

```
In [ ]: import matplotlib.pyplot as plt
import numpy as np
import os
import tensorflow as tf
import keras_tuner as kt
```

```
/usr/local/lib/python3.8/dist-packages/scipy/__init__.py:146: UserWarning: A NumPy version >=1.16.5 and <1.23.0 is required for this version of SciPy
(detected version 1.23.0
warnings.warn(f"A NumPy version >={np_minversion} and <{np_maxversion}")
```

```
In [ ]: PATH = "Dataset"
MODEL = "ResNet50"
```

```
In [ ]: train_dir = os.path.join(PATH, 'train')
validation_dir = os.path.join(PATH, 'val')
```

```
In [ ]: BATCH_SIZE = 32
IMG_SIZE = (224, 224)

train_dataset = tf.keras.utils.image_dataset_from_directory(train_dir,
                                                            shuffle=True,
                                                            batch_size=BATCH_SIZE,
                                                            image_size=IMG_SIZE)
```

Found 7560 files belonging to 4 classes.

```
In [ ]: validation_dataset = tf.keras.utils.image_dataset_from_directory(validation_dir,
                                                                    shuffle=True,
                                                                    batch_size=BATCH_SIZE,
                                                                    image_size=IMG_SIZE)
```

Found 3240 files belonging to 4 classes.

```
In [ ]: class_names = train_dataset.class_names

plt.figure(figsize=(10, 10))
for images, labels in train_dataset.take(1):
    for i in range(9):
        ax = plt.subplot(3, 3, i + 1)
        plt.imshow(images[i].numpy().astype("uint8"))
        plt.title(class_names[labels[i]])
        plt.axis("off")
```



```
In [ ]: val_batches = tf.data.experimental.cardinality(validation_dataset)
test_dataset = validation_dataset.take(val_batches // 3)
validation_dataset = validation_dataset.skip(val_batches // 3)
```

```
In [ ]: print('Number of validation batches: %d' % tf.data.experimental.cardinality(validation_dataset))
print('Number of test batches: %d' % tf.data.experimental.cardinality(test_dataset))

Number of validation batches: 68
Number of test batches: 34
```

```
In [ ]: AUTOTUNE = tf.data.AUTOTUNE

train_dataset = train_dataset.prefetch(buffer_size=AUTOTUNE)
validation_dataset = validation_dataset.prefetch(buffer_size=AUTOTUNE)
test_dataset = test_dataset.prefetch(buffer_size=AUTOTUNE)
```

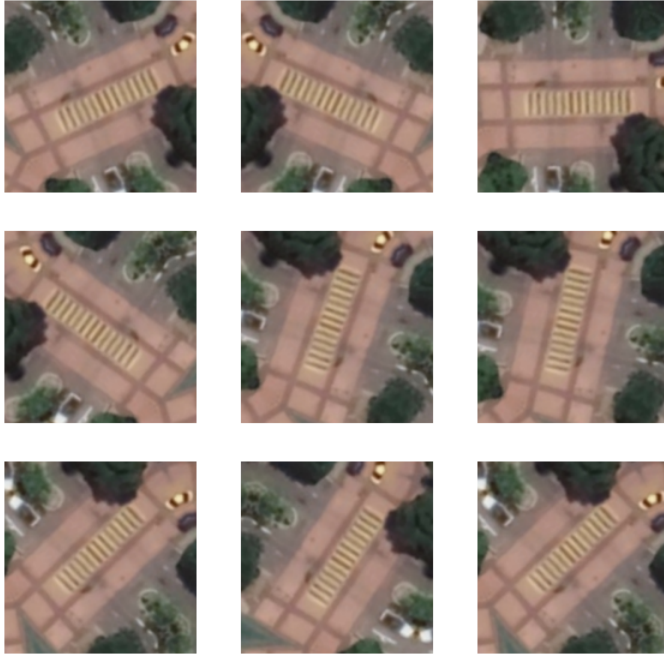
```
In [ ]: data_augmentation = tf.keras.Sequential([
    tf.keras.layers.RandomFlip('horizontal'),
    tf.keras.layers.RandomRotation(0.2),
])
```

```
In [ ]: for image, _ in train_dataset.take(1):
    plt.figure(figsize=(10, 10))
```

```

first_image = image[0]
for i in range(9):
    ax = plt.subplot(3, 3, i + 1)
    augmented_image = data_augmentation(tf.expand_dims(first_image, 0))
    plt.imshow(augmented_image[0] / 255)
    plt.axis('off')

```



```
In [ ]: preprocess_input = tf.keras.applications.resnet50.preprocess_input
```

```
In [ ]: from tensorflow.keras.applications import ResNet50
```

```

base_model = ResNet50(input_shape=(224,224,3),
                      include_top=False,
                      weights="imagenet")

```

```

base_model.trainable=True
# trainable_at = int(len(base_model.layers)/3)

# # freeze 1/3 of the layers
# for layer in base_model.layers[:trainable_at]:
#     layer.trainable=False

```

```

Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/resnet/resnet50_weights_tf_dim_ordering_tf_kernels_notop.h5
94773248/94765736 [=====] - 5s 0us/step
94781440/94765736 [=====] - 5s 0us/step

```

```
In [ ]: image_batch, label_batch = next(iter(train_dataset))
feature_batch = base_model(image_batch)
print(feature_batch.shape)

(32, 7, 7, 2048)
```

```
In [ ]: global_average_layer = tf.keras.layers.GlobalAveragePooling2D()
feature_batch_average = global_average_layer(feature_batch)
print(feature_batch_average.shape)

(32, 2048)
```

```
In [ ]: # Create ResNet50 model
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Rescaling, Conv2D, MaxPooling2D, BatchNormalization, Dropout, Dense, Flatten, InputLayer
from tensorflow.keras.applications import ResNet50

class ResNet50HyperModel(keras.HyperModel):

    # Create class for hyperparameter tuning
    def build(self, hp):

        base_model = ResNet50(input_shape=(224,224,3),
                              include_top=False,
                              weights="imagenet")

        base_model.trainable=True

        inputs = tf.keras.Input(shape=(224, 224, 3))
        x = preprocess_input(inputs)
        x = base_model(x, training=True)
        x = global_average_layer(x)
        x = Dense(256, activation="relu", kernel_initializer='he_uniform')(x)
        x = Dropout(0.2)(x)
        x = Dense(32, activation="relu", kernel_initializer='he_uniform')(x)
        x = Dropout(0.2)(x)
        outputs = Dense(4, activation='softmax', kernel_initializer='he_uniform')(x)
        model = tf.keras.Model(inputs, outputs)

        # Tune the learning rate for the optimizer
        # Choose an optimal value from 0.01, 0.001, or 0.0001
        hp_learning_rate = hp.Choice('learning_rate', values=[1e-2, 1e-3, 1e-4])

```

```

# compile model
model.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=hp_learning_rate),
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=False),
              metrics=['accuracy'])

return model

def fit(self, hp, model, *args, **kwargs):
    return model.fit(
        *args,
        batch_size=hp.Choice("batch_size", [32, 64]),
        **kwargs
    )

```

```

In [ ]: tuner = kt.GridSearch(
    ResNet50HyperModel(),
    objective="val_accuracy",
    seed=0,
    directory=MODEL,
    project_name=MODEL
)

```

```

In [ ]: # Logging to tensorboard

from datetime import datetime

log_dir = f"logs/fit/{MODEL}_" + datetime.now().strftime("%Y%m%d-%H%M%S")
tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir=log_dir, histogram_freq=1)

```

```

In [ ]: tuner.search(train_dataset,
    epochs=50,
    validation_data=validation_dataset,
    callbacks=[tensorboard_callback],
    use_multiprocessing=True)

```

```

Trial 6 Complete [00h 15m 18s]
val_accuracy: 0.9865241646766663

Best val_accuracy So Far: 0.9865241646766663
Total elapsed time: 01h 31m 29s
INFO:tensorflow:Oracle triggered exit

```

```

In [ ]: best_model = tuner.get_best_models(1)[0]
best_model.build(input_shape=(224,224,3))
best_model.summary()

```

Model: "model"

Layer (type)	Output Shape	Param #
=====		
input_2 (InputLayer)	[(None, 224, 224, 3)]	0
tf.__operators__.getitem (SlicingOpLambda)	(None, 224, 224, 3)	0
tf.nn.bias_add (TFOpLambda)	(None, 224, 224, 3)	0
resnet50 (Functional)	(None, 7, 7, 2048)	23587712
global_average_pooling2d (GlobalAveragePooling2D)	(None, 2048)	0
dense (Dense)	(None, 256)	524544
dropout (Dropout)	(None, 256)	0
dense_1 (Dense)	(None, 32)	8224
dropout_1 (Dropout)	(None, 32)	0
dense_2 (Dense)	(None, 4)	132
=====		
Total params: 24,120,612		
Trainable params: 24,067,492		
Non-trainable params: 53,120		

```

In [ ]: tuner.results_summary()

```

```
Results summary
Results in ResNet50/ResNet50
Showing 10 best trials
Objective(name="val_accuracy", direction="max")
```

```
Trial 0005 summary
Hyperparameters:
learning_rate: 0.0001
batch_size: 64
Score: 0.9865241646766663
```

```
Trial 0004 summary
Hyperparameters:
learning_rate: 0.0001
batch_size: 32
Score: 0.9851301312446594
```

```
Trial 0002 summary
Hyperparameters:
learning_rate: 0.001
batch_size: 32
Score: 0.9609665274620056
```

```
Trial 0003 summary
Hyperparameters:
learning_rate: 0.001
batch_size: 64
Score: 0.9595724940299988
```

```
Trial 0001 summary
Hyperparameters:
learning_rate: 0.01
batch_size: 64
Score: 0.32016727328300476
```

```
Trial 0000 summary
Hyperparameters:
learning_rate: 0.01
batch_size: 32
Score: 0.25464683771133423
```

```
In [ ]: loss, accuracy = best_model.evaluate(test_dataset)
print('Test accuracy :', accuracy)

34/34 [=====] - 2s 26ms/step - loss: 0.0714 - accuracy: 0.9853
Test accuracy : 0.9852941036224365
```

```
In [ ]: loss, accuracy = best_model.evaluate(test_dataset)
print('Test accuracy :', accuracy)
# Retrieve a batch of images from the test set
image_batch, label_batch = test_dataset.as_numpy_iterator().next()
predictions = best_model.predict_on_batch(image_batch)

prediction_label = []
for prediction in predictions:
    pred = max(prediction)
    prediction_label.append(prediction.tolist().index(pred))

## Apply a sigmoid since our model returns logits
# predictions = tf.nn.sigmoid(predictions)
# predictions = tf.where(predictions < 0.5, 0, 1)

print('Predictions:\n', prediction_label)
print('Labels:\n', label_batch)

plt.figure(figsize=(10, 10))
for i in range(9):
    ax = plt.subplot(3, 3, i + 1)
    plt.imshow(image_batch[i].astype("uint8"))
    plt.title(class_names[prediction_label[i]])
    plt.axis("off")

34/34 [=====] - 1s 25ms/step - loss: 0.0613 - accuracy: 0.9871
Test accuracy : 0.9871323704719543
Predictions:
[2, 1, 3, 2, 1, 2, 2, 1, 2, 1, 3, 0, 0, 0, 1, 2, 0, 1, 2, 0, 0, 2, 0, 3, 1, 1, 0, 1, 0, 0, 0]
Labels:
[2 1 3 2 1 2 2 1 2 1 3 0 0 0 1 2 0 1 2 0 0 2 0 3 1 1 0 1 0 0 0]
```

overpass



intersection



roundabout



overpass



intersection



overpass



overpass



overpass



intersection

