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 = "VGG19"
```

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.vgg19.preprocess_input
```

In [ ]:
```
from tensorflow.keras.applications import VGG19

base_model = VGG19(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
```

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

```
(32, 7, 7, 512)
```

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

```
(32, 512)
```

In [ ]:
```
# Create VGG19 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 VGG19


class VGG19HyperModel(kt.HyperModel):

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

        base_model = VGG19(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(
    VGG19HyperModel(),
    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 37s]
val_accuracy: 0.9790892004966736

Best val_accuracy So Far: 0.9790892004966736
Total elapsed time: 01h 31m 47s
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 (S  (None, 224, 224, 3)      0
 licingOpLambda)

 tf.nn.bias_add (TFOpLambda)  (None, 224, 224, 3)      0

 vgg19 (Functional)          (None, 7, 7, 512)         20024384

 global_average_pooling2d (G  (None, 512)              0
 lobalAveragePooling2D)

 dense (Dense)               (None, 256)               131328

 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: 20,164,068
Trainable params: 20,164,068
Non-trainable params: 0
_________________________________________________________________
```

In [ ]:
```
tuner.results_summary()
```

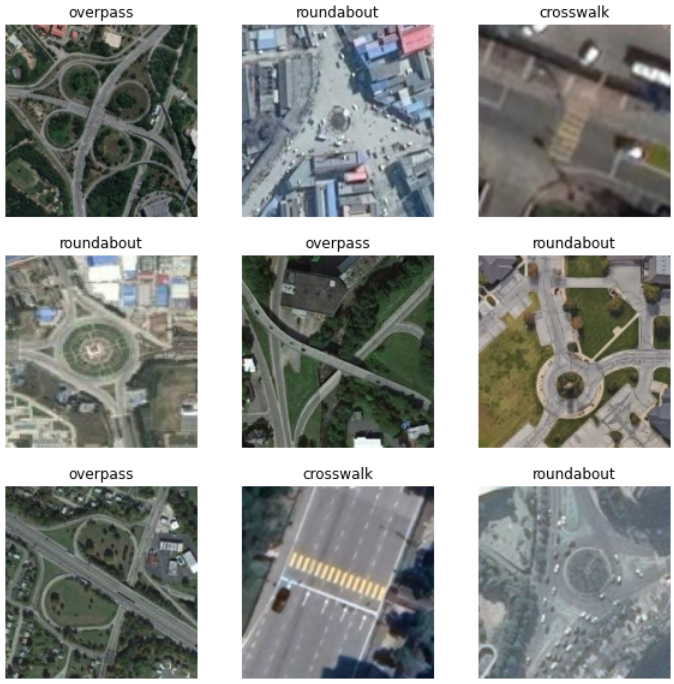
```
Results summary
Results in VGG19/VGG19
Showing 10 best trials
Objective(name="val_accuracy", direction="max")

Trial 0005 summary
Hyperparameters:
learning_rate: 0.0001
batch_size: 64
Score: 0.9790892004966736

Trial 0004 summary
Hyperparameters:
learning_rate: 0.0001
batch_size: 32
Score: 0.9776951670646667

Trial 0002 summary
Hyperparameters:
learning_rate: 0.001
batch_size: 32
Score: 0.9000929594039917

Trial 0003 summary
Hyperparameters:
learning_rate: 0.001
batch_size: 64
Score: 0.8907992839813232

Trial 0001 summary
Hyperparameters:
learning_rate: 0.01
batch_size: 64
Score: 0.26022306084632874

Trial 0000 summary
Hyperparameters:
learning_rate: 0.01
batch_size: 32
Score: 0.2565055787563324
```

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

```
34/34 [==============================] - 1s 24ms/step - loss: 0.1108 - accuracy: 0.9862
Test accuracy : 0.986213207244873
```

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 22ms/step - loss: 0.1267 - accuracy: 0.9871
Test accuracy : 0.9871323704719543
Predictions:
 [2, 3, 0, 3, 2, 3, 2, 0, 3, 2, 0, 2, 1, 0, 2, 1, 1, 2, 1, 0, 0, 2, 2, 2, 0, 3, 1, 0, 3, 1, 0, 3]
Labels:
 [2 3 0 3 2 3 2 0 3 2 0 2 1 0 2 1 1 2 1 0 0 2 2 2 0 3 1 0 3 1 0 3]
```


overpass
roundabout
crosswalk
roundabout
overpass
roundabout
overpass
crosswalk
roundabout