical_accuracy: 0.9565
Epoch 94/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0375 -
categorical_accuracy: 0.9823 - val_loss: 0.3341 -
val_categorical_accuracy: 0.8913
Epoch 95/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0428 -
categorical_accuracy: 0.9823 - val_loss: 0.1238 -
val_categorical_accuracy: 0.9348
Epoch 96/100
8/8 [==============================] - 1s 96ms/step - loss: 0.0586 -
categorical_accuracy: 0.9779 - val_loss: 0.2384 -
val_categorical_accuracy: 0.9348
Epoch 97/100
8/8 [==============================] - 1s 95ms/step - loss: 0.0416 -
categorical_accuracy: 0.9823 - val_loss: 0.0847 -
val_categorical_accuracy: 0.9565
Epoch 98/100
8/8 [==============================] - 1s 100ms/step - loss: 0.0564 -
categorical_accuracy: 0.9735 - val_loss: 0.1920 -
val_categorical_accuracy: 0.9348
Epoch 99/100
8/8 [==============================] - 1s 123ms/step - loss: 0.0586 -
categorical_accuracy: 0.9823 - val_loss: 0.1463 -
val_categorical_accuracy: 0.9348
Epoch 100/100
8/8 [==============================] - 1s 105ms/step - loss: 0.0640 -
categorical_accuracy: 0.9823 - val_loss: 0.2269 -
val_categorical_accuracy: 0.9348
2/2 [==============================] - 0s 14ms/step - loss: 0.4298 -
categorical_accuracy: 0.8696
Test accuracy: 0.8695651888847351
Epoch 1/100
8/8 [==============================] - 1s 105ms/step - loss: 3.5071 -
categorical_accuracy: 0.2434 - val_loss: 3.5752 -
val_categorical_accuracy: 0.3478
Epoch 2/100
8/8 [==============================] - 1s 99ms/step - loss: 3.4757 -
```

```
categorical_accuracy: 0.2434 - val_loss: 3.5544 -
val_categorical_accuracy: 0.3478
Epoch 3/100
8/8 [==============================] - 1s 100ms/step - loss: 3.4252 -
categorical_accuracy: 0.2389 - val_loss: 3.5335 -
val_categorical_accuracy: 0.3478
Epoch 4/100
8/8 [==============================] - 1s 102ms/step - loss: 3.4028 -
categorical_accuracy: 0.2389 - val_loss: 3.5125 -
val_categorical_accuracy: 0.3478
Epoch 5/100
8/8 [==============================] - 1s 94ms/step - loss: 3.4123 -
categorical_accuracy: 0.2345 - val_loss: 3.4915 -
val_categorical_accuracy: 0.3478
Epoch 6/100
8/8 [==============================] - 1s 100ms/step - loss: 3.3512 -
categorical_accuracy: 0.2434 - val_loss: 3.4705 -
val_categorical_accuracy: 0.3478
Epoch 7/100
8/8 [==============================] - 1s 100ms/step - loss: 3.3280 -
categorical_accuracy: 0.2389 - val_loss: 3.4496 -
val_categorical_accuracy: 0.3478
Epoch 8/100
8/8 [==============================] - 1s 100ms/step - loss: 3.3521 -
categorical_accuracy: 0.2434 - val_loss: 3.4298 -
val_categorical_accuracy: 0.3478
Epoch 9/100
8/8 [==============================] - 1s 100ms/step - loss: 3.3603 -
categorical_accuracy: 0.2301 - val_loss: 3.4110 -
val_categorical_accuracy: 0.3478
Epoch 10/100
8/8 [==============================] - 1s 100ms/step - loss: 3.3235 -
categorical_accuracy: 0.2478 - val_loss: 3.3925 -
val_categorical_accuracy: 0.3478
Epoch 11/100
8/8 [==============================] - 1s 114ms/step - loss: 3.2598 -
categorical_accuracy: 0.2478 - val_loss: 3.3748 -
val_categorical_accuracy: 0.3478
Epoch 12/100
8/8 [==============================] - 1s 95ms/step - loss: 3.2191 -
categorical_accuracy: 0.2434 - val_loss: 3.3556 -
val_categorical_accuracy: 0.3478
Epoch 13/100
8/8 [==============================] - 1s 100ms/step - loss: 3.2188 -
categorical_accuracy: 0.2434 - val_loss: 3.3372 -
val_categorical_accuracy: 0.3478
Epoch 14/100
8/8 [==============================] - 1s 101ms/step - loss: 3.2428 -
categorical_accuracy: 0.2434 - val_loss: 3.3185 -
val_categorical_accuracy: 0.3478
```

```
Epoch 15/100
8/8 [==============================] - 1s 100ms/step - loss: 3.1833 -
categorical_accuracy: 0.2434 - val_loss: 3.2988 -
val_categorical_accuracy: 0.3478
Epoch 16/100
8/8 [==============================] - 1s 96ms/step - loss: 3.1976 -
categorical_accuracy: 0.2478 - val_loss: 3.2803 -
val_categorical_accuracy: 0.3478
Epoch 17/100
8/8 [==============================] - 1s 117ms/step - loss: 3.1624 -
categorical_accuracy: 0.2434 - val_loss: 3.2630 -
val_categorical_accuracy: 0.3478
Epoch 18/100
8/8 [==============================] - 1s 115ms/step - loss: 3.1614 -
categorical_accuracy: 0.2522 - val_loss: 3.2444 -
val_categorical_accuracy: 0.3478
Epoch 19/100
8/8 [==============================] - 1s 100ms/step - loss: 3.1247 -
categorical_accuracy: 0.2522 - val_loss: 3.2260 -
val_categorical_accuracy: 0.3478
Epoch 20/100
8/8 [==============================] - 1s 101ms/step - loss: 3.1328 -
categorical_accuracy: 0.2522 - val_loss: 3.2079 -
val_categorical_accuracy: 0.3478
Epoch 21/100
8/8 [==============================] - 1s 113ms/step - loss: 3.0601 -
categorical_accuracy: 0.2522 - val_loss: 3.1895 -
val_categorical_accuracy: 0.3478
Epoch 22/100
8/8 [==============================] - 1s 101ms/step - loss: 3.0700 -
categorical_accuracy: 0.2434 - val_loss: 3.1710 -
val_categorical_accuracy: 0.3478
Epoch 23/100
8/8 [==============================] - 1s 99ms/step - loss: 3.0579 -
categorical_accuracy: 0.2522 - val_loss: 3.1506 -
val_categorical_accuracy: 0.3478
Epoch 24/100
8/8 [==============================] - 1s 100ms/step - loss: 2.9924 -
categorical_accuracy: 0.2566 - val_loss: 3.1312 -
val_categorical_accuracy: 0.3478
Epoch 25/100
8/8 [==============================] - 1s 101ms/step - loss: 3.0067 -
categorical_accuracy: 0.2566 - val_loss: 3.1130 -
val_categorical_accuracy: 0.3478
Epoch 26/100
8/8 [==============================] - 1s 96ms/step - loss: 3.0113 -
categorical_accuracy: 0.2566 - val_loss: 3.0948 -
val_categorical_accuracy: 0.3478
Epoch 27/100
8/8 [==============================] - 1s 100ms/step - loss: 2.9588 -
```

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categorical_accuracy: 0.2566 - val_loss: 3.0783 -
val_categorical_accuracy: 0.3478
Epoch 28/100
8/8 [==============================] - 1s 96ms/step - loss: 3.0192 -
categorical_accuracy: 0.2522 - val_loss: 3.0611 -
val_categorical_accuracy: 0.3478
Epoch 29/100
8/8 [==============================] - 1s 100ms/step - loss: 2.9542 -
categorical_accuracy: 0.2566 - val_loss: 3.0434 -
val_categorical_accuracy: 0.3478
Epoch 30/100
8/8 [==============================] - 1s 100ms/step - loss: 2.9272 -
categorical_accuracy: 0.2699 - val_loss: 3.0247 -
val_categorical_accuracy: 0.3478
Epoch 31/100
8/8 [==============================] - 1s 114ms/step - loss: 2.9072 -
categorical_accuracy: 0.2743 - val_loss: 3.0045 -
val_categorical_accuracy: 0.3478
Epoch 32/100
8/8 [==============================] - 1s 100ms/step - loss: 2.9079 -
categorical_accuracy: 0.2655 - val_loss: 2.9880 -
val_categorical_accuracy: 0.3478
Epoch 33/100
8/8 [==============================] - 1s 102ms/step - loss: 2.8672 -
categorical_accuracy: 0.2655 - val_loss: 2.9699 -
val_categorical_accuracy: 0.3478
Epoch 34/100
8/8 [==============================] - 1s 102ms/step - loss: 2.8171 -
categorical_accuracy: 0.2788 - val_loss: 2.9518 -
val_categorical_accuracy: 0.3478
Epoch 35/100
8/8 [==============================] - 1s 100ms/step - loss: 2.8388 -
categorical_accuracy: 0.2965 - val_loss: 2.9356 -
val_categorical_accuracy: 0.3478
Epoch 36/100
8/8 [==============================] - 1s 106ms/step - loss: 2.8749 -
categorical_accuracy: 0.2788 - val_loss: 2.9192 -
val_categorical_accuracy: 0.3478
Epoch 37/100
8/8 [==============================] - 1s 108ms/step - loss: 2.8249 -
categorical_accuracy: 0.2832 - val_loss: 2.9003 -
val_categorical_accuracy: 0.3478
Epoch 38/100
8/8 [==============================] - 1s 100ms/step - loss: 2.7965 -
categorical_accuracy: 0.2655 - val_loss: 2.8837 -
val_categorical_accuracy: 0.3478
Epoch 39/100
8/8 [==============================] - 1s 102ms/step - loss: 2.7990 -
categorical_accuracy: 0.2743 - val_loss: 2.8681 -
val_categorical_accuracy: 0.3478
```

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Epoch 40/100
8/8 [==============================] - 1s 114ms/step - loss: 2.7763 -
categorical_accuracy: 0.2699 - val_loss: 2.8536 -
val_categorical_accuracy: 0.3478
Epoch 41/100
8/8 [==============================] - 1s 101ms/step - loss: 2.7491 -
categorical_accuracy: 0.2788 - val_loss: 2.8384 -
val_categorical_accuracy: 0.3478
Epoch 42/100
8/8 [==============================] - 1s 95ms/step - loss: 2.6918 -
categorical_accuracy: 0.2832 - val_loss: 2.8233 -
val_categorical_accuracy: 0.3478
Epoch 43/100
8/8 [==============================] - 1s 103ms/step - loss: 2.7227 -
categorical_accuracy: 0.2876 - val_loss: 2.8096 -
val_categorical_accuracy: 0.3478
Epoch 44/100
8/8 [==============================] - 1s 101ms/step - loss: 2.6988 -
categorical_accuracy: 0.2788 - val_loss: 2.7952 -
val_categorical_accuracy: 0.3478
Epoch 45/100
8/8 [==============================] - 1s 96ms/step - loss: 2.7082 -
categorical_accuracy: 0.2788 - val_loss: 2.7800 -
val_categorical_accuracy: 0.3478
Epoch 46/100
8/8 [==============================] - 1s 102ms/step - loss: 2.6828 -
categorical_accuracy: 0.2788 - val_loss: 2.7639 -
val_categorical_accuracy: 0.3478
Epoch 47/100
8/8 [==============================] - 1s 102ms/step - loss: 2.6609 -
categorical_accuracy: 0.2920 - val_loss: 2.7487 -
val_categorical_accuracy: 0.3478
Epoch 48/100
8/8 [==============================] - 1s 105ms/step - loss: 2.6260 -
categorical_accuracy: 0.2965 - val_loss: 2.7329 -
val_categorical_accuracy: 0.3478
Epoch 49/100
8/8 [==============================] - 1s 97ms/step - loss: 2.6207 -
categorical_accuracy: 0.2920 - val_loss: 2.7180 -
val_categorical_accuracy: 0.3478
Epoch 50/100
8/8 [==============================] - 1s 101ms/step - loss: 2.6324 -
categorical_accuracy: 0.2876 - val_loss: 2.7041 -
val_categorical_accuracy: 0.3478
Epoch 51/100
8/8 [==============================] - 1s 102ms/step - loss: 2.5762 -
categorical_accuracy: 0.3230 - val_loss: 2.6910 -
val_categorical_accuracy: 0.3478
Epoch 52/100
8/8 [==============================] - 1s 101ms/step - loss: 2.5933 -
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categorical_accuracy: 0.3097 - val_loss: 2.6759 -
val_categorical_accuracy: 0.3478
Epoch 53/100
8/8 [==============================] - 1s 96ms/step - loss: 2.6017 -
categorical_accuracy: 0.2832 - val_loss: 2.6601 -
val_categorical_accuracy: 0.3478
Epoch 54/100
8/8 [==============================] - 1s 101ms/step - loss: 2.5806 -
categorical_accuracy: 0.3097 - val_loss: 2.6453 -
val_categorical_accuracy: 0.3478
Epoch 55/100
8/8 [==============================] - 1s 112ms/step - loss: 2.5598 -
categorical_accuracy: 0.3142 - val_loss: 2.6303 -
val_categorical_accuracy: 0.3478
Epoch 56/100
8/8 [==============================] - 1s 102ms/step - loss: 2.5530 -
categorical_accuracy: 0.3142 - val_loss: 2.6162 -
val_categorical_accuracy: 0.3478
Epoch 57/100
8/8 [==============================] - 1s 118ms/step - loss: 2.5217 -
categorical_accuracy: 0.3319 - val_loss: 2.6017 -
val_categorical_accuracy: 0.3478
Epoch 58/100
8/8 [==============================] - 1s 105ms/step - loss: 2.4983 -
categorical_accuracy: 0.3186 - val_loss: 2.5874 -
val_categorical_accuracy: 0.3478
Epoch 59/100
8/8 [==============================] - 1s 104ms/step - loss: 2.4796 -
categorical_accuracy: 0.3186 - val_loss: 2.5737 -
val_categorical_accuracy: 0.3478
Epoch 60/100
8/8 [==============================] - 1s 103ms/step - loss: 2.4805 -
categorical_accuracy: 0.3274 - val_loss: 2.5591 -
val_categorical_accuracy: 0.3478
Epoch 61/100
8/8 [==============================] - 1s 102ms/step - loss: 2.4737 -
categorical_accuracy: 0.3097 - val_loss: 2.5448 -
val_categorical_accuracy: 0.3478
Epoch 62/100
8/8 [==============================] - 1s 101ms/step - loss: 2.4332 -
categorical_accuracy: 0.3274 - val_loss: 2.5309 -
val_categorical_accuracy: 0.3478
Epoch 63/100
8/8 [==============================] - 1s 97ms/step - loss: 2.4523 -
categorical_accuracy: 0.3407 - val_loss: 2.5171 -
val_categorical_accuracy: 0.3478
Epoch 64/100
8/8 [==============================] - 1s 101ms/step - loss: 2.4588 -
categorical_accuracy: 0.3274 - val_loss: 2.5041 -
val_categorical_accuracy: 0.3478
```

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Epoch 65/100
8/8 [==============================] - 1s 101ms/step - loss: 2.4321 -
categorical_accuracy: 0.3407 - val_loss: 2.4912 -
val_categorical_accuracy: 0.3478
Epoch 66/100
8/8 [==============================] - 1s 102ms/step - loss: 2.3858 -
categorical_accuracy: 0.3363 - val_loss: 2.4775 -
val_categorical_accuracy: 0.3478
Epoch 67/100
8/8 [==============================] - 1s 115ms/step - loss: 2.4078 -
categorical_accuracy: 0.3274 - val_loss: 2.4644 -
val_categorical_accuracy: 0.3478
Epoch 68/100
8/8 [==============================] - 1s 101ms/step - loss: 2.3910 -
categorical_accuracy: 0.3274 - val_loss: 2.4506 -
val_categorical_accuracy: 0.3478
Epoch 69/100
8/8 [==============================] - 1s 102ms/step - loss: 2.3754 -
categorical_accuracy: 0.3274 - val_loss: 2.4367 -
val_categorical_accuracy: 0.3478
Epoch 70/100
8/8 [==============================] - 1s 115ms/step - loss: 2.3519 -
categorical_accuracy: 0.3451 - val_loss: 2.4235 -
val_categorical_accuracy: 0.3478
Epoch 71/100
8/8 [==============================] - 1s 102ms/step - loss: 2.3520 -
categorical_accuracy: 0.3407 - val_loss: 2.4101 -
val_categorical_accuracy: 0.3478
Epoch 72/100
8/8 [==============================] - 1s 102ms/step - loss: 2.3138 -
categorical_accuracy: 0.3496 - val_loss: 2.3959 -
val_categorical_accuracy: 0.3478
Epoch 73/100
8/8 [==============================] - 1s 108ms/step - loss: 2.3502 -
categorical_accuracy: 0.3584 - val_loss: 2.3827 -
val_categorical_accuracy: 0.3478
Epoch 74/100
8/8 [==============================] - 1s 110ms/step - loss: 2.2883 -
categorical_accuracy: 0.3540 - val_loss: 2.3684 -
val_categorical_accuracy: 0.3478
Epoch 75/100
8/8 [==============================] - 1s 101ms/step - loss: 2.3029 -
categorical_accuracy: 0.3584 - val_loss: 2.3541 -
val_categorical_accuracy: 0.3478
Epoch 76/100
8/8 [==============================] - 1s 101ms/step - loss: 2.2899 -
categorical_accuracy: 0.3628 - val_loss: 2.3405 -
val_categorical_accuracy: 0.3478
Epoch 77/100
8/8 [==============================] - 1s 97ms/step - loss: 2.2561 -
```

```
categorical_accuracy: 0.3850 - val_loss: 2.3264 -
val_categorical_accuracy: 0.3478
Epoch 78/100
8/8 [==============================] - 1s 101ms/step - loss: 2.2556 -
categorical_accuracy: 0.3496 - val_loss: 2.3115 -
val_categorical_accuracy: 0.3478
Epoch 79/100
8/8 [==============================] - 1s 103ms/step - loss: 2.2505 -
categorical_accuracy: 0.3584 - val_loss: 2.2964 -
val_categorical_accuracy: 0.3478
Epoch 80/100
8/8 [==============================] - 1s 114ms/step - loss: 2.2122 -
categorical_accuracy: 0.3628 - val_loss: 2.2827 -
val_categorical_accuracy: 0.3478
Epoch 81/100
8/8 [==============================] - 1s 101ms/step - loss: 2.1921 -
categorical_accuracy: 0.3805 - val_loss: 2.2689 -
val_categorical_accuracy: 0.3478
Epoch 82/100
8/8 [==============================] - 1s 101ms/step - loss: 2.1943 -
categorical_accuracy: 0.3717 - val_loss: 2.2547 -
val_categorical_accuracy: 0.3478
Epoch 83/100
8/8 [==============================] - 1s 102ms/step - loss: 2.1713 -
categorical_accuracy: 0.3850 - val_loss: 2.2413 -
val_categorical_accuracy: 0.3478
Epoch 84/100
8/8 [==============================] - 1s 101ms/step - loss: 2.1581 -
categorical_accuracy: 0.3805 - val_loss: 2.2286 -
val_categorical_accuracy: 0.3478
Epoch 85/100
8/8 [==============================] - 1s 101ms/step - loss: 2.1639 -
categorical_accuracy: 0.3850 - val_loss: 2.2162 -
val_categorical_accuracy: 0.3478
Epoch 86/100
8/8 [==============================] - 1s 101ms/step - loss: 2.1493 -
categorical_accuracy: 0.3850 - val_loss: 2.2041 -
val_categorical_accuracy: 0.3478
Epoch 87/100
8/8 [==============================] - 1s 101ms/step - loss: 2.1257 -
categorical_accuracy: 0.3850 - val_loss: 2.1921 -
val_categorical_accuracy: 0.3478
Epoch 88/100
8/8 [==============================] - 1s 102ms/step - loss: 2.1117 -
categorical_accuracy: 0.3894 - val_loss: 2.1798 -
val_categorical_accuracy: 0.3478
Epoch 89/100
8/8 [==============================] - 1s 101ms/step - loss: 2.0923 -
categorical_accuracy: 0.3805 - val_loss: 2.1660 -
val_categorical_accuracy: 0.3478
```

```
Epoch 90/100
8/8 [==============================] - 1s 101ms/step - loss: 2.0817 -
categorical_accuracy: 0.3938 - val_loss: 2.1529 -
val_categorical_accuracy: 0.3478
Epoch 91/100
8/8 [==============================] - 1s 101ms/step - loss: 2.0915 -
categorical_accuracy: 0.3938 - val_loss: 2.1394 -
val_categorical_accuracy: 0.3478
Epoch 92/100
8/8 [==============================] - 1s 115ms/step - loss: 2.0516 -
categorical_accuracy: 0.3938 - val_loss: 2.1262 -
val_categorical_accuracy: 0.3478
Epoch 93/100
8/8 [==============================] - 1s 101ms/step - loss: 2.0442 -
categorical_accuracy: 0.4159 - val_loss: 2.1133 -
val_categorical_accuracy: 0.3478
Epoch 94/100
8/8 [==============================] - 1s 101ms/step - loss: 2.0573 -
categorical_accuracy: 0.4071 - val_loss: 2.1005 -
val_categorical_accuracy: 0.3478
Epoch 95/100
8/8 [==============================] - 1s 102ms/step - loss: 2.0349 -
categorical_accuracy: 0.3938 - val_loss: 2.0879 -
val_categorical_accuracy: 0.3478
Epoch 96/100
8/8 [==============================] - 1s 101ms/step - loss: 2.0141 -
categorical_accuracy: 0.4027 - val_loss: 2.0744 -
val_categorical_accuracy: 0.3478
Epoch 97/100
8/8 [==============================] - 1s 101ms/step - loss: 1.9991 -
categorical_accuracy: 0.4159 - val_loss: 2.0600 -
val_categorical_accuracy: 0.3478
Epoch 98/100
8/8 [==============================] - 1s 101ms/step - loss: 2.0004 -
categorical_accuracy: 0.3938 - val_loss: 2.0462 -
val_categorical_accuracy: 0.3478
Epoch 99/100
8/8 [==============================] - 1s 96ms/step - loss: 1.9775 -
categorical_accuracy: 0.4292 - val_loss: 2.0323 -
val_categorical_accuracy: 0.3478
Epoch 100/100
8/8 [==============================] - 1s 100ms/step - loss: 1.9591 -
categorical_accuracy: 0.4115 - val_loss: 2.0195 -
val_categorical_accuracy: 0.3478
2/2 [==============================] - 0s 14ms/step - loss: 2.9147 -
categorical_accuracy: 0.1957
Test accuracy: 0.19565217196941376
```

After hypertuning the final model works best with learning rate as 0.001 since the accuracy we get is around 89 percent

```
conv_model = train(learning_rate=0.001,base_model=my_model)
```

```
Epoch 1/100
8/8 [==============================] - 1s 120ms/step - loss: 3.6839 -
categorical_accuracy: 0.3142 - val_loss: 2.9845 -
val_categorical_accuracy: 0.4348
Epoch 2/100
8/8 [==============================] - 1s 102ms/step - loss: 2.5416 -
categorical_accuracy: 0.3628 - val_loss: 1.8135 -
val_categorical_accuracy: 0.4565
Epoch 3/100
8/8 [==============================] - 1s 101ms/step - loss: 1.4672 -
categorical_accuracy: 0.4779 - val_loss: 1.1117 -
val_categorical_accuracy: 0.5870
Epoch 4/100
8/8 [==============================] - 1s 97ms/step - loss: 0.9598 -
categorical_accuracy: 0.5619 - val_loss: 0.7914 -
val_categorical_accuracy: 0.6087
Epoch 5/100
8/8 [==============================] - 1s 116ms/step - loss: 0.7107 -
categorical_accuracy: 0.6327 - val_loss: 0.5740 -
val_categorical_accuracy: 0.7391
Epoch 6/100
8/8 [==============================] - 1s 116ms/step - loss: 0.6091 -
categorical_accuracy: 0.8097 - val_loss: 0.5079 -
val_categorical_accuracy: 0.7391
Epoch 7/100
8/8 [==============================] - 1s 102ms/step - loss: 0.5596 -
categorical_accuracy: 0.7699 - val_loss: 0.4584 -
val_categorical_accuracy: 0.7609
Epoch 8/100
8/8 [==============================] - 1s 103ms/step - loss: 0.5014 -
categorical_accuracy: 0.7743 - val_loss: 0.4400 -
val_categorical_accuracy: 0.7609
Epoch 9/100
8/8 [==============================] - 1s 102ms/step - loss: 0.4406 -
categorical_accuracy: 0.8628 - val_loss: 0.4526 -
val_categorical_accuracy: 0.8478
Epoch 10/100
8/8 [==============================] - 1s 113ms/step - loss: 0.3896 -
categorical_accuracy: 0.9336 - val_loss: 0.4985 -
val_categorical_accuracy: 0.8261
Epoch 11/100
8/8 [==============================] - 1s 104ms/step - loss: 0.3384 -
categorical_accuracy: 0.9336 - val_loss: 0.4063 -
val_categorical_accuracy: 0.8913
Epoch 12/100
8/8 [==============================] - 1s 115ms/step - loss: 0.2892 -
```

```
categorical_accuracy: 0.9513 - val_loss: 0.3772 -
val_categorical_accuracy: 0.8913
Epoch 13/100
8/8 [==============================] - 1s 102ms/step - loss: 0.2772 -
categorical_accuracy: 0.9469 - val_loss: 0.2582 -
val_categorical_accuracy: 0.8913
Epoch 14/100
8/8 [==============================] - 1s 103ms/step - loss: 0.2733 -
categorical_accuracy: 0.9425 - val_loss: 0.3262 -
val_categorical_accuracy: 0.8913
Epoch 15/100
8/8 [==============================] - 1s 99ms/step - loss: 0.2179 -
categorical_accuracy: 0.9779 - val_loss: 0.4009 -
val_categorical_accuracy: 0.8913
Epoch 16/100
8/8 [==============================] - 1s 102ms/step - loss: 0.2031 -
categorical_accuracy: 0.9602 - val_loss: 0.3866 -
val_categorical_accuracy: 0.8913
Epoch 17/100
8/8 [==============================] - 1s 103ms/step - loss: 0.1782 -
categorical_accuracy: 0.9602 - val_loss: 0.2959 -
val_categorical_accuracy: 0.8913
Epoch 18/100
8/8 [==============================] - 1s 102ms/step - loss: 0.1739 -
categorical_accuracy: 0.9690 - val_loss: 0.4740 -
val_categorical_accuracy: 0.8696
Epoch 19/100
8/8 [==============================] - 1s 116ms/step - loss: 0.1782 -
categorical_accuracy: 0.9602 - val_loss: 0.4152 -
val_categorical_accuracy: 0.8913
Epoch 20/100
8/8 [==============================] - 1s 103ms/step - loss: 0.1501 -
categorical_accuracy: 0.9779 - val_loss: 0.2847 -
val_categorical_accuracy: 0.8913
Epoch 21/100
8/8 [==============================] - 1s 104ms/step - loss: 0.1420 -
categorical_accuracy: 0.9779 - val_loss: 0.2750 -
val_categorical_accuracy: 0.8913
Epoch 22/100
8/8 [==============================] - 1s 103ms/step - loss: 0.1477 -
categorical_accuracy: 0.9690 - val_loss: 0.2993 -
val_categorical_accuracy: 0.8913
Epoch 23/100
8/8 [==============================] - 1s 103ms/step - loss: 0.1344 -
categorical_accuracy: 0.9779 - val_loss: 0.4369 -
val_categorical_accuracy: 0.8696
Epoch 24/100
8/8 [==============================] - 1s 103ms/step - loss: 0.1305 -
categorical_accuracy: 0.9646 - val_loss: 0.3121 -
val_categorical_accuracy: 0.8913
```

```
Epoch 25/100
8/8 [==============================] - 1s 117ms/step - loss: 0.1376 -
categorical_accuracy: 0.9558 - val_loss: 0.2683 -
val_categorical_accuracy: 0.9130
Epoch 26/100
8/8 [==============================] - 1s 104ms/step - loss: 0.1185 -
categorical_accuracy: 0.9779 - val_loss: 0.2769 -
val_categorical_accuracy: 0.8913
Epoch 27/100
8/8 [==============================] - 1s 103ms/step - loss: 0.1148 -
categorical_accuracy: 0.9690 - val_loss: 0.3810 -
val_categorical_accuracy: 0.8913
Epoch 28/100
8/8 [==============================] - 1s 121ms/step - loss: 0.1092 -
categorical_accuracy: 0.9690 - val_loss: 0.2993 -
val_categorical_accuracy: 0.8913
Epoch 29/100
8/8 [==============================] - 1s 111ms/step - loss: 0.1225 -
categorical_accuracy: 0.9646 - val_loss: 0.3324 -
val_categorical_accuracy: 0.8913
Epoch 30/100
8/8 [==============================] - 1s 117ms/step - loss: 0.1232 -
categorical_accuracy: 0.9690 - val_loss: 0.3381 -
val_categorical_accuracy: 0.8913
Epoch 31/100
8/8 [==============================] - 1s 103ms/step - loss: 0.1115 -
categorical_accuracy: 0.9690 - val_loss: 0.3526 -
val_categorical_accuracy: 0.8913
Epoch 32/100
8/8 [==============================] - 1s 104ms/step - loss: 0.1033 -
categorical_accuracy: 0.9690 - val_loss: 0.3300 -
val_categorical_accuracy: 0.8913
Epoch 33/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0947 -
categorical_accuracy: 0.9867 - val_loss: 0.3338 -
val_categorical_accuracy: 0.8913
Epoch 34/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0957 -
categorical_accuracy: 0.9690 - val_loss: 0.3563 -
val_categorical_accuracy: 0.8913
Epoch 35/100
8/8 [==============================] - 1s 117ms/step - loss: 0.0997 -
categorical_accuracy: 0.9646 - val_loss: 0.3011 -
val_categorical_accuracy: 0.8913
Epoch 36/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0957 -
categorical_accuracy: 0.9690 - val_loss: 0.3433 -
val_categorical_accuracy: 0.8913
Epoch 37/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0919 -
```

```
categorical_accuracy: 0.9735 - val_loss: 0.3905 -
val_categorical_accuracy: 0.8913
Epoch 38/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0844 -
categorical_accuracy: 0.9779 - val_loss: 0.2950 -
val_categorical_accuracy: 0.8913
Epoch 39/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0832 -
categorical_accuracy: 0.9779 - val_loss: 0.3190 -
val_categorical_accuracy: 0.8913
Epoch 40/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0858 -
categorical_accuracy: 0.9779 - val_loss: 0.3663 -
val_categorical_accuracy: 0.8913
Epoch 41/100
8/8 [==============================] - 1s 103ms/step - loss: 0.0804 -
categorical_accuracy: 0.9823 - val_loss: 0.2717 -
val_categorical_accuracy: 0.8913
Epoch 42/100
8/8 [==============================] - 1s 106ms/step - loss: 0.0887 -
categorical_accuracy: 0.9735 - val_loss: 0.3035 -
val_categorical_accuracy: 0.8913
Epoch 43/100
8/8 [==============================] - 1s 118ms/step - loss: 0.0884 -
categorical_accuracy: 0.9823 - val_loss: 0.3145 -
val_categorical_accuracy: 0.8913
Epoch 44/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0790 -
categorical_accuracy: 0.9779 - val_loss: 0.3384 -
val_categorical_accuracy: 0.8913
Epoch 45/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0848 -
categorical_accuracy: 0.9690 - val_loss: 0.3178 -
val_categorical_accuracy: 0.8913
Epoch 46/100
8/8 [==============================] - 1s 105ms/step - loss: 0.0786 -
categorical_accuracy: 0.9912 - val_loss: 0.2402 -
val_categorical_accuracy: 0.9130
Epoch 47/100
8/8 [==============================] - 1s 116ms/step - loss: 0.0917 -
categorical_accuracy: 0.9602 - val_loss: 0.4450 -
val_categorical_accuracy: 0.8913
Epoch 48/100
8/8 [==============================] - 1s 117ms/step - loss: 0.1271 -
categorical_accuracy: 0.9469 - val_loss: 0.5368 -
val_categorical_accuracy: 0.8478
Epoch 49/100
8/8 [==============================] - 1s 104ms/step - loss: 0.1084 -
categorical_accuracy: 0.9735 - val_loss: 0.1131 -
val_categorical_accuracy: 0.9348
```

```
Epoch 50/100
8/8 [==============================] - 1s 103ms/step - loss: 0.1165 -
categorical_accuracy: 0.9602 - val_loss: 0.3063 -
val_categorical_accuracy: 0.8913
Epoch 51/100
8/8 [==============================] - 1s 104ms/step - loss: 0.1047 -
categorical_accuracy: 0.9690 - val_loss: 0.5804 -
val_categorical_accuracy: 0.8478
Epoch 52/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0905 -
categorical_accuracy: 0.9779 - val_loss: 0.2964 -
val_categorical_accuracy: 0.8913
Epoch 53/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0839 -
categorical_accuracy: 0.9690 - val_loss: 0.2139 -
val_categorical_accuracy: 0.9348
Epoch 54/100
8/8 [==============================] - 1s 103ms/step - loss: 0.0804 -
categorical_accuracy: 0.9690 - val_loss: 0.2445 -
val_categorical_accuracy: 0.9130
Epoch 55/100
8/8 [==============================] - 1s 103ms/step - loss: 0.0777 -
categorical_accuracy: 0.9823 - val_loss: 0.3278 -
val_categorical_accuracy: 0.8913
Epoch 56/100
8/8 [==============================] - 1s 118ms/step - loss: 0.0905 -
categorical_accuracy: 0.9735 - val_loss: 0.3580 -
val_categorical_accuracy: 0.8913
Epoch 57/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0814 -
categorical_accuracy: 0.9779 - val_loss: 0.2337 -
val_categorical_accuracy: 0.9348
Epoch 58/100
8/8 [==============================] - 1s 98ms/step - loss: 0.0934 -
categorical_accuracy: 0.9823 - val_loss: 0.3486 -
val_categorical_accuracy: 0.8913
Epoch 59/100
8/8 [==============================] - 1s 117ms/step - loss: 0.0694 -
categorical_accuracy: 0.9779 - val_loss: 0.2889 -
val_categorical_accuracy: 0.8913
Epoch 60/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0750 -
categorical_accuracy: 0.9779 - val_loss: 0.2618 -
val_categorical_accuracy: 0.8913
Epoch 61/100
8/8 [==============================] - 1s 103ms/step - loss: 0.0741 -
categorical_accuracy: 0.9867 - val_loss: 0.3183 -
val_categorical_accuracy: 0.8913
Epoch 62/100
8/8 [==============================] - 1s 103ms/step - loss: 0.0704 -
```

```
categorical_accuracy: 0.9690 - val_loss: 0.3706 -
val_categorical_accuracy: 0.8913
Epoch 63/100
8/8 [==============================] - 1s 103ms/step - loss: 0.0654 -
categorical_accuracy: 0.9823 - val_loss: 0.4381 -
val_categorical_accuracy: 0.8913
Epoch 64/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0799 -
categorical_accuracy: 0.9823 - val_loss: 0.4537 -
val_categorical_accuracy: 0.8913
Epoch 65/100
8/8 [==============================] - 1s 116ms/step - loss: 0.0707 -
categorical_accuracy: 0.9823 - val_loss: 0.2534 -
val_categorical_accuracy: 0.9130
Epoch 66/100
8/8 [==============================] - 1s 105ms/step - loss: 0.0744 -
categorical_accuracy: 0.9646 - val_loss: 0.2264 -
val_categorical_accuracy: 0.9130
Epoch 67/100
8/8 [==============================] - 1s 105ms/step - loss: 0.1361 -
categorical_accuracy: 0.9425 - val_loss: 0.2653 -
val_categorical_accuracy: 0.9130
Epoch 68/100
8/8 [==============================] - 1s 106ms/step - loss: 0.1025 -
categorical_accuracy: 0.9690 - val_loss: 0.3935 -
val_categorical_accuracy: 0.8913
Epoch 69/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0843 -
categorical_accuracy: 0.9735 - val_loss: 0.3184 -
val_categorical_accuracy: 0.8913
Epoch 70/100
8/8 [==============================] - 1s 103ms/step - loss: 0.0812 -
categorical_accuracy: 0.9690 - val_loss: 0.1957 -
val_categorical_accuracy: 0.9348
Epoch 71/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0804 -
categorical_accuracy: 0.9735 - val_loss: 0.2939 -
val_categorical_accuracy: 0.8913
Epoch 72/100
8/8 [==============================] - 1s 105ms/step - loss: 0.0588 -
categorical_accuracy: 0.9867 - val_loss: 0.3002 -
val_categorical_accuracy: 0.8913
Epoch 73/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0695 -
categorical_accuracy: 0.9823 - val_loss: 0.3027 -
val_categorical_accuracy: 0.8913
Epoch 74/100
8/8 [==============================] - 1s 105ms/step - loss: 0.0821 -
categorical_accuracy: 0.9735 - val_loss: 0.3467 -
val_categorical_accuracy: 0.8913
```

```
Epoch 75/100
8/8 [==============================] - 1s 103ms/step - loss: 0.0809 -
categorical_accuracy: 0.9690 - val_loss: 0.2013 -
val_categorical_accuracy: 0.9348
Epoch 76/100
8/8 [==============================] - 1s 105ms/step - loss: 0.0711 -
categorical_accuracy: 0.9779 - val_loss: 0.3105 -
val_categorical_accuracy: 0.8913
Epoch 77/100
8/8 [==============================] - 1s 105ms/step - loss: 0.0611 -
categorical_accuracy: 0.9823 - val_loss: 0.3690 -
val_categorical_accuracy: 0.8913
Epoch 78/100
8/8 [==============================] - 1s 105ms/step - loss: 0.0682 -
categorical_accuracy: 0.9779 - val_loss: 0.4104 -
val_categorical_accuracy: 0.8913
Epoch 79/100
8/8 [==============================] - 1s 107ms/step - loss: 0.0630 -
categorical_accuracy: 0.9779 - val_loss: 0.3435 -
val_categorical_accuracy: 0.8913
Epoch 80/100
8/8 [==============================] - 1s 106ms/step - loss: 0.0572 -
categorical_accuracy: 0.9779 - val_loss: 0.3238 -
val_categorical_accuracy: 0.8913
Epoch 81/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0643 -
categorical_accuracy: 0.9779 - val_loss: 0.3134 -
val_categorical_accuracy: 0.8913
Epoch 82/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0906 -
categorical_accuracy: 0.9558 - val_loss: 0.2065 -
val_categorical_accuracy: 0.9348
Epoch 83/100
8/8 [==============================] - 1s 117ms/step - loss: 0.0768 -
categorical_accuracy: 0.9646 - val_loss: 0.3096 -
val_categorical_accuracy: 0.8913
Epoch 84/100
8/8 [==============================] - 1s 106ms/step - loss: 0.0589 -
categorical_accuracy: 0.9823 - val_loss: 0.3843 -
val_categorical_accuracy: 0.8913
Epoch 85/100
8/8 [==============================] - 1s 111ms/step - loss: 0.0547 -
categorical_accuracy: 0.9867 - val_loss: 0.2411 -
val_categorical_accuracy: 0.9130
Epoch 86/100
8/8 [==============================] - 1s 109ms/step - loss: 0.0669 -
categorical_accuracy: 0.9779 - val_loss: 0.2940 -
val_categorical_accuracy: 0.8913
Epoch 87/100
8/8 [==============================] - 1s 111ms/step - loss: 0.0839 -
```

```
categorical_accuracy: 0.9735 - val_loss: 0.5014 -
val_categorical_accuracy: 0.8913
Epoch 88/100
8/8 [==============================] - 1s 107ms/step - loss: 0.0669 -
categorical_accuracy: 0.9735 - val_loss: 0.3068 -
val_categorical_accuracy: 0.8913
Epoch 89/100
8/8 [==============================] - 1s 105ms/step - loss: 0.0688 -
categorical_accuracy: 0.9823 - val_loss: 0.2346 -
val_categorical_accuracy: 0.9130
Epoch 90/100
8/8 [==============================] - 1s 105ms/step - loss: 0.0729 -
categorical_accuracy: 0.9735 - val_loss: 0.2717 -
val_categorical_accuracy: 0.9130
Epoch 91/100
8/8 [==============================] - 1s 107ms/step - loss: 0.0572 -
categorical_accuracy: 0.9779 - val_loss: 0.2627 -
val_categorical_accuracy: 0.9130
Epoch 92/100
8/8 [==============================] - 1s 102ms/step - loss: 0.0588 -
categorical_accuracy: 0.9735 - val_loss: 0.2898 -
val_categorical_accuracy: 0.8913
Epoch 93/100
8/8 [==============================] - 1s 107ms/step - loss: 0.0617 -
categorical_accuracy: 0.9823 - val_loss: 0.3170 -
val_categorical_accuracy: 0.8913
Epoch 94/100
8/8 [==============================] - 1s 105ms/step - loss: 0.0582 -
categorical_accuracy: 0.9823 - val_loss: 0.2250 -
val_categorical_accuracy: 0.9130
Epoch 95/100
8/8 [==============================] - 1s 120ms/step - loss: 0.0671 -
categorical_accuracy: 0.9646 - val_loss: 0.3115 -
val_categorical_accuracy: 0.8913
Epoch 96/100
8/8 [==============================] - 1s 101ms/step - loss: 0.0693 -
categorical_accuracy: 0.9823 - val_loss: 0.3182 -
val_categorical_accuracy: 0.8913
Epoch 97/100
8/8 [==============================] - 1s 101ms/step - loss: 0.0515 -
categorical_accuracy: 0.9867 - val_loss: 0.2566 -
val_categorical_accuracy: 0.9130
Epoch 98/100
8/8 [==============================] - 1s 105ms/step - loss: 0.0494 -
categorical_accuracy: 0.9823 - val_loss: 0.3057 -
val_categorical_accuracy: 0.8913
Epoch 99/100
8/8 [==============================] - 1s 104ms/step - loss: 0.0623 -
categorical_accuracy: 0.9779 - val_loss: 0.3104 -
val_categorical_accuracy: 0.8913
```

```
Epoch 100/100
8/8 [==============================] - 1s 99ms/step - loss: 0.0541 -
categorical_accuracy: 0.9912 - val_loss: 0.2946 -
val_categorical_accuracy: 0.8913
2/2 [==============================] - 0s 16ms/step - loss: 0.6026 -
categorical_accuracy: 0.8913
Test accuracy: 0.8913043737411499
```

Classification Report

```
y_pred = conv_model.predict(X_test)

# Convert predicted probabilities to class labels
y_pred_labels = np.argmax(y_pred, axis=1)

y_test_labels = np.argmax(y_test, axis=1)

print(classification_report(y_test_labels,
y_pred_labels,zero_division=1))
```

```
2/2 [==============================] - 0s 22ms/step
              precision    recall  f1-score   support

           0       1.00      0.95      0.97        20
           1       0.94      0.79      0.86        19
           2       0.64      1.00      0.78         7

    accuracy                           0.89        46
   macro avg       0.86      0.91      0.87        46
weighted avg       0.92      0.89      0.90        46
```
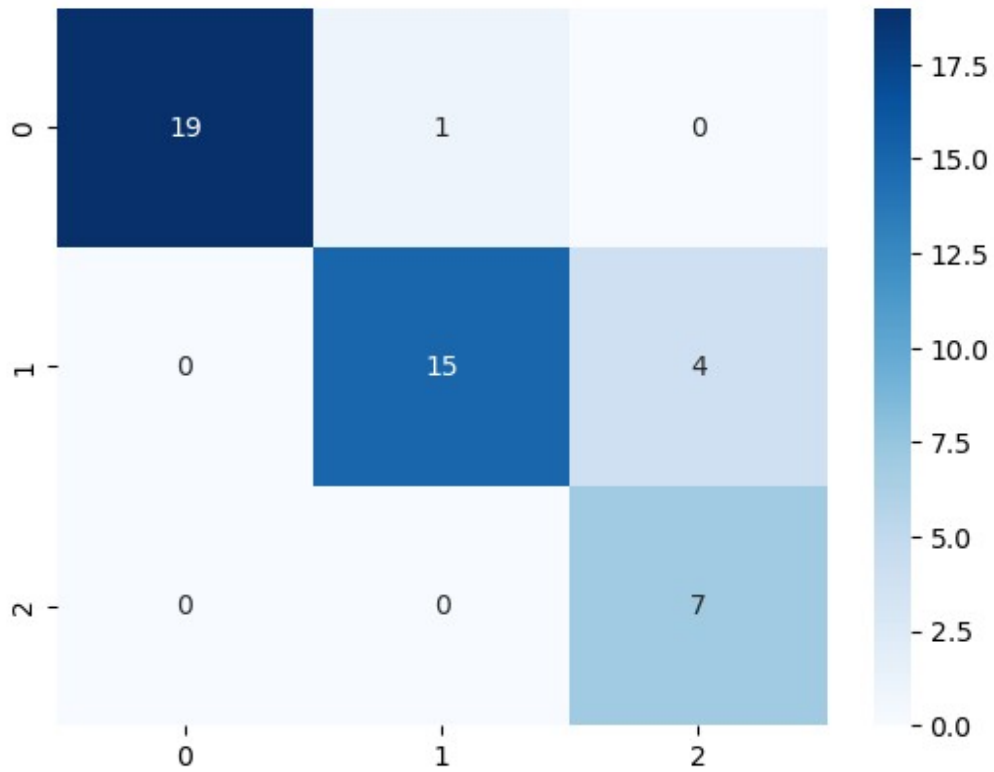
Observing the report, we can see that classification for one class is good compared to other two classes as they share some similar characteristics.

Confusion matrix

```
cm = confusion_matrix(y_test_labels, y_pred_labels)
sns.heatmap(cm, annot=True, cmap="Blues")
```

```
<Axes: >
```

```
display(X_test,y_test,y_pred_labels,num_samples=16,rows=4,columns=4)
```

Incorrectly classified images

Actual-Pebbles | Pred-Plants

Actual-Pebbles | Pred-Plants

Actual-Pebbles | Pred-Plants

Actual-Pebbles | Pred-Plants

Actual-Flowers | Pred-Pebbles

Correctly classified images

Actual-Plants | Pred-Plants · Actual-Flowers | Pred-Flowers · Actual-Pebbles | Pred-Pebbles · Actual-Flowers | Pred-Flowers

Actual-Flowers | Pred-Flowers · Actual-Flowers | Pred-Flowers · Actual-Plants | Pred-Plants · Actual-Pebbles | Pred-Pebbles

Actual-Plants | Pred-Plants · Actual-Pebbles | Pred-Pebbles · Actual-Flowers | Pred-Flowers · Actual-Flowers | Pred-Flowers

Actual-Flowers | Pred-Flowers · Actual-Flowers | Pred-Flowers · Actual-Pebbles | Pred-Pebbles · Actual-Pebbles | Pred-Pebbles

Conclusion

Performance of the deep nueral network we used is better in comparision to the pretrained model for this particular dataset is because of following possible reasons

The deep neural network we designed was specifically designed for the task at hand, whereas the pre-trained model was designed for a different task. While pre-trained model was fine-tuned for the specific task, it was not optimized for the particular characteristics of this particular dataset being used. Whereas, this custom-designed convolutional neural network is tailored to this specific dataset and task at hand, which resulted in better performance.

Also, the size and complexity of the dataset plays a major role. This dataset is small and simpler, and a smaller less complex model sometimes perform better than a larger, more complex pre-trained model, like ResNet50 in our case. On the other hand, for larger or

more complex datasets, a deep neural network with a larger capacity like ResNet50 may be needed to achieve better performance.