```python
#Used to mount google drive to colab so that files can be accessed
from google drive
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly
remount, call drive.mount("/content/drive", force_remount=True).
```

```python
#Importing necessary libraries for the project
import tensorflow as tf
from keras.utils import image_dataset_from_directory
from keras.applications.vgg16 import VGG16
from tensorflow import keras
from keras import layers

# Directories
#specifying the directories where the datasets of train, validation
and test are stored
train_dirs = [
    '/content/drive/MyDrive/ProjetoIA/dataset/train1',
    '/content/drive/MyDrive/ProjetoIA/dataset/train2',
    '/content/drive/MyDrive/ProjetoIA/dataset/train4',
    '/content/drive/MyDrive/ProjetoIA/dataset/train5'
]
validation_dir = '/content/drive/MyDrive/ProjetoIA/dataset/train3'
test_dir = '/content/drive/MyDrive/ProjetoIA/dataset/test'

# Parameters
IMG_SIZE = 150
BATCH_SIZE = 32

# Function to load datasets from multiple directories and concatenate
them
def load_and_concatenate_datasets(directories, img_size, batch_size):
    datasets = [] #list to store the datasets
    for directory in directories:
        # Load dataset from directory
        dataset = image_dataset_from_directory(
            directory,
            image_size=(img_size, img_size),
            batch_size=batch_size
        )
        datasets.append(dataset) #append the dataset to the list
    return datasets

# Load train datasets and concatenate
train_datasets = load_and_concatenate_datasets(train_dirs, IMG_SIZE,
BATCH_SIZE)
#combine the train datasets in a unique dataset
train_dataset = tf.data.Dataset.sample_from_datasets(train_datasets)
```

```
# Load validation and test datasets
validation_dataset = image_dataset_from_directory(
    validation_dir,
    image_size=(IMG_SIZE, IMG_SIZE),
    batch_size=BATCH_SIZE
)
test_dataset = image_dataset_from_directory(
    test_dir,
    image_size=(IMG_SIZE, IMG_SIZE),
    batch_size=BATCH_SIZE
)

# Extract class names from one of the datasets
example_dataset = image_dataset_from_directory(
    train_dirs[0],
    image_size=(IMG_SIZE, IMG_SIZE),
    batch_size=BATCH_SIZE
)
class_names = example_dataset.class_names
print(class_names)
```

```
Found 10400 files belonging to 10 classes.
Found 9600 files belonging to 10 classes.
Found 10000 files belonging to 10 classes.
Found 10000 files belonging to 10 classes.
Found 10000 files belonging to 10 classes.
Found 10000 files belonging to 1 classes.
Found 10400 files belonging to 10 classes.
['000_airplane', '001_automobile', '002_bird', '003_cat', '004_deer',
'005_dog', '006_frog', '007_horse', '008_ship', '009_truck']
```

```
# Build the model
# Create the base model from the pre-trained model VGG16 with weights
from ImageNet
# excluding the top layers

# Fine-tuning the model
conv_base = VGG16(weights="imagenet", include_top=False)
conv_base.trainable = True #defining that the convolutional base is
trainable
for layer in conv_base.layers[:-2]: #excluding the last two layers
    layer.trainable = False #defining that the layers are not
trainable
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/vgg16/vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5
58889256/58889256 [==============================] - 0s 0us/step
```

```
# Data augmentation
#Flip horizontal ramdomly, rotate randomly 10%, and zoom randomly 20%
data_augmentation = keras.Sequential(
    [
        layers.RandomFlip("horizontal"),
        layers.RandomRotation(0.1),
        layers.RandomZoom(0.2),
    ]
)

inputs = keras.Input(shape=(150, 150, 3)) # defining the input shape,
considering the image redimensioned to 150x150 with 3 channels(RGB)
x = data_augmentation(inputs) #applying the transformations of the
data augmentation
x = keras.applications.vgg16.preprocess_input(x)  # Apply input value
scaling
x = conv_base(x)
x = layers.Flatten()(x)
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)

# Compile the model
model.compile(
    loss="sparse_categorical_crossentropy",
    optimizer=keras.optimizers.RMSprop(learning_rate=1e-5),
    metrics=["accuracy"]
)

# Adding ModelCheckpoint callback
# its for saving the best model based on the validation loss
# and has a patience of 5 epochs to avoid overfitting
checkpoint_cb = tf.keras.callbacks.ModelCheckpoint(

'/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_bes
t.h5',
    save_best_only=True,
    monitor='val_loss',
    mode='min',
    verbose=1
)
early_stop = tf.keras.callbacks.EarlyStopping(monitor='val_loss',
                           patience=5,
                           verbose=1)

# Train the model with fine-tuning and checkpointing
history = model.fit(
    train_dataset,
    epochs=30,
```

```python
    validation_data=validation_dataset,
    callbacks=[checkpoint_cb, early_stop]
)

# Save the final model
model.save('/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_
with_DA.h5')
```

```
Epoch 1/30
   1251/Unknown - 432s 343ms/step - loss: 4.7180 - accuracy: 0.3935
Epoch 1: val_loss improved from inf to 1.10213, saving model to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/engine/
training.py:3103: UserWarning: You are saving your model as an HDF5
file via `model.save()`. This file format is considered legacy. We
recommend using instead the native Keras format, e.g.
`model.save('my_model.keras')`.
  saving_api.save_model(
```

```
1251/1251 [==============================] - 525s 417ms/step - loss:
4.7180 - accuracy: 0.3935 - val_loss: 1.1021 - val_accuracy: 0.6955
Epoch 2/30
1251/1251 [==============================] - ETA: 0s - loss: 1.5968 -
accuracy: 0.5622
Epoch 2: val_loss improved from 1.10213 to 0.78613, saving model to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
1251/1251 [==============================] - 507s 405ms/step - loss:
1.5968 - accuracy: 0.5622 - val_loss: 0.7861 - val_accuracy: 0.7512
Epoch 3/30
1251/1251 [==============================] - ETA: 0s - loss: 1.2200 -
accuracy: 0.6291
Epoch 3: val_loss improved from 0.78613 to 0.67552, saving model to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
1251/1251 [==============================] - 503s 401ms/step - loss:
1.2200 - accuracy: 0.6291 - val_loss: 0.6755 - val_accuracy: 0.7887
Epoch 4/30
1251/1251 [==============================] - ETA: 0s - loss: 1.0614 -
accuracy: 0.6738
Epoch 4: val_loss improved from 0.67552 to 0.62552, saving model to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
1251/1251 [==============================] - 506s 404ms/step - loss:
1.0614 - accuracy: 0.6738 - val_loss: 0.6255 - val_accuracy: 0.8092
Epoch 5/30
1251/1251 [==============================] - ETA: 0s - loss: 0.9670 -
accuracy: 0.7042
```

```
Epoch 5: val_loss improved from 0.62552 to 0.59257, saving model to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
1251/1251 [==============================] - 505s 403ms/step - loss:
0.9670 - accuracy: 0.7042 - val_loss: 0.5926 - val_accuracy: 0.8283
Epoch 6/30
1251/1251 [==============================] - ETA: 0s - loss: 0.9084 -
accuracy: 0.7232
Epoch 6: val_loss improved from 0.59257 to 0.58089, saving model to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
1251/1251 [==============================] - 511s 408ms/step - loss:
0.9084 - accuracy: 0.7232 - val_loss: 0.5809 - val_accuracy: 0.8318
Epoch 7/30
1251/1251 [==============================] - ETA: 0s - loss: 0.8698 -
accuracy: 0.7358
Epoch 7: val_loss improved from 0.58089 to 0.55890, saving model to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
1251/1251 [==============================] - 513s 410ms/step - loss:
0.8698 - accuracy: 0.7358 - val_loss: 0.5589 - val_accuracy: 0.8352
Epoch 8/30
1251/1251 [==============================] - ETA: 0s - loss: 0.8222 -
accuracy: 0.7515
Epoch 8: val_loss improved from 0.55890 to 0.54758, saving model to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
1251/1251 [==============================] - 515s 411ms/step - loss:
0.8222 - accuracy: 0.7515 - val_loss: 0.5476 - val_accuracy: 0.8456
Epoch 9/30
1251/1251 [==============================] - ETA: 0s - loss: 0.7934 -
accuracy: 0.7589
Epoch 9: val_loss improved from 0.54758 to 0.53366, saving model to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
1251/1251 [==============================] - 514s 410ms/step - loss:
0.7934 - accuracy: 0.7589 - val_loss: 0.5337 - val_accuracy: 0.8481
Epoch 10/30
1251/1251 [==============================] - ETA: 0s - loss: 0.7689 -
accuracy: 0.7658
Epoch 10: val_loss did not improve from 0.53366
1251/1251 [==============================] - 505s 403ms/step - loss:
0.7689 - accuracy: 0.7658 - val_loss: 0.5367 - val_accuracy: 0.8532
Epoch 11/30
1251/1251 [==============================] - ETA: 0s - loss: 0.7599 -
accuracy: 0.7729
Epoch 11: val_loss improved from 0.53366 to 0.51702, saving model
to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
```

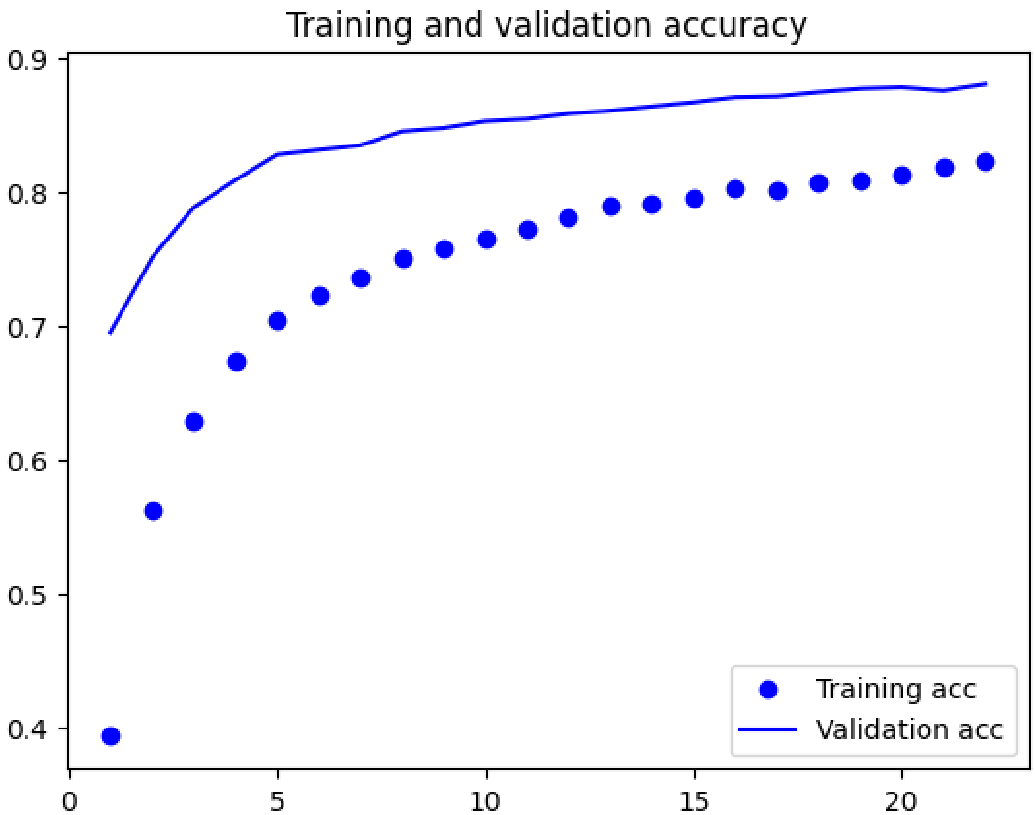
```
.h5
1251/1251 [==============================] - 504s 403ms/step - loss:
0.7599 - accuracy: 0.7729 - val_loss: 0.5170 - val_accuracy: 0.8549
Epoch 12/30
1251/1251 [==============================] - ETA: 0s - loss: 0.7336 -
accuracy: 0.7819
Epoch 12: val_loss improved from 0.51702 to 0.50995, saving model
to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
1251/1251 [==============================] - 504s 402ms/step - loss:
0.7336 - accuracy: 0.7819 - val_loss: 0.5099 - val_accuracy: 0.8589
Epoch 13/30
1251/1251 [==============================] - ETA: 0s - loss: 0.7138 -
accuracy: 0.7894
Epoch 13: val_loss improved from 0.50995 to 0.49804, saving model
to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
1251/1251 [==============================] - 504s 402ms/step - loss:
0.7138 - accuracy: 0.7894 - val_loss: 0.4980 - val_accuracy: 0.8610
Epoch 14/30
1251/1251 [==============================] - ETA: 0s - loss: 0.6994 -
accuracy: 0.7911
Epoch 14: val_loss improved from 0.49804 to 0.49517, saving model
to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
1251/1251 [==============================] - 509s 406ms/step - loss:
0.6994 - accuracy: 0.7911 - val_loss: 0.4952 - val_accuracy: 0.8642
Epoch 15/30
1251/1251 [==============================] - ETA: 0s - loss: 0.6965 -
accuracy: 0.7961
Epoch 15: val_loss did not improve from 0.49517
1251/1251 [==============================] - 511s 407ms/step - loss:
0.6965 - accuracy: 0.7961 - val_loss: 0.4969 - val_accuracy: 0.8673
Epoch 16/30
1251/1251 [==============================] - ETA: 0s - loss: 0.6730 -
accuracy: 0.8030
Epoch 16: val_loss improved from 0.49517 to 0.48713, saving model
to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
1251/1251 [==============================] - 514s 410ms/step - loss:
0.6730 - accuracy: 0.8030 - val_loss: 0.4871 - val_accuracy: 0.8711
Epoch 17/30
1251/1251 [==============================] - ETA: 0s - loss: 0.6666 -
accuracy: 0.8023
Epoch 17: val_loss improved from 0.48713 to 0.47518, saving model
```

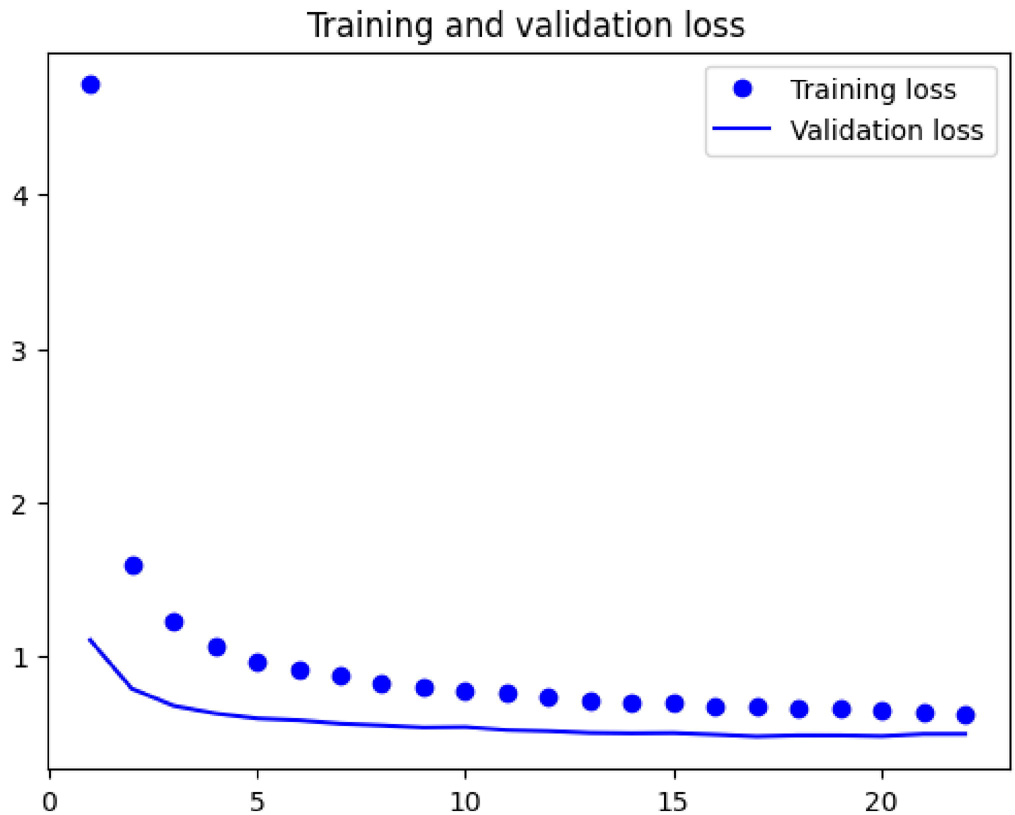
```
to
/content/drive/MyDrive/ProjetoIA/models/CNN_modeloT_TL_FT_with_DA_best
.h5
1251/1251 [==============================] - 513s 410ms/step - loss:
0.6666 - accuracy: 0.8023 - val_loss: 0.4752 - val_accuracy: 0.8718
Epoch 18/30
1251/1251 [==============================] - ETA: 0s - loss: 0.6631 -
accuracy: 0.8078
Epoch 18: val_loss did not improve from 0.47518
1251/1251 [==============================] - 509s 406ms/step - loss:
0.6631 - accuracy: 0.8078 - val_loss: 0.4823 - val_accuracy: 0.8749
Epoch 19/30
1251/1251 [==============================] - ETA: 0s - loss: 0.6527 -
accuracy: 0.8094
Epoch 19: val_loss did not improve from 0.47518
1251/1251 [==============================] - 516s 412ms/step - loss:
0.6527 - accuracy: 0.8094 - val_loss: 0.4818 - val_accuracy: 0.8775
Epoch 20/30
1251/1251 [==============================] - ETA: 0s - loss: 0.6440 -
accuracy: 0.8131
Epoch 20: val_loss did not improve from 0.47518
1251/1251 [==============================] - 518s 414ms/step - loss:
0.6440 - accuracy: 0.8131 - val_loss: 0.4770 - val_accuracy: 0.8785
Epoch 21/30
1251/1251 [==============================] - ETA: 0s - loss: 0.6271 -
accuracy: 0.8186
Epoch 21: val_loss did not improve from 0.47518
1251/1251 [==============================] - 510s 407ms/step - loss:
0.6271 - accuracy: 0.8186 - val_loss: 0.4908 - val_accuracy: 0.8760
Epoch 22/30
1251/1251 [==============================] - ETA: 0s - loss: 0.6234 -
accuracy: 0.8234
Epoch 22: val_loss did not improve from 0.47518
1251/1251 [==============================] - 506s 404ms/step - loss:
0.6234 - accuracy: 0.8234 - val_loss: 0.4909 - val_accuracy: 0.8808
Epoch 22: early stopping

#Displaying curves of loss and accuracy

import matplotlib.pyplot as plt
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']
epochs = range(1, len(acc) + 1)
plt.plot(epochs, acc, 'bo', label='Training acc')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.legend()
plt.figure()
```

```
plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.legend()
plt.show()
```






```
#We can later load it and test it:
#loaded_model =
keras.models.load_model('/content/drive/MyDrive/ProjetoIA/models/CNN_m
odeloT_TL_FT_with_DA.h5')
val_loss, val_acc = model.evaluate(validation_dataset)
print('val_acc:', val_acc)

313/313 [==============================] - 87s 277ms/step - loss:
0.4909 - accuracy: 0.8808
val_acc: 0.8808000087738037
```

Foram avaliados 313 batches no conjunto de validação Perda calculada no conjunto de validação 0.4909 Previsão do conjunto de validação com 88.08% das previsões foram corretas.