oftj94fdx

June 19, 2024

[9]:
```
import os, shutil
train_dir = 'C:/Users/flavi/Desktop/Projeto-20240530/train'
validation_dir = 'C:/Users/flavi/Desktop/Projeto-20240530/validation'
test_dir = 'C:/Users/flavi/Desktop/Projeto-20240530/test'
```

[10]:
```
from keras.utils import image_dataset_from_directory
IMG_SIZE = 150
train_dataset = image_dataset_from_directory(
train_dir,
image_size=(IMG_SIZE, IMG_SIZE),
batch_size=32)
validation_dataset = image_dataset_from_directory(
validation_dir,
image_size=(IMG_SIZE, IMG_SIZE),
batch_size=32)
test_dataset = image_dataset_from_directory(
test_dir,
image_size=(IMG_SIZE, IMG_SIZE),
batch_size=32)
```

```
Found 40000 files belonging to 10 classes.
Found 10000 files belonging to 10 classes.
Found 10000 files belonging to 10 classes.
```

[11]:
```
from tensorflow import keras
from tensorflow.keras import layers
from tensorflow.keras.preprocessing import image
import numpy as np
import tensorflow as tf  # Import TensorFlow explicitly

from tensorflow.keras.applications import VGG16  # Correct import statement for␣
↪VGG16

conv_base = VGG16(weights='imagenet', include_top=False, input_shape=(IMG_SIZE,␣
↪IMG_SIZE, 3))

# Função para extrair características e rótulos dos datasets
```

```python
def get_features_and_labels(dataset):
    all_features = []
    all_labels = []
    for images, labels in dataset:
        preprocessed_images = keras.applications.vgg16.preprocess_input(images)
        features = conv_base.predict(preprocessed_images)
        all_features.append(features)
        all_labels.append(labels)
    return np.concatenate(all_features), np.concatenate(all_labels)


# Extrair características dos datasets de treino, validação e teste
train_features, train_labels = get_features_and_labels(train_dataset)
val_features, val_labels = get_features_and_labels(validation_dataset)
test_features, test_labels = get_features_and_labels(test_dataset)

# Definição do modelo denso a partir das características extraídas
inputs = keras.Input(shape=(4, 4, 512))
x = layers.Flatten()(inputs)
x = layers.Dense(256, activation='relu')(x)
x = layers.Dropout(0.5)(x)
outputs = layers.Dense(10, activation="softmax")(x)
model = keras.Model(inputs, outputs)
```

```
1/1             1s 596ms/step
1/1             1s 536ms/step
1/1             1s 528ms/step
1/1             1s 508ms/step
1/1             0s 485ms/step
1/1             1s 526ms/step
1/1             1s 525ms/step
1/1             1s 504ms/step
1/1             1s 512ms/step
1/1             0s 495ms/step
1/1             1s 530ms/step
1/1             1s 517ms/step
1/1             0s 493ms/step
1/1             1s 529ms/step
1/1             1s 501ms/step
1/1             1s 512ms/step
1/1             0s 486ms/step
1/1             0s 466ms/step
1/1             0s 469ms/step
1/1             0s 498ms/step
1/1             0s 495ms/step
1/1             0s 481ms/step
1/1             0s 497ms/step
```

```
1/1             1s 505ms/step
1/1             1s 503ms/step
1/1             0s 474ms/step
1/1             0s 490ms/step
1/1             0s 483ms/step
1/1             0s 495ms/step
1/1             1s 537ms/step
1/1             0s 447ms/step
1/1             0s 488ms/step
1/1             0s 466ms/step
1/1             0s 489ms/step
1/1             0s 490ms/step
1/1             0s 490ms/step
1/1             0s 483ms/step
1/1             1s 510ms/step
1/1             0s 495ms/step
1/1             0s 475ms/step
1/1             0s 434ms/step
1/1             0s 488ms/step
1/1             0s 488ms/step
1/1             0s 468ms/step
1/1             0s 440ms/step
1/1             1s 505ms/step
1/1             0s 479ms/step
1/1             0s 500ms/step
1/1             0s 500ms/step
1/1             1s 517ms/step
1/1             0s 490ms/step
1/1             0s 473ms/step
1/1             0s 476ms/step
1/1             1s 545ms/step
1/1             1s 505ms/step
1/1             0s 497ms/step
1/1             1s 518ms/step
1/1             0s 494ms/step
1/1             0s 476ms/step
1/1             0s 465ms/step
1/1             0s 491ms/step
1/1             0s 487ms/step
1/1             1s 500ms/step
1/1             1s 507ms/step
1/1             1s 508ms/step
1/1             0s 473ms/step
1/1             0s 475ms/step
1/1             1s 518ms/step
1/1             0s 497ms/step
1/1             1s 506ms/step
1/1             0s 478ms/step
```

```
1/1             1s 502ms/step
1/1             1s 502ms/step
1/1             1s 505ms/step
1/1             1s 502ms/step
1/1             0s 485ms/step
1/1             0s 484ms/step
1/1             0s 494ms/step
1/1             1s 507ms/step
1/1             0s 486ms/step
1/1             0s 487ms/step
1/1             1s 507ms/step
1/1             0s 492ms/step
1/1             1s 508ms/step
1/1             0s 493ms/step
1/1             0s 475ms/step
1/1             0s 473ms/step
1/1             0s 481ms/step
1/1             0s 474ms/step
1/1             0s 467ms/step
1/1             0s 484ms/step
1/1             0s 469ms/step
1/1             0s 470ms/step
1/1             0s 469ms/step
1/1             0s 474ms/step
1/1             0s 500ms/step
1/1             0s 471ms/step
1/1             0s 468ms/step
1/1             0s 478ms/step
1/1             0s 484ms/step
1/1             0s 476ms/step
1/1             1s 519ms/step
1/1             0s 459ms/step
1/1             0s 461ms/step
1/1             0s 461ms/step
1/1             0s 455ms/step
1/1             0s 469ms/step
1/1             0s 458ms/step
1/1             0s 462ms/step
1/1             0s 460ms/step
1/1             0s 462ms/step
1/1             0s 498ms/step
1/1             0s 472ms/step
1/1             0s 463ms/step
1/1             0s 459ms/step
1/1             0s 468ms/step
1/1             0s 459ms/step
1/1             0s 463ms/step
1/1             0s 451ms/step
```

```
1/1             0s 460ms/step
1/1             0s 459ms/step
1/1             0s 462ms/step
1/1             0s 464ms/step
1/1             0s 468ms/step
1/1             0s 460ms/step
1/1             0s 457ms/step
1/1             0s 459ms/step
1/1             0s 468ms/step
1/1             0s 459ms/step
1/1             0s 465ms/step
1/1             0s 466ms/step
1/1             0s 462ms/step
1/1             0s 458ms/step
1/1             0s 458ms/step
1/1             0s 472ms/step
1/1             0s 459ms/step
1/1             0s 465ms/step
1/1             0s 487ms/step
1/1             0s 465ms/step
1/1             0s 461ms/step
1/1             0s 462ms/step
1/1             0s 460ms/step
1/1             0s 458ms/step
1/1             0s 461ms/step
1/1             0s 459ms/step
1/1             0s 486ms/step
1/1             0s 478ms/step
1/1             0s 489ms/step
1/1             0s 470ms/step
1/1             0s 472ms/step
1/1             0s 469ms/step
1/1             0s 477ms/step
1/1             0s 482ms/step
1/1             0s 480ms/step
1/1             0s 491ms/step
1/1             0s 471ms/step
1/1             0s 482ms/step
1/1             0s 465ms/step
1/1             0s 489ms/step
1/1             0s 469ms/step
1/1             0s 470ms/step
1/1             0s 469ms/step
1/1             0s 469ms/step
1/1             0s 482ms/step
1/1             0s 469ms/step
1/1             0s 469ms/step
1/1             0s 466ms/step
```

```
1/1             0s 465ms/step
1/1             0s 467ms/step
1/1             0s 465ms/step
1/1             0s 461ms/step
1/1             0s 463ms/step
1/1             0s 463ms/step
1/1             0s 460ms/step
1/1             0s 460ms/step
1/1             0s 462ms/step
1/1             0s 459ms/step
1/1             0s 466ms/step
1/1             0s 463ms/step
1/1             0s 499ms/step
1/1             0s 458ms/step
1/1             0s 466ms/step
1/1             0s 461ms/step
1/1             0s 468ms/step
1/1             0s 458ms/step
1/1             0s 459ms/step
1/1             0s 464ms/step
1/1             0s 466ms/step
1/1             0s 464ms/step
1/1             0s 458ms/step
1/1             0s 460ms/step
1/1             0s 465ms/step
1/1             0s 468ms/step
1/1             0s 468ms/step
1/1             0s 468ms/step
1/1             0s 460ms/step
1/1             0s 500ms/step
1/1             0s 475ms/step
1/1             0s 460ms/step
1/1             0s 465ms/step
1/1             0s 463ms/step
1/1             0s 465ms/step
1/1             0s 462ms/step
1/1             0s 458ms/step
1/1             0s 460ms/step
1/1             0s 464ms/step
1/1             0s 463ms/step
1/1             0s 467ms/step
1/1             0s 461ms/step
1/1             0s 463ms/step
1/1             0s 465ms/step
1/1             0s 464ms/step
1/1             0s 466ms/step
1/1             0s 458ms/step
1/1             0s 458ms/step
```

```
1/1             0s 459ms/step
1/1             0s 468ms/step
1/1             0s 465ms/step
1/1             0s 458ms/step
1/1             0s 462ms/step
1/1             0s 458ms/step
1/1             0s 464ms/step
1/1             0s 462ms/step
1/1             0s 474ms/step
1/1             0s 476ms/step
1/1             0s 467ms/step
1/1             0s 459ms/step
1/1             0s 462ms/step
1/1             0s 466ms/step
1/1             0s 467ms/step
1/1             0s 468ms/step
1/1             0s 457ms/step
1/1             0s 465ms/step
1/1             0s 471ms/step
1/1             0s 460ms/step
1/1             0s 487ms/step
1/1             0s 457ms/step
1/1             0s 465ms/step
1/1             0s 460ms/step
1/1             0s 459ms/step
1/1             0s 464ms/step
1/1             0s 470ms/step
1/1             0s 461ms/step
1/1             0s 461ms/step
1/1             0s 480ms/step
1/1             0s 465ms/step
1/1             0s 458ms/step
1/1             0s 459ms/step
1/1             0s 457ms/step
1/1             0s 467ms/step
1/1             0s 458ms/step
1/1             0s 467ms/step
1/1             0s 462ms/step
1/1             0s 450ms/step
1/1             0s 460ms/step
1/1             0s 466ms/step
1/1             0s 461ms/step
1/1             0s 457ms/step
1/1             0s 466ms/step
1/1             0s 457ms/step
1/1             0s 465ms/step
1/1             0s 463ms/step
1/1             0s 465ms/step
```

```
1/1             0s 458ms/step
1/1             0s 461ms/step
1/1             0s 461ms/step
1/1             0s 463ms/step
1/1             0s 458ms/step
1/1             0s 460ms/step
1/1             0s 495ms/step
1/1             0s 466ms/step
1/1             0s 467ms/step
1/1             0s 473ms/step
1/1             0s 465ms/step
1/1             0s 462ms/step
1/1             0s 463ms/step
1/1             0s 458ms/step
1/1             0s 461ms/step
1/1             0s 459ms/step
1/1             0s 463ms/step
1/1             0s 466ms/step
1/1             0s 460ms/step
1/1             0s 465ms/step
1/1             0s 462ms/step
1/1             0s 456ms/step
1/1             0s 465ms/step
1/1             0s 482ms/step
1/1             0s 457ms/step
1/1             0s 469ms/step
1/1             0s 461ms/step
1/1             0s 467ms/step
1/1             0s 461ms/step
1/1             0s 471ms/step
1/1             0s 465ms/step
1/1             0s 465ms/step
1/1             0s 457ms/step
1/1             0s 466ms/step
1/1             0s 477ms/step
1/1             0s 466ms/step
1/1             0s 459ms/step
1/1             0s 494ms/step
1/1             0s 466ms/step
1/1             0s 465ms/step
1/1             0s 460ms/step
1/1             0s 462ms/step
1/1             0s 456ms/step
1/1             0s 466ms/step
1/1             0s 459ms/step
1/1             0s 468ms/step
1/1             0s 458ms/step
1/1             0s 458ms/step
```

```
1/1             0s 458ms/step
1/1             0s 463ms/step
1/1             0s 459ms/step
1/1             0s 463ms/step
1/1             0s 463ms/step
1/1             0s 472ms/step
1/1             0s 467ms/step
1/1             0s 466ms/step
1/1             0s 471ms/step
1/1             0s 466ms/step
1/1             0s 462ms/step
1/1             0s 463ms/step
1/1             0s 466ms/step
1/1             0s 458ms/step
1/1             0s 458ms/step
1/1             0s 464ms/step
1/1             0s 465ms/step
1/1             0s 461ms/step
1/1             0s 482ms/step
1/1             0s 465ms/step
1/1             0s 464ms/step
1/1             0s 468ms/step
1/1             0s 488ms/step
1/1             0s 457ms/step
1/1             0s 458ms/step
1/1             0s 465ms/step
1/1             0s 471ms/step
1/1             0s 471ms/step
1/1             0s 462ms/step
1/1             0s 460ms/step
1/1             0s 458ms/step
1/1             0s 462ms/step
1/1             1s 500ms/step
1/1             0s 464ms/step
1/1             0s 458ms/step
1/1             0s 458ms/step
1/1             0s 462ms/step
1/1             0s 460ms/step
1/1             0s 463ms/step
1/1             0s 460ms/step
1/1             0s 465ms/step
1/1             0s 465ms/step
1/1             0s 460ms/step
1/1             0s 462ms/step
1/1             0s 460ms/step
1/1             0s 465ms/step
1/1             0s 482ms/step
1/1             0s 459ms/step
```

```
1/1             0s 465ms/step
1/1             0s 465ms/step
1/1             0s 461ms/step
1/1             0s 465ms/step
1/1             0s 462ms/step
1/1             0s 465ms/step
1/1             0s 463ms/step
1/1             0s 466ms/step
1/1             0s 464ms/step
1/1             0s 460ms/step
1/1             0s 459ms/step
1/1             0s 462ms/step
1/1             0s 457ms/step
1/1             0s 458ms/step
1/1             0s 477ms/step
1/1             0s 459ms/step
1/1             0s 463ms/step
1/1             0s 461ms/step
1/1             0s 467ms/step
1/1             0s 458ms/step
1/1             0s 465ms/step
1/1             0s 470ms/step
1/1             0s 461ms/step
1/1             0s 461ms/step
1/1             1s 501ms/step
1/1             0s 464ms/step
1/1             0s 465ms/step
1/1             0s 463ms/step
1/1             0s 463ms/step
1/1             0s 466ms/step
1/1             0s 474ms/step
1/1             0s 462ms/step
1/1             0s 459ms/step
1/1             0s 466ms/step
1/1             0s 467ms/step
1/1             0s 457ms/step
1/1             0s 476ms/step
1/1             0s 464ms/step
1/1             0s 463ms/step
1/1             0s 472ms/step
1/1             0s 464ms/step
1/1             0s 466ms/step
1/1             0s 460ms/step
1/1             0s 465ms/step
1/1             0s 463ms/step
1/1             0s 466ms/step
1/1             0s 476ms/step
1/1             0s 457ms/step
```

```
1/1             0s 465ms/step
1/1             0s 485ms/step
1/1             0s 459ms/step
1/1             0s 472ms/step
1/1             0s 465ms/step
1/1             0s 466ms/step
1/1             0s 466ms/step
1/1             0s 461ms/step
1/1             0s 467ms/step
1/1             0s 463ms/step
1/1             0s 459ms/step
1/1             0s 465ms/step
1/1             0s 489ms/step
1/1             0s 459ms/step
1/1             0s 477ms/step
1/1             0s 468ms/step
1/1             0s 463ms/step
1/1             0s 465ms/step
1/1             0s 477ms/step
1/1             0s 469ms/step
1/1             0s 461ms/step
1/1             0s 460ms/step
1/1             0s 462ms/step
1/1             0s 486ms/step
1/1             0s 462ms/step
1/1             0s 462ms/step
1/1             0s 459ms/step
1/1             0s 461ms/step
1/1             0s 469ms/step
1/1             0s 474ms/step
1/1             0s 466ms/step
1/1             0s 470ms/step
1/1             0s 459ms/step
1/1             0s 463ms/step
1/1             0s 466ms/step
1/1             0s 460ms/step
1/1             0s 465ms/step
1/1             0s 467ms/step
1/1             0s 461ms/step
1/1             0s 465ms/step
1/1             0s 458ms/step
1/1             0s 463ms/step
1/1             0s 466ms/step
1/1             0s 474ms/step
1/1             0s 458ms/step
1/1             1s 502ms/step
1/1             0s 462ms/step
1/1             0s 460ms/step
```

```
1/1             0s 459ms/step
1/1             0s 460ms/step
1/1             0s 460ms/step
1/1             0s 461ms/step
1/1             0s 460ms/step
1/1             0s 466ms/step
1/1             0s 463ms/step
1/1             0s 461ms/step
1/1             0s 465ms/step
1/1             0s 476ms/step
1/1             0s 464ms/step
1/1             0s 458ms/step
1/1             0s 461ms/step
1/1             0s 465ms/step
1/1             0s 459ms/step
1/1             0s 459ms/step
1/1             0s 466ms/step
1/1             0s 465ms/step
1/1             0s 472ms/step
1/1             1s 511ms/step
1/1             0s 460ms/step
1/1             0s 465ms/step
1/1             0s 465ms/step
1/1             0s 462ms/step
1/1             0s 459ms/step
1/1             0s 461ms/step
1/1             0s 461ms/step
1/1             0s 460ms/step
1/1             0s 476ms/step
1/1             0s 457ms/step
1/1             0s 457ms/step
1/1             0s 485ms/step
1/1             0s 467ms/step
1/1             0s 458ms/step
1/1             0s 465ms/step
1/1             0s 464ms/step
1/1             0s 456ms/step
1/1             0s 462ms/step
1/1             0s 460ms/step
1/1             0s 491ms/step
1/1             0s 458ms/step
1/1             0s 463ms/step
1/1             0s 465ms/step
1/1             0s 459ms/step
1/1             0s 462ms/step
1/1             0s 462ms/step
1/1             0s 465ms/step
1/1             0s 466ms/step
```

```
1/1             0s 466ms/step
1/1             0s 463ms/step
1/1             0s 461ms/step
1/1             0s 460ms/step
1/1             0s 461ms/step
1/1             0s 458ms/step
1/1             0s 465ms/step
1/1             0s 464ms/step
1/1             0s 459ms/step
1/1             0s 468ms/step
1/1             0s 461ms/step
1/1             1s 510ms/step
1/1             0s 461ms/step
1/1             0s 468ms/step
1/1             0s 463ms/step
1/1             0s 470ms/step
1/1             0s 461ms/step
1/1             0s 460ms/step
1/1             0s 460ms/step
1/1             0s 462ms/step
1/1             0s 461ms/step
1/1             0s 458ms/step
1/1             0s 466ms/step
1/1             0s 461ms/step
1/1             0s 469ms/step
1/1             0s 469ms/step
1/1             0s 462ms/step
1/1             0s 470ms/step
1/1             0s 462ms/step
1/1             0s 458ms/step
1/1             0s 464ms/step
1/1             0s 486ms/step
1/1             0s 465ms/step
1/1             0s 464ms/step
1/1             0s 465ms/step
1/1             0s 459ms/step
1/1             0s 459ms/step
1/1             0s 468ms/step
1/1             0s 464ms/step
1/1             0s 473ms/step
1/1             0s 459ms/step
1/1             0s 461ms/step
1/1             0s 460ms/step
1/1             0s 458ms/step
1/1             0s 474ms/step
1/1             0s 468ms/step
1/1             0s 461ms/step
1/1             0s 467ms/step
```

```
1/1             0s 459ms/step
1/1             0s 494ms/step
1/1             0s 463ms/step
1/1             0s 467ms/step
1/1             0s 462ms/step
1/1             0s 468ms/step
1/1             0s 459ms/step
1/1             0s 464ms/step
1/1             0s 463ms/step
1/1             0s 462ms/step
1/1             0s 457ms/step
1/1             0s 466ms/step
1/1             0s 462ms/step
1/1             0s 466ms/step
1/1             0s 465ms/step
1/1             0s 458ms/step
1/1             0s 463ms/step
1/1             0s 462ms/step
1/1             0s 458ms/step
1/1             0s 467ms/step
1/1             0s 471ms/step
1/1             0s 460ms/step
1/1             0s 458ms/step
1/1             0s 467ms/step
1/1             0s 468ms/step
1/1             0s 463ms/step
1/1             0s 461ms/step
1/1             0s 467ms/step
1/1             0s 465ms/step
1/1             0s 462ms/step
1/1             0s 471ms/step
1/1             0s 479ms/step
1/1             0s 461ms/step
1/1             0s 471ms/step
1/1             0s 475ms/step
1/1             0s 463ms/step
1/1             0s 468ms/step
1/1             0s 477ms/step
1/1             0s 475ms/step
1/1             0s 467ms/step
1/1             0s 461ms/step
1/1             0s 469ms/step
1/1             0s 465ms/step
1/1             0s 464ms/step
1/1             0s 465ms/step
1/1             0s 473ms/step
1/1             0s 465ms/step
1/1             0s 465ms/step
```

```
1/1             0s 465ms/step
1/1             0s 461ms/step
1/1             0s 469ms/step
1/1             0s 464ms/step
1/1             0s 454ms/step
1/1             1s 506ms/step
1/1             0s 460ms/step
1/1             0s 471ms/step
1/1             0s 463ms/step
1/1             0s 469ms/step
1/1             0s 461ms/step
1/1             0s 460ms/step
1/1             0s 466ms/step
1/1             0s 460ms/step
1/1             0s 470ms/step
1/1             0s 459ms/step
1/1             0s 462ms/step
1/1             0s 493ms/step
1/1             0s 474ms/step
1/1             0s 479ms/step
1/1             0s 460ms/step
1/1             0s 471ms/step
1/1             0s 498ms/step
1/1             0s 482ms/step
1/1             0s 458ms/step
1/1             0s 462ms/step
1/1             0s 461ms/step
1/1             0s 458ms/step
1/1             0s 465ms/step
1/1             0s 459ms/step
1/1             0s 483ms/step
1/1             0s 459ms/step
1/1             0s 463ms/step
1/1             0s 469ms/step
1/1             0s 455ms/step
1/1             0s 467ms/step
1/1             0s 460ms/step
1/1             0s 459ms/step
1/1             0s 466ms/step
1/1             0s 456ms/step
1/1             0s 461ms/step
1/1             0s 453ms/step
1/1             0s 464ms/step
1/1             0s 497ms/step
1/1             0s 468ms/step
1/1             0s 465ms/step
1/1             0s 465ms/step
1/1             0s 458ms/step
```

```
1/1             0s 467ms/step
1/1             0s 479ms/step
1/1             0s 465ms/step
1/1             0s 467ms/step
1/1             0s 467ms/step
1/1             0s 461ms/step
1/1             0s 473ms/step
1/1             0s 466ms/step
1/1             0s 465ms/step
1/1             0s 464ms/step
1/1             0s 467ms/step
1/1             0s 494ms/step
1/1             0s 463ms/step
1/1             0s 466ms/step
1/1             0s 458ms/step
1/1             0s 476ms/step
1/1             0s 458ms/step
1/1             0s 484ms/step
1/1             0s 463ms/step
1/1             0s 462ms/step
1/1             0s 466ms/step
1/1             0s 459ms/step
1/1             0s 467ms/step
1/1             0s 459ms/step
1/1             0s 460ms/step
1/1             0s 458ms/step
1/1             0s 460ms/step
1/1             0s 480ms/step
1/1             0s 459ms/step
1/1             0s 463ms/step
1/1             0s 490ms/step
1/1             0s 459ms/step
1/1             0s 468ms/step
1/1             0s 460ms/step
1/1             0s 459ms/step
1/1             0s 461ms/step
1/1             0s 465ms/step
1/1             0s 459ms/step
1/1             0s 466ms/step
1/1             0s 460ms/step
1/1             0s 464ms/step
1/1             0s 472ms/step
1/1             0s 464ms/step
1/1             0s 500ms/step
1/1             0s 465ms/step
1/1             0s 463ms/step
1/1             0s 473ms/step
1/1             0s 472ms/step
```

```
1/1             0s 465ms/step
1/1             0s 462ms/step
1/1             0s 475ms/step
1/1             0s 464ms/step
1/1             0s 460ms/step
1/1             0s 459ms/step
1/1             0s 457ms/step
1/1             0s 460ms/step
1/1             0s 466ms/step
1/1             0s 460ms/step
1/1             0s 466ms/step
1/1             0s 478ms/step
1/1             0s 459ms/step
1/1             0s 462ms/step
1/1             0s 467ms/step
1/1             0s 488ms/step
1/1             0s 458ms/step
1/1             0s 479ms/step
1/1             0s 459ms/step
1/1             0s 465ms/step
1/1             0s 463ms/step
1/1             0s 465ms/step
1/1             0s 463ms/step
1/1             0s 465ms/step
1/1             0s 473ms/step
1/1             0s 458ms/step
1/1             0s 461ms/step
1/1             0s 484ms/step
1/1             0s 468ms/step
1/1             0s 462ms/step
1/1             0s 464ms/step
1/1             0s 469ms/step
1/1             0s 477ms/step
1/1             0s 462ms/step
1/1             0s 472ms/step
1/1             0s 461ms/step
1/1             0s 454ms/step
1/1             0s 463ms/step
1/1             0s 465ms/step
1/1             0s 461ms/step
1/1             0s 475ms/step
1/1             0s 465ms/step
1/1             0s 484ms/step
1/1             0s 465ms/step
1/1             0s 473ms/step
1/1             0s 462ms/step
1/1             0s 465ms/step
1/1             0s 464ms/step
```

```
1/1             0s 468ms/step
1/1             0s 460ms/step
1/1             0s 461ms/step
1/1             0s 466ms/step
1/1             0s 462ms/step
1/1             0s 459ms/step
1/1             0s 463ms/step
1/1             0s 463ms/step
1/1             0s 459ms/step
1/1             0s 477ms/step
1/1             0s 459ms/step
1/1             0s 462ms/step
1/1             0s 480ms/step
1/1             0s 471ms/step
1/1             0s 460ms/step
1/1             0s 463ms/step
1/1             0s 465ms/step
1/1             0s 468ms/step
1/1             0s 462ms/step
1/1             0s 460ms/step
1/1             0s 462ms/step
1/1             0s 460ms/step
1/1             0s 465ms/step
1/1             0s 465ms/step
1/1             0s 493ms/step
1/1             0s 459ms/step
1/1             1s 513ms/step
1/1             0s 459ms/step
1/1             0s 459ms/step
1/1             0s 461ms/step
1/1             0s 464ms/step
1/1             0s 466ms/step
1/1             0s 464ms/step
1/1             0s 459ms/step
1/1             0s 460ms/step
1/1             0s 469ms/step
1/1             0s 462ms/step
1/1             0s 468ms/step
1/1             0s 465ms/step
1/1             0s 484ms/step
1/1             0s 471ms/step
1/1             0s 472ms/step
1/1             0s 467ms/step
1/1             0s 463ms/step
1/1             0s 458ms/step
1/1             0s 465ms/step
1/1             0s 461ms/step
1/1             0s 474ms/step
```

```
1/1             0s 464ms/step
1/1             0s 463ms/step
1/1             0s 459ms/step
1/1             0s 465ms/step
1/1             0s 472ms/step
1/1             0s 476ms/step
1/1             0s 499ms/step
1/1             0s 463ms/step
1/1             0s 473ms/step
1/1             1s 511ms/step
1/1             0s 470ms/step
1/1             0s 462ms/step
1/1             0s 461ms/step
1/1             0s 460ms/step
1/1             0s 453ms/step
1/1             0s 458ms/step
1/1             0s 465ms/step
1/1             0s 459ms/step
1/1             0s 458ms/step
1/1             0s 465ms/step
1/1             0s 470ms/step
1/1             0s 493ms/step
1/1             0s 466ms/step
1/1             0s 468ms/step
1/1             0s 468ms/step
1/1             0s 463ms/step
1/1             0s 461ms/step
1/1             0s 464ms/step
1/1             0s 459ms/step
1/1             0s 463ms/step
1/1             0s 459ms/step
1/1             0s 460ms/step
1/1             0s 456ms/step
1/1             0s 461ms/step
1/1             0s 466ms/step
1/1             0s 472ms/step
1/1             0s 483ms/step
1/1             0s 471ms/step
1/1             0s 458ms/step
1/1             0s 460ms/step
1/1             0s 465ms/step
1/1             0s 465ms/step
1/1             0s 461ms/step
1/1             0s 462ms/step
1/1             0s 465ms/step
1/1             0s 472ms/step
1/1             0s 465ms/step
1/1             0s 469ms/step
```

```
1/1             0s 467ms/step
1/1             0s 485ms/step
1/1             0s 463ms/step
1/1             0s 464ms/step
1/1             0s 460ms/step
1/1             0s 457ms/step
1/1             0s 464ms/step
1/1             0s 463ms/step
1/1             0s 479ms/step
1/1             0s 469ms/step
1/1             0s 462ms/step
1/1             0s 462ms/step
1/1             0s 462ms/step
1/1             0s 461ms/step
1/1             0s 496ms/step
1/1             0s 465ms/step
1/1             0s 475ms/step
1/1             0s 465ms/step
1/1             0s 475ms/step
1/1             0s 465ms/step
1/1             0s 467ms/step
1/1             0s 461ms/step
1/1             0s 475ms/step
1/1             0s 465ms/step
1/1             0s 472ms/step
1/1             0s 459ms/step
1/1             0s 456ms/step
1/1             0s 488ms/step
1/1             0s 469ms/step
1/1             0s 466ms/step
1/1             0s 466ms/step
1/1             0s 463ms/step
1/1             1s 572ms/step
1/1             1s 529ms/step
1/1             0s 469ms/step
1/1             0s 467ms/step
1/1             0s 472ms/step
1/1             0s 464ms/step
1/1             0s 492ms/step
1/1             0s 460ms/step
1/1             0s 467ms/step
1/1             0s 463ms/step
1/1             0s 466ms/step
1/1             0s 500ms/step
1/1             1s 511ms/step
1/1             0s 461ms/step
1/1             0s 474ms/step
1/1             0s 479ms/step
```

```
1/1             0s 467ms/step
1/1             0s 497ms/step
1/1             1s 508ms/step
1/1             0s 465ms/step
1/1             0s 472ms/step
1/1             0s 460ms/step
1/1             0s 465ms/step
1/1             0s 468ms/step
1/1             0s 468ms/step
1/1             0s 466ms/step
1/1             0s 464ms/step
1/1             0s 466ms/step
1/1             0s 463ms/step
1/1             0s 467ms/step
1/1             0s 472ms/step
1/1             0s 462ms/step
1/1             0s 488ms/step
1/1             0s 465ms/step
1/1             0s 463ms/step
1/1             0s 461ms/step
1/1             0s 460ms/step
1/1             0s 462ms/step
1/1             0s 467ms/step
1/1             0s 461ms/step
1/1             0s 464ms/step
1/1             0s 467ms/step
1/1             0s 479ms/step
1/1             0s 467ms/step
1/1             0s 493ms/step
1/1             0s 466ms/step
1/1             0s 482ms/step
1/1             0s 461ms/step
1/1             0s 459ms/step
1/1             0s 463ms/step
1/1             0s 459ms/step
1/1             0s 459ms/step
1/1             0s 468ms/step
1/1             0s 458ms/step
1/1             0s 459ms/step
1/1             0s 493ms/step
1/1             0s 498ms/step
1/1             0s 469ms/step
1/1             1s 557ms/step
1/1             1s 512ms/step
1/1             1s 510ms/step
1/1             1s 521ms/step
1/1             1s 563ms/step
1/1             1s 521ms/step
```

```
1/1             1s 557ms/step
1/1             1s 527ms/step
1/1             1s 562ms/step
1/1             1s 518ms/step
1/1             1s 557ms/step
1/1             1s 527ms/step
1/1             1s 517ms/step
1/1             1s 522ms/step
1/1             0s 483ms/step
1/1             0s 463ms/step
1/1             0s 464ms/step
1/1             0s 460ms/step
1/1             0s 499ms/step
1/1             0s 466ms/step
1/1             0s 467ms/step
1/1             0s 464ms/step
1/1             0s 464ms/step
1/1             0s 461ms/step
1/1             0s 465ms/step
1/1             0s 466ms/step
1/1             0s 465ms/step
1/1             0s 457ms/step
1/1             1s 542ms/step
1/1             0s 461ms/step
1/1             0s 468ms/step
1/1             0s 458ms/step
1/1             0s 462ms/step
1/1             0s 472ms/step
1/1             0s 474ms/step
1/1             0s 468ms/step
1/1             0s 471ms/step
1/1             0s 461ms/step
1/1             0s 496ms/step
1/1             0s 460ms/step
1/1             0s 465ms/step
1/1             0s 463ms/step
1/1             0s 467ms/step
1/1             0s 461ms/step
1/1             0s 465ms/step
1/1             0s 469ms/step
1/1             0s 467ms/step
1/1             1s 502ms/step
1/1             1s 512ms/step
1/1             1s 508ms/step
1/1             0s 479ms/step
1/1             0s 472ms/step
1/1             0s 497ms/step
1/1             0s 481ms/step
```

```
1/1             0s 481ms/step
1/1             1s 516ms/step
1/1             0s 487ms/step
1/1             0s 483ms/step
1/1             1s 505ms/step
1/1             0s 489ms/step
1/1             0s 486ms/step
1/1             0s 466ms/step
1/1             1s 536ms/step
1/1             0s 486ms/step
1/1             0s 497ms/step
1/1             0s 494ms/step
1/1             0s 476ms/step
1/1             0s 480ms/step
1/1             0s 485ms/step
1/1             0s 495ms/step
1/1             0s 500ms/step
1/1             1s 505ms/step
1/1             0s 475ms/step
1/1             0s 475ms/step
1/1             0s 479ms/step
1/1             0s 471ms/step
1/1             0s 479ms/step
1/1             0s 474ms/step
1/1             0s 481ms/step
1/1             0s 477ms/step
1/1             0s 476ms/step
1/1             0s 491ms/step
1/1             0s 479ms/step
1/1             0s 473ms/step
1/1             0s 475ms/step
1/1             0s 466ms/step
1/1             0s 480ms/step
1/1             0s 479ms/step
1/1             0s 482ms/step
1/1             0s 465ms/step
1/1             1s 519ms/step
1/1             0s 490ms/step
1/1             0s 480ms/step
1/1             0s 469ms/step
1/1             1s 500ms/step
1/1             0s 472ms/step
1/1             0s 475ms/step
1/1             0s 470ms/step
1/1             0s 476ms/step
1/1             0s 463ms/step
1/1             1s 506ms/step
1/1             0s 469ms/step
```

```
1/1             0s 468ms/step
1/1             0s 469ms/step
1/1             0s 470ms/step
1/1             0s 478ms/step
1/1             0s 475ms/step
1/1             0s 468ms/step
1/1             0s 484ms/step
1/1             0s 479ms/step
1/1             1s 524ms/step
1/1             0s 473ms/step
1/1             0s 470ms/step
1/1             0s 477ms/step
1/1             0s 474ms/step
1/1             0s 469ms/step
1/1             0s 472ms/step
1/1             0s 473ms/step
1/1             0s 471ms/step
1/1             0s 476ms/step
1/1             0s 475ms/step
1/1             1s 509ms/step
1/1             0s 479ms/step
1/1             0s 468ms/step
1/1             0s 478ms/step
1/1             0s 464ms/step
1/1             0s 463ms/step
1/1             0s 470ms/step
1/1             0s 475ms/step
1/1             0s 469ms/step
1/1             0s 472ms/step
1/1             1s 516ms/step
1/1             0s 469ms/step
1/1             0s 481ms/step
1/1             0s 480ms/step
1/1             0s 461ms/step
1/1             0s 479ms/step
1/1             0s 471ms/step
1/1             0s 470ms/step
1/1             0s 476ms/step
1/1             0s 467ms/step
1/1             0s 493ms/step
1/1             0s 468ms/step
1/1             0s 475ms/step
1/1             0s 466ms/step
1/1             0s 478ms/step
1/1             0s 466ms/step
1/1             0s 466ms/step
1/1             0s 471ms/step
1/1             0s 465ms/step
```

```
1/1             0s 472ms/step
1/1             0s 499ms/step
1/1             0s 469ms/step
1/1             0s 481ms/step
1/1             0s 470ms/step
1/1             0s 471ms/step
1/1             0s 466ms/step
1/1             0s 473ms/step
1/1             0s 470ms/step
1/1             0s 474ms/step
1/1             0s 468ms/step
1/1             1s 505ms/step
1/1             0s 470ms/step
1/1             0s 494ms/step
1/1             0s 465ms/step
1/1             0s 477ms/step
1/1             0s 474ms/step
1/1             0s 476ms/step
1/1             0s 469ms/step
1/1             0s 470ms/step
1/1             0s 465ms/step
1/1             0s 499ms/step
1/1             0s 470ms/step
1/1             0s 469ms/step
1/1             0s 485ms/step
1/1             0s 469ms/step
1/1             0s 483ms/step
1/1             0s 471ms/step
1/1             0s 470ms/step
1/1             0s 476ms/step
1/1             0s 475ms/step
1/1             0s 493ms/step
1/1             0s 469ms/step
1/1             0s 475ms/step
1/1             0s 475ms/step
1/1             0s 476ms/step
1/1             0s 474ms/step
1/1             0s 485ms/step
1/1             0s 468ms/step
1/1             0s 475ms/step
1/1             0s 474ms/step
1/1             0s 498ms/step
1/1             0s 469ms/step
1/1             0s 468ms/step
1/1             0s 500ms/step
1/1             0s 471ms/step
1/1             0s 485ms/step
1/1             0s 470ms/step
```

```
1/1             0s 471ms/step
1/1             0s 468ms/step
1/1             0s 470ms/step
1/1             0s 487ms/step
1/1             0s 476ms/step
1/1             0s 469ms/step
1/1             0s 473ms/step
1/1             0s 475ms/step
1/1             0s 484ms/step
1/1             0s 479ms/step
1/1             0s 475ms/step
1/1             0s 465ms/step
1/1             0s 463ms/step
1/1             0s 493ms/step
1/1             0s 484ms/step
1/1             0s 469ms/step
1/1             0s 472ms/step
1/1             0s 468ms/step
1/1             0s 471ms/step
1/1             0s 494ms/step
1/1             0s 468ms/step
1/1             0s 468ms/step
1/1             0s 472ms/step
1/1             1s 507ms/step
1/1             0s 471ms/step
1/1             0s 487ms/step
1/1             0s 476ms/step
1/1             0s 475ms/step
1/1             0s 473ms/step
1/1             0s 475ms/step
1/1             0s 478ms/step
1/1             0s 467ms/step
1/1             0s 471ms/step
1/1             0s 493ms/step
1/1             0s 470ms/step
1/1             0s 468ms/step
1/1             0s 470ms/step
1/1             0s 470ms/step
1/1             0s 473ms/step
1/1             0s 468ms/step
1/1             0s 470ms/step
1/1             0s 466ms/step
1/1             1s 514ms/step
1/1             0s 474ms/step
1/1             0s 491ms/step
1/1             0s 492ms/step
1/1             0s 468ms/step
1/1             0s 465ms/step
```

```
1/1             0s 472ms/step
1/1             0s 478ms/step
1/1             0s 473ms/step
1/1             1s 536ms/step
1/1             0s 465ms/step
1/1             0s 488ms/step
1/1             0s 480ms/step
1/1             0s 468ms/step
1/1             0s 467ms/step
1/1             0s 481ms/step
1/1             0s 466ms/step
1/1             0s 465ms/step
1/1             0s 493ms/step
1/1             0s 472ms/step
1/1             0s 475ms/step
1/1             0s 472ms/step
1/1             0s 472ms/step
1/1             0s 491ms/step
1/1             0s 473ms/step
1/1             0s 469ms/step
1/1             0s 476ms/step
1/1             1s 501ms/step
1/1             0s 474ms/step
1/1             0s 472ms/step
1/1             0s 479ms/step
1/1             0s 481ms/step
1/1             0s 467ms/step
1/1             0s 478ms/step
1/1             0s 469ms/step
1/1             0s 500ms/step
1/1             0s 469ms/step
1/1             0s 470ms/step
1/1             0s 469ms/step
1/1             0s 475ms/step
1/1             0s 475ms/step
1/1             1s 501ms/step
1/1             0s 483ms/step
1/1             0s 483ms/step
1/1             0s 477ms/step
1/1             0s 484ms/step
1/1             1s 560ms/step
1/1             1s 606ms/step
1/1             0s 479ms/step
1/1             0s 468ms/step
1/1             0s 470ms/step
1/1             0s 493ms/step
1/1             0s 473ms/step
1/1             0s 470ms/step
```

```
1/1             0s 472ms/step
1/1             0s 472ms/step
1/1             0s 473ms/step
1/1             0s 476ms/step
1/1             0s 467ms/step
1/1             0s 500ms/step
1/1             0s 469ms/step
1/1             0s 470ms/step
1/1             0s 474ms/step
1/1             0s 465ms/step
1/1             0s 476ms/step
1/1             0s 474ms/step
1/1             0s 467ms/step
1/1             1s 513ms/step
1/1             0s 474ms/step
1/1             0s 467ms/step
1/1             0s 469ms/step
1/1             0s 478ms/step
1/1             0s 480ms/step
1/1             0s 476ms/step
1/1             0s 486ms/step
1/1             1s 509ms/step
1/1             0s 463ms/step
1/1             0s 466ms/step
1/1             0s 479ms/step
1/1             0s 469ms/step
1/1             0s 473ms/step
1/1             0s 467ms/step
1/1             0s 482ms/step
1/1             0s 472ms/step
1/1             0s 492ms/step
1/1             0s 465ms/step
1/1             0s 475ms/step
1/1             0s 478ms/step
1/1             0s 469ms/step
1/1             0s 490ms/step
1/1             0s 480ms/step
1/1             0s 475ms/step
1/1             0s 470ms/step
1/1             0s 470ms/step
1/1             0s 471ms/step
1/1             0s 470ms/step
1/1             1s 504ms/step
1/1             0s 468ms/step
1/1             0s 496ms/step
1/1             0s 474ms/step
1/1             0s 484ms/step
1/1             0s 475ms/step
```

```
1/1             0s 472ms/step
1/1             0s 486ms/step
1/1             0s 479ms/step
1/1             0s 465ms/step
1/1             0s 467ms/step
1/1             0s 477ms/step
1/1             0s 466ms/step
1/1             0s 476ms/step
1/1             1s 514ms/step
1/1             0s 480ms/step
1/1             0s 472ms/step
1/1             0s 471ms/step
1/1             0s 469ms/step
1/1             0s 467ms/step
1/1             0s 497ms/step
1/1             0s 498ms/step
1/1             0s 482ms/step
1/1             0s 470ms/step
1/1             0s 469ms/step
1/1             0s 475ms/step
1/1             0s 479ms/step
1/1             0s 470ms/step
1/1             0s 489ms/step
1/1             0s 482ms/step
1/1             0s 486ms/step
1/1             0s 473ms/step
1/1             0s 470ms/step
1/1             0s 468ms/step
1/1             0s 470ms/step
1/1             1s 503ms/step
1/1             0s 476ms/step
1/1             0s 465ms/step
1/1             0s 471ms/step
1/1             0s 471ms/step
1/1             0s 475ms/step
1/1             0s 475ms/step
1/1             0s 490ms/step
1/1             0s 473ms/step
1/1             0s 476ms/step
1/1             0s 495ms/step
1/1             0s 477ms/step
1/1             0s 472ms/step
1/1             0s 480ms/step
1/1             0s 493ms/step
1/1             0s 465ms/step
1/1             0s 486ms/step
1/1             0s 467ms/step
1/1             0s 479ms/step
```

```
1/1             0s 463ms/step
1/1             0s 473ms/step
1/1             0s 490ms/step
1/1             0s 469ms/step
1/1             0s 473ms/step
1/1             0s 481ms/step
1/1             0s 472ms/step
1/1             0s 471ms/step
1/1             0s 482ms/step
1/1             0s 488ms/step
1/1             0s 477ms/step
1/1             0s 473ms/step
1/1             0s 470ms/step
1/1             0s 465ms/step
1/1             0s 467ms/step
1/1             0s 472ms/step
1/1             1s 513ms/step
1/1             0s 477ms/step
1/1             0s 476ms/step
1/1             0s 469ms/step
1/1             0s 469ms/step
1/1             0s 471ms/step
1/1             0s 471ms/step
1/1             0s 496ms/step
1/1             1s 500ms/step
1/1             0s 475ms/step
1/1             0s 470ms/step
1/1             0s 486ms/step
1/1             0s 471ms/step
1/1             0s 479ms/step
1/1             0s 491ms/step
1/1             0s 480ms/step
1/1             0s 471ms/step
1/1             0s 476ms/step
1/1             0s 479ms/step
1/1             0s 467ms/step
1/1             0s 467ms/step
1/1             1s 501ms/step
1/1             0s 476ms/step
1/1             0s 470ms/step
1/1             0s 495ms/step
1/1             0s 467ms/step
1/1             0s 475ms/step
1/1             0s 469ms/step
1/1             0s 494ms/step
1/1             0s 470ms/step
1/1             0s 479ms/step
1/1             0s 470ms/step
```

```
1/1             0s 469ms/step
1/1             0s 477ms/step
1/1             0s 470ms/step
1/1             0s 496ms/step
1/1             0s 472ms/step
1/1             0s 472ms/step
1/1             0s 471ms/step
1/1             0s 469ms/step
1/1             0s 460ms/step
1/1             0s 472ms/step
1/1             1s 512ms/step
1/1             0s 478ms/step
1/1             0s 481ms/step
1/1             0s 474ms/step
1/1             0s 490ms/step
1/1             0s 469ms/step
1/1             0s 470ms/step
1/1             1s 508ms/step
1/1             0s 483ms/step
1/1             0s 473ms/step
1/1             0s 468ms/step
1/1             0s 480ms/step
1/1             0s 466ms/step
1/1             0s 489ms/step
1/1             0s 487ms/step
1/1             0s 472ms/step
1/1             0s 478ms/step
1/1             0s 471ms/step
1/1             0s 470ms/step
1/1             0s 467ms/step
1/1             0s 477ms/step
1/1             1s 506ms/step
1/1             0s 470ms/step
1/1             0s 470ms/step
1/1             0s 476ms/step
1/1             0s 470ms/step
1/1             0s 470ms/step
1/1             0s 470ms/step
1/1             0s 494ms/step
1/1             0s 483ms/step
1/1             0s 467ms/step
1/1             0s 477ms/step
1/1             0s 470ms/step
1/1             0s 465ms/step
1/1             0s 477ms/step
1/1             0s 500ms/step
1/1             0s 483ms/step
1/1             0s 470ms/step
```

```
1/1             0s 475ms/step
1/1             0s 475ms/step
1/1             0s 466ms/step
1/1             0s 485ms/step
1/1             0s 496ms/step
1/1             0s 471ms/step
1/1             0s 474ms/step
1/1             0s 468ms/step
1/1             0s 474ms/step
1/1             0s 477ms/step
1/1             0s 474ms/step
1/1             1s 502ms/step
1/1             0s 472ms/step
1/1             0s 471ms/step
1/1             0s 469ms/step
1/1             0s 467ms/step
1/1             0s 470ms/step
1/1             1s 530ms/step
1/1             1s 504ms/step
1/1             0s 469ms/step
1/1             0s 473ms/step
1/1             0s 471ms/step
1/1             0s 471ms/step
1/1             0s 477ms/step
1/1             0s 486ms/step
1/1             0s 475ms/step
1/1             0s 485ms/step
1/1             0s 472ms/step
1/1             0s 483ms/step
1/1             0s 486ms/step
1/1             0s 481ms/step
1/1             1s 501ms/step
1/1             0s 471ms/step
1/1             0s 477ms/step
1/1             0s 482ms/step
1/1             0s 471ms/step
1/1             0s 480ms/step
1/1             0s 484ms/step
1/1             1s 510ms/step
1/1             0s 470ms/step
1/1             0s 477ms/step
1/1             0s 492ms/step
1/1             0s 469ms/step
1/1             0s 472ms/step
1/1             0s 469ms/step
1/1             1s 510ms/step
1/1             0s 471ms/step
1/1             0s 477ms/step
```

```
1/1             0s 477ms/step
1/1             0s 473ms/step
1/1             0s 483ms/step
1/1             0s 469ms/step
1/1             0s 496ms/step
1/1             0s 465ms/step
1/1             0s 481ms/step
1/1             0s 477ms/step
1/1             0s 468ms/step
1/1             0s 483ms/step
1/1             0s 499ms/step
1/1             0s 497ms/step
1/1             0s 484ms/step
1/1             0s 472ms/step
1/1             0s 477ms/step
1/1             0s 471ms/step
1/1             0s 469ms/step
1/1             0s 472ms/step
1/1             1s 500ms/step
1/1             0s 467ms/step
1/1             0s 468ms/step
1/1             0s 473ms/step
1/1             0s 472ms/step
1/1             0s 467ms/step
1/1             0s 470ms/step
1/1             1s 518ms/step
1/1             0s 474ms/step
1/1             0s 473ms/step
1/1             0s 469ms/step
1/1             0s 475ms/step
1/1             0s 469ms/step
1/1             0s 472ms/step
1/1             0s 489ms/step
1/1             0s 482ms/step
1/1             0s 472ms/step
1/1             0s 468ms/step
1/1             0s 479ms/step
1/1             0s 477ms/step
1/1             0s 469ms/step
1/1             1s 517ms/step
1/1             0s 470ms/step
1/1             0s 470ms/step
1/1             0s 478ms/step
1/1             0s 484ms/step
1/1             0s 469ms/step
1/1             0s 471ms/step
1/1             0s 498ms/step
1/1             0s 467ms/step
```

```
1/1             0s 477ms/step
1/1             0s 472ms/step
1/1             0s 487ms/step
1/1             0s 476ms/step
1/1             0s 484ms/step
1/1             0s 497ms/step
1/1             0s 469ms/step
1/1             0s 494ms/step
1/1             0s 488ms/step
1/1             0s 468ms/step
1/1             0s 468ms/step
1/1             0s 470ms/step
1/1             0s 500ms/step
1/1             0s 469ms/step
1/1             0s 473ms/step
1/1             0s 470ms/step
1/1             0s 468ms/step
1/1             0s 470ms/step
1/1             0s 477ms/step
1/1             0s 499ms/step
1/1             0s 468ms/step
1/1             0s 471ms/step
1/1             0s 496ms/step
1/1             0s 468ms/step
1/1             0s 462ms/step
1/1             0s 477ms/step
1/1             1s 512ms/step
1/1             0s 467ms/step
1/1             0s 470ms/step
1/1             0s 478ms/step
1/1             0s 470ms/step
1/1             0s 467ms/step
1/1             1s 504ms/step
1/1             0s 489ms/step
1/1             0s 469ms/step
1/1             0s 472ms/step
1/1             0s 475ms/step
1/1             0s 472ms/step
1/1             0s 473ms/step
1/1             0s 479ms/step
1/1             1s 537ms/step
1/1             0s 458ms/step
1/1             0s 477ms/step
1/1             0s 464ms/step
1/1             0s 469ms/step
1/1             0s 467ms/step
1/1             0s 475ms/step
1/1             1s 512ms/step
```

```
1/1             0s 475ms/step
1/1             0s 474ms/step
1/1             0s 470ms/step
1/1             0s 313ms/step
1/1             1s 560ms/step
1/1             0s 491ms/step
1/1             0s 496ms/step
1/1             0s 466ms/step
1/1             0s 469ms/step
1/1             0s 481ms/step
1/1             0s 487ms/step
1/1             0s 469ms/step
1/1             0s 469ms/step
1/1             0s 489ms/step
1/1             0s 477ms/step
1/1             0s 473ms/step
1/1             0s 465ms/step
1/1             0s 474ms/step
1/1             0s 469ms/step
1/1             0s 471ms/step
1/1             0s 490ms/step
1/1             0s 468ms/step
1/1             0s 467ms/step
1/1             0s 475ms/step
1/1             0s 472ms/step
1/1             0s 470ms/step
1/1             0s 468ms/step
1/1             1s 503ms/step
1/1             0s 471ms/step
1/1             0s 467ms/step
1/1             0s 484ms/step
1/1             0s 469ms/step
1/1             0s 494ms/step
1/1             0s 488ms/step
1/1             0s 500ms/step
1/1             0s 467ms/step
1/1             0s 467ms/step
1/1             0s 469ms/step
1/1             0s 472ms/step
1/1             0s 470ms/step
1/1             0s 472ms/step
1/1             0s 499ms/step
1/1             0s 480ms/step
1/1             0s 465ms/step
1/1             0s 475ms/step
1/1             0s 466ms/step
1/1             0s 476ms/step
1/1             0s 461ms/step
```

```
1/1             1s 500ms/step
1/1             0s 469ms/step
1/1             0s 470ms/step
1/1             0s 469ms/step
1/1             0s 470ms/step
1/1             0s 477ms/step
1/1             0s 472ms/step
1/1             0s 491ms/step
1/1             0s 466ms/step
1/1             0s 469ms/step
1/1             0s 472ms/step
1/1             0s 480ms/step
1/1             1s 501ms/step
1/1             0s 476ms/step
1/1             1s 500ms/step
1/1             0s 467ms/step
1/1             0s 474ms/step
1/1             0s 472ms/step
1/1             0s 467ms/step
1/1             0s 463ms/step
1/1             0s 471ms/step
1/1             1s 503ms/step
1/1             0s 476ms/step
1/1             0s 476ms/step
1/1             0s 475ms/step
1/1             0s 477ms/step
1/1             0s 472ms/step
1/1             0s 474ms/step
1/1             0s 483ms/step
1/1             0s 470ms/step
1/1             0s 479ms/step
1/1             0s 470ms/step
1/1             0s 471ms/step
1/1             0s 458ms/step
1/1             0s 488ms/step
1/1             0s 491ms/step
1/1             0s 474ms/step
1/1             0s 471ms/step
1/1             0s 474ms/step
1/1             0s 465ms/step
1/1             0s 469ms/step
1/1             1s 515ms/step
1/1             0s 472ms/step
1/1             0s 468ms/step
1/1             0s 467ms/step
1/1             0s 477ms/step
1/1             0s 464ms/step
1/1             1s 510ms/step
```

```
1/1             0s 473ms/step
1/1             0s 460ms/step
1/1             0s 488ms/step
1/1             0s 500ms/step
1/1             1s 513ms/step
1/1             0s 488ms/step
1/1             0s 480ms/step
1/1             0s 468ms/step
1/1             0s 491ms/step
1/1             1s 532ms/step
1/1             1s 512ms/step
1/1             0s 496ms/step
1/1             1s 508ms/step
1/1             0s 486ms/step
1/1             0s 475ms/step
1/1             0s 486ms/step
1/1             0s 479ms/step
1/1             1s 501ms/step
1/1             1s 504ms/step
1/1             0s 483ms/step
1/1             0s 492ms/step
1/1             0s 478ms/step
1/1             0s 469ms/step
1/1             0s 488ms/step
1/1             0s 488ms/step
1/1             1s 531ms/step
1/1             1s 556ms/step
1/1             1s 514ms/step
1/1             1s 605ms/step
1/1             1s 563ms/step
1/1             1s 568ms/step
1/1             1s 603ms/step
1/1             1s 569ms/step
1/1             1s 574ms/step
1/1             1s 623ms/step
1/1             1s 626ms/step
1/1             1s 555ms/step
1/1             1s 577ms/step
1/1             1s 569ms/step
1/1             0s 495ms/step
1/1             0s 482ms/step
1/1             0s 498ms/step
1/1             1s 642ms/step
1/1             1s 638ms/step
1/1             1s 500ms/step
1/1             0s 483ms/step
1/1             0s 463ms/step
1/1             0s 464ms/step
```

```
1/1             0s 461ms/step
1/1             1s 503ms/step
1/1             0s 475ms/step
1/1             0s 475ms/step
1/1             0s 469ms/step
1/1             0s 465ms/step
1/1             0s 463ms/step
1/1             0s 480ms/step
1/1             0s 472ms/step
1/1             0s 460ms/step
1/1             0s 468ms/step
1/1             1s 547ms/step
1/1             1s 510ms/step
1/1             0s 490ms/step
1/1             0s 462ms/step
1/1             0s 466ms/step
1/1             0s 462ms/step
1/1             0s 475ms/step
1/1             0s 460ms/step
1/1             1s 504ms/step
1/1             0s 460ms/step
1/1             0s 465ms/step
1/1             0s 470ms/step
1/1             0s 463ms/step
1/1             0s 460ms/step
1/1             0s 484ms/step
1/1             0s 464ms/step
1/1             0s 462ms/step
1/1             0s 466ms/step
1/1             0s 468ms/step
1/1             1s 520ms/step
1/1             1s 510ms/step
1/1             0s 467ms/step
1/1             0s 462ms/step
1/1             0s 460ms/step
1/1             0s 480ms/step
1/1             0s 485ms/step
1/1             1s 501ms/step
1/1             0s 467ms/step
1/1             0s 463ms/step
1/1             0s 480ms/step
1/1             0s 463ms/step
1/1             0s 465ms/step
1/1             0s 483ms/step
1/1             0s 470ms/step
1/1             0s 470ms/step
1/1             0s 493ms/step
1/1             0s 497ms/step
```

```
1/1             0s 462ms/step
1/1             0s 488ms/step
1/1             0s 462ms/step
1/1             0s 459ms/step
1/1             0s 463ms/step
1/1             0s 459ms/step
1/1             0s 462ms/step
1/1             1s 515ms/step
1/1             0s 468ms/step
1/1             0s 469ms/step
1/1             0s 463ms/step
1/1             0s 461ms/step
1/1             0s 464ms/step
1/1             0s 492ms/step
1/1             0s 466ms/step
1/1             0s 466ms/step
1/1             0s 462ms/step
1/1             0s 463ms/step
1/1             0s 468ms/step
1/1             1s 515ms/step
1/1             0s 466ms/step
1/1             0s 468ms/step
1/1             0s 466ms/step
1/1             0s 471ms/step
1/1             0s 462ms/step
1/1             1s 508ms/step
1/1             0s 463ms/step
1/1             0s 461ms/step
1/1             0s 462ms/step
1/1             0s 466ms/step
1/1             0s 469ms/step
1/1             1s 535ms/step
1/1             0s 462ms/step
1/1             0s 464ms/step
1/1             0s 468ms/step
1/1             0s 463ms/step
1/1             0s 462ms/step
1/1             0s 491ms/step
1/1             0s 465ms/step
1/1             0s 465ms/step
1/1             0s 463ms/step
1/1             0s 469ms/step
1/1             0s 475ms/step
1/1             1s 530ms/step
1/1             0s 471ms/step
1/1             0s 463ms/step
1/1             0s 470ms/step
1/1             0s 465ms/step
```

```
1/1             0s 490ms/step
1/1             0s 464ms/step
1/1             0s 471ms/step
1/1             0s 462ms/step
1/1             0s 466ms/step
1/1             0s 466ms/step
1/1             1s 511ms/step
1/1             1s 528ms/step
1/1             1s 562ms/step
1/1             1s 536ms/step
1/1             1s 538ms/step
1/1             1s 523ms/step
1/1             1s 561ms/step
1/1             1s 527ms/step
1/1             0s 476ms/step
1/1             1s 519ms/step
1/1             0s 498ms/step
1/1             1s 558ms/step
1/1             1s 579ms/step
1/1             1s 518ms/step
1/1             1s 513ms/step
1/1             1s 555ms/step
1/1             1s 535ms/step
1/1             1s 586ms/step
1/1             1s 570ms/step
1/1             1s 512ms/step
1/1             1s 578ms/step
1/1             1s 559ms/step
1/1             0s 474ms/step
1/1             0s 494ms/step
1/1             1s 505ms/step
1/1             0s 476ms/step
1/1             0s 473ms/step
1/1             0s 489ms/step
1/1             0s 471ms/step
1/1             0s 473ms/step
1/1             1s 518ms/step
1/1             0s 494ms/step
1/1             0s 474ms/step
1/1             1s 509ms/step
1/1             0s 475ms/step
1/1             0s 489ms/step
1/1             0s 473ms/step
1/1             0s 472ms/step
1/1             1s 519ms/step
1/1             1s 520ms/step
1/1             1s 530ms/step
1/1             0s 493ms/step
```

```
1/1             0s 499ms/step
1/1             1s 517ms/step
1/1             1s 565ms/step
1/1             1s 577ms/step
1/1             1s 551ms/step
1/1             1s 547ms/step
1/1             1s 551ms/step
1/1             1s 541ms/step
1/1             1s 572ms/step
1/1             1s 531ms/step
1/1             1s 546ms/step
1/1             1s 538ms/step
1/1             1s 544ms/step
1/1             1s 562ms/step
1/1             1s 525ms/step
1/1             1s 533ms/step
1/1             1s 544ms/step
1/1             1s 558ms/step
1/1             1s 577ms/step
1/1             1s 537ms/step
1/1             1s 529ms/step
1/1             1s 531ms/step
1/1             1s 551ms/step
1/1             1s 557ms/step
1/1             1s 571ms/step
1/1             1s 550ms/step
1/1             1s 534ms/step
1/1             1s 519ms/step
1/1             0s 305ms/step
```

[12]:
```python
from tensorflow.keras.optimizers import RMSprop

model.compile(
    optimizer=RMSprop(),  # Use RMSprop optimizer
    loss='sparse_categorical_crossentropy',
    metrics=['accuracy']
)
```

[13]:
```python
from keras.callbacks import ReduceLROnPlateau

reduce_lr = ReduceLROnPlateau(
    monitor='val_loss',
    factor=0.2,
    patience=2,
    min_lr=0.001
)
```

[14]:
```
from keras.callbacks import EarlyStopping

early_stopping = EarlyStopping(
    monitor='val_loss',
    patience=10,
    restore_best_weights=True
)
```

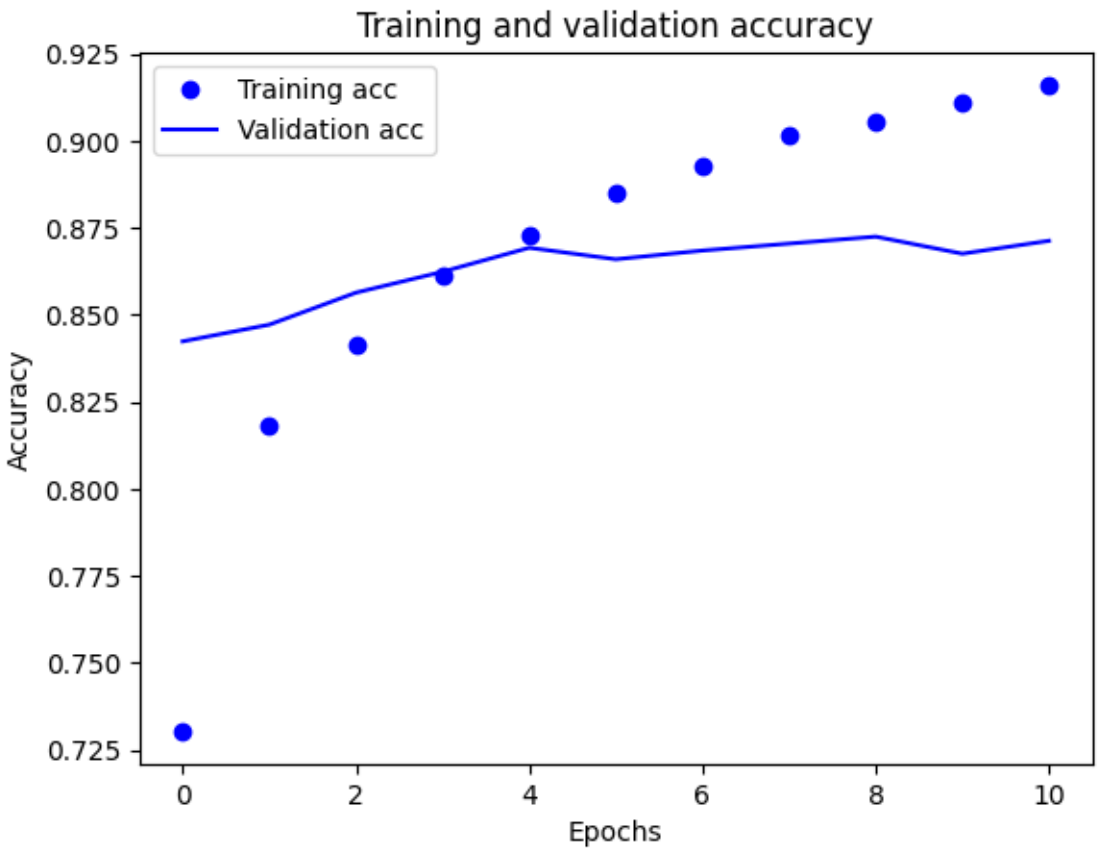
[15]:
```
from keras.callbacks import ModelCheckpoint

model_checkpoint = ModelCheckpoint(
    filepath='C:/Users/flavi/Desktop/projetoClassificaoDeImagens/
 ↪dl_project_2201707_2211044/ModelosT/ModelT_RMSpropOptimizer.keras',
    save_best_only=True,
    monitor='val_loss'
)
```

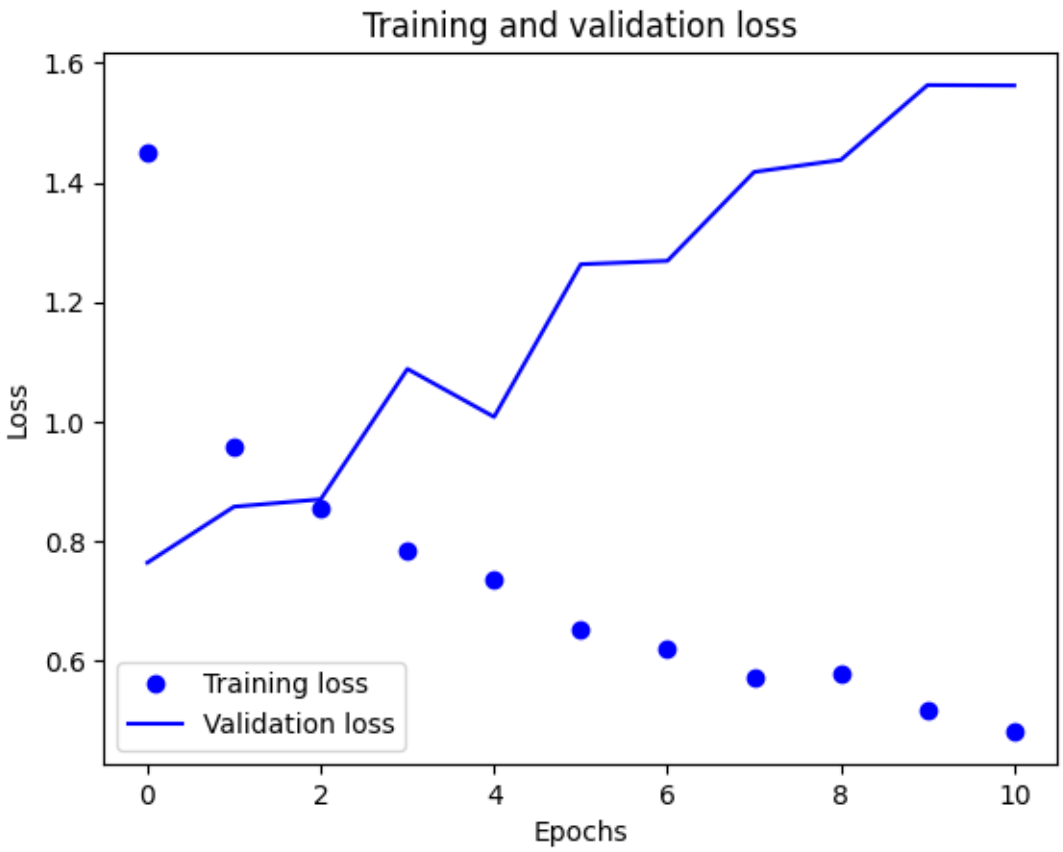
[16]:
```
callbacks = [reduce_lr, early_stopping, model_checkpoint]

# Train the model using the extracted features
history = model.fit(
    train_features, train_labels,
    epochs=50,
    validation_data=(val_features, val_labels),
    callbacks=callbacks
)
```

```
Epoch 1/50
1250/1250             12s 10ms/step -
accuracy: 0.6706 - loss: 2.5303 - val_accuracy: 0.8424 - val_loss: 0.7643 -
learning_rate: 0.0010
Epoch 2/50
1250/1250             11s 9ms/step -
accuracy: 0.8164 - loss: 0.9273 - val_accuracy: 0.8472 - val_loss: 0.8579 -
learning_rate: 0.0010
Epoch 3/50
1250/1250             11s 9ms/step -
accuracy: 0.8437 - loss: 0.8118 - val_accuracy: 0.8564 - val_loss: 0.8702 -
learning_rate: 0.0010
Epoch 4/50
1250/1250             11s 8ms/step -
accuracy: 0.8638 - loss: 0.7647 - val_accuracy: 0.8624 - val_loss: 1.0881 -
learning_rate: 0.0010
Epoch 5/50
1250/1250             10s 8ms/step -
accuracy: 0.8746 - loss: 0.7093 - val_accuracy: 0.8693 - val_loss: 1.0080 -
learning_rate: 0.0010
```

```
Epoch 6/50
1250/1250             10s 8ms/step -
accuracy: 0.8878 - loss: 0.6249 - val_accuracy: 0.8660 - val_loss: 1.2631 -
learning_rate: 0.0010
Epoch 7/50
1250/1250             11s 9ms/step -
accuracy: 0.8947 - loss: 0.6161 - val_accuracy: 0.8685 - val_loss: 1.2688 -
learning_rate: 0.0010
Epoch 8/50
1250/1250             10s 8ms/step -
accuracy: 0.9049 - loss: 0.5503 - val_accuracy: 0.8705 - val_loss: 1.4174 -
learning_rate: 0.0010
Epoch 9/50
1250/1250             10s 8ms/step -
accuracy: 0.9079 - loss: 0.5438 - val_accuracy: 0.8725 - val_loss: 1.4375 -
learning_rate: 0.0010
Epoch 10/50
1250/1250             10s 8ms/step -
accuracy: 0.9138 - loss: 0.4806 - val_accuracy: 0.8676 - val_loss: 1.5626 -
learning_rate: 0.0010
Epoch 11/50
1250/1250             11s 9ms/step -
accuracy: 0.9182 - loss: 0.4605 - val_accuracy: 0.8713 - val_loss: 1.5619 -
learning_rate: 0.0010
```

[17]:
```python
import matplotlib.pyplot as plt
plt.plot(history.history['accuracy'], 'bo', label='Training acc')
plt.plot(history.history['val_accuracy'], 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()

plt.plot(history.history['loss'], 'bo', label='Training loss')
plt.plot(history.history['val_loss'], 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()
```


Training and validation accuracy
Training acc
Validation acc
Accuracy
Epochs
0.925
0.900
0.875
0.850
0.825
0.800
0.775
0.750
0.725
0
2
4
6
8
10



[18]:
```
val_loss, val_acc = model.evaluate(val_features, val_labels)
print('Validation Accuracy:', val_acc)
```

```
313/313             0s 816us/step -
accuracy: 0.8458 - loss: 0.7600
Validation Accuracy: 0.8424000144004822
```

[19]:
```
loss, accuracy = model.evaluate(test_features, test_labels)
print(f"Loss: {loss}, Accuracy: {accuracy}")
```

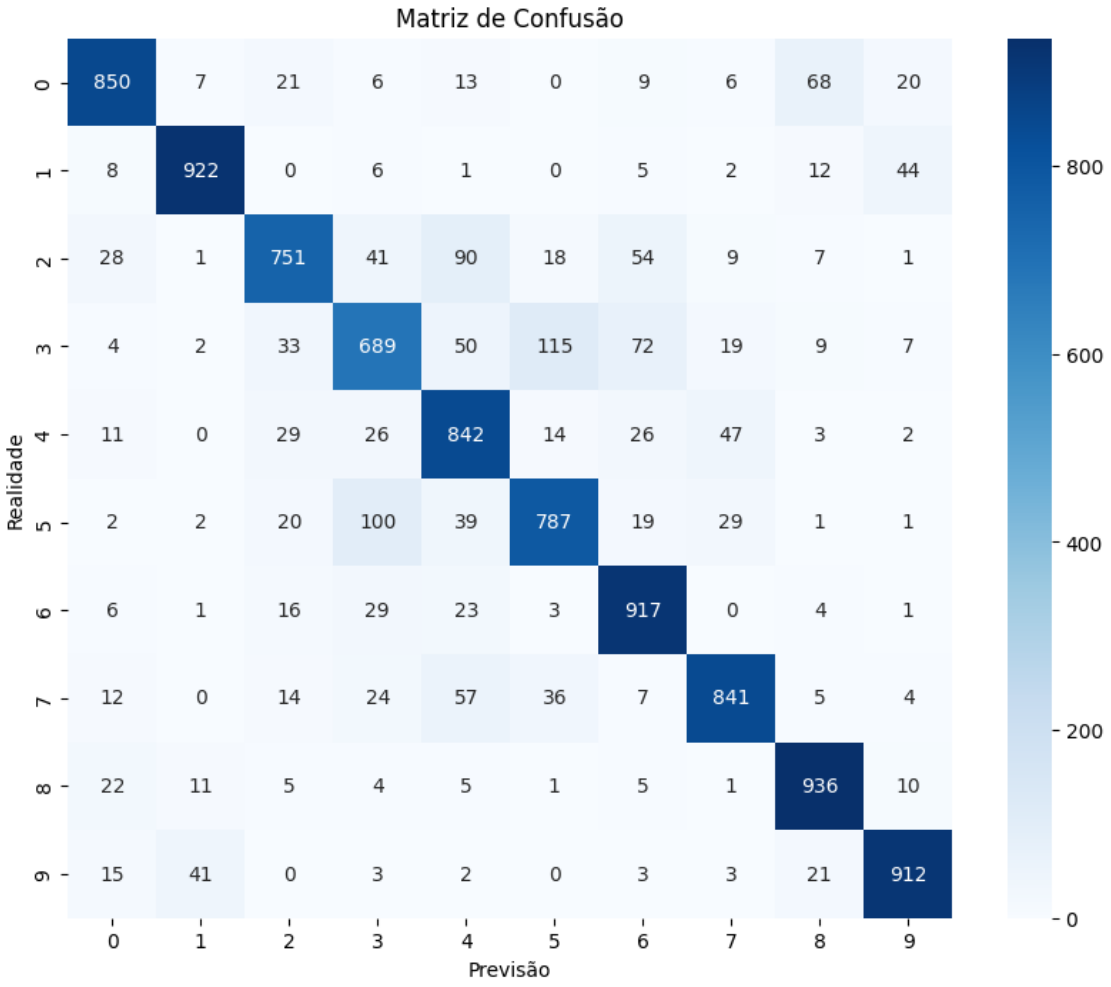
```
313/313             0s 851us/step -
accuracy: 0.8454 - loss: 0.7394
Loss: 0.736763596534729, Accuracy: 0.8446999788284302
```

[20]:
```
import numpy as np
from sklearn.metrics import confusion_matrix, classification_report
import seaborn as sns
import matplotlib.pyplot as plt

def evaluate_model(model, features, labels):
```

```
    predictions = model.predict(features)
    predicted_labels = np.argmax(predictions, axis=1)  # Convert probabilities␣
 ↪to class labels
    return labels, predicted_labels  # Return true labels and predicted labels

# Obter previsões e rótulos reais para o conjunto de testes
true_labels, predicted_labels = evaluate_model(model, test_features,␣
 ↪test_labels)

# Compute the confusion matrix
conf_matrix = confusion_matrix(true_labels, predicted_labels)

# Plot the confusion matrix
plt.figure(figsize=(10, 8))
sns.heatmap(conf_matrix, annot=True, fmt="d", cmap="Blues",␣
 ↪xticklabels=range(10), yticklabels=range(10))
plt.title('Matriz de Confusão')
plt.xlabel('Previsão')
plt.ylabel('Realidade')
plt.show()

# Print classification report
class_names = [str(i) for i in range(10)]  # Define class names based on your␣
 ↪dataset
print(classification_report(true_labels, predicted_labels,␣
 ↪target_names=class_names))

# Plot precision, recall, and F1-score
report = classification_report(true_labels, predicted_labels,␣
 ↪target_names=class_names, output_dict=True)

metrics = {'precision': [], 'recall': [], 'f1-score': []}
for cls in class_names:
    metrics['precision'].append(report[cls]['precision'])
    metrics['recall'].append(report[cls]['recall'])
    metrics['f1-score'].append(report[cls]['f1-score'])

plt.figure(figsize=(10, 6))
bar_width = 0.2
index = np.arange(len(class_names))

plt.bar(index, metrics['precision'], bar_width, label='Precision')
plt.bar(index + bar_width, metrics['recall'], bar_width, label='Recall')
plt.bar(index + 2*bar_width, metrics['f1-score'], bar_width, label='F1-score')

plt.xlabel('Class')
```

```
plt.ylabel('Scores')
plt.title('Precision, Recall e F1-score para cada classe')
plt.xticks(index + bar_width, class_names)
plt.legend()

plt.tight_layout()
plt.show()
```

```
313/313                 0s 751us/step
```



	precision	recall	f1-score	support
0	0.89	0.85	0.87	1000
1	0.93	0.92	0.93	1000
2	0.84	0.75	0.80	1000
3	0.74	0.69	0.71	1000
4	0.75	0.84	0.79	1000

5	0.81	0.79	0.80	1000
6	0.82	0.92	0.87	1000
7	0.88	0.84	0.86	1000
8	0.88	0.94	0.91	1000
9	0.91	0.91	0.91	1000
accuracy			0.84	10000
macro avg	0.85	0.84	0.84	10000
weighted avg	0.85	0.84	0.84	10000