Computer Vision and Sensor Fusion 2025 Exercise 3

This is the Notebook file of my project work on course Computer Vision and Sensor Fusion course. This Notebook is based on Object Detection API. This notebook will walk you step by step through the process of using a pre-trained model to detect objects in an image. I have done the implementation of my own fine-tuned model for detect different objects from urban view.

I have created a dataset which contains following different objects:

- Cars
- Bicycles
- Busses
- Motorcycles
- Pedestrians
- Traffic Lights
- Traffig Signs
- Trash Bins

For each object I have collected so far about 25 images. All these images have been converted to .JPG format and their annotations have created by using labelImg software, which will execute their annotation in .xml format.

Datasize could be much larger, but this projects shows the idea of how the model will be fine tuned and how it performs with this amount of data. Most likely, more data should be added to make more reliable predictions here.

Let's get to the work!

Imports

In [ ]:
```
# Import all the needed libraries

#Tensorflow
import tensorflow as tf

# File handling libraries
import os
import io
import glob
import shutil
import xml.etree.ElementTree as ET
import pathlib

# Data manipulation libraries
import pandas as pd
import random
import numpy as np
from collections import namedtuple

# Python Imaging Library
from PIL import Image

# Display libraries
from IPython.display import display

# Plotting libraries
import matplotlib.pyplot as plt
%matplotlib inline
```

Import the object detection module.

In [2]:
```
from object_detection.utils import ops as utils_ops
from object_detection.utils import label_map_util as label_map_util
from object_detection.utils import visualization_utils as vis_util
```

Patches:

In [3]:
```
# patch tf1 into `utils.ops`
utils_ops.tf = tf.compat.v1

# Patch the location of gfile
tf.gfile = tf.io.gfile
```

Data management and loading

Here we are doing the data management, where we are loading the data, handling all the images and splitting them to their own datasets. Each run will give us a random set of train, evaluation and test sets from the whole dataset of 200 images and their annotations will be also separeted correctly.

In [ ]:
```
# Our data is stored in the data directory
data_dir = 'data'
image_data_dir = os.path.join(data_dir, 'images_jpg')
annotation_path = os.path.join(data_dir, 'annotations')

# Create train, validation, and test directories
train_dir = os.path.join(data_dir, 'train')
validation_dir = os.path.join(data_dir, 'validation')
test_dir = os.path.join(data_dir, 'test')

# Clear the directories
for directory in [train_dir, validation_dir, test_dir]:
    shutil.rmtree(directory, ignore_errors=True)
    os.makedirs(directory, exist_ok=True)
    os.makedirs(os.path.join(directory, 'annotations'), exist_ok=True)

# Get all image files
images = glob.glob(os.path.join(image_data_dir, '*.jpg'))

# Shuffle images
random.shuffle(images)

# Split data
train_images = images[:int(0.7 * len(images))]
validation_images = images[int(0.7 * len(images)):int(0.85 * len(images))]
test_images = images[int(0.85 * len(images)):]

# Function to copy images and annotations
def copy_files(image_list, target_dir):
    annotation_dir = os.path.join(target_dir, 'annotations')

    for image in image_list:
        # Copy image
        shutil.copy(image, os.path.join(target_dir, os.path.basename(image)))

        # Find corresponding annotation file
        annotation_file = os.path.join(annotation_path, os.path.basename(image).replace('.jpg', '.xml'))
        if os.path.exists(annotation_file):
            shutil.copy(annotation_file, os.path.join(annotation_dir, os.path.basename(annotation_file)))

# Copy images and annotations for their own directories
copy_files(train_images, train_dir)
copy_files(validation_images, validation_dir)
copy_files(test_images, test_dir)


# Function to convert XML annotations to CSV
# These following function are based on the following file:
# https://gist.github.com/iKhushPatel/ed1f837656b155d9b94d45b42e00f5e4
def xml_to_csv(path):
    xml_list = []
    for xml_file in glob.glob(path + '/*.xml'):
        tree = ET.parse(xml_file)
        root = tree.getroot()
        for member in root.findall('object'):
            value = (root.find('filename').text,
                     int(root.find('size')[0].text),
                     int(root.find('size')[1].text),
                     member[0].text,
                     int(member[4][0].text),
                     int(member[4][1].text),
                     int(member[4][2].text),
                     int(member[4][3].text)
                     )
            xml_list.append(value)
    column_name = ['filename', 'width', 'height', 'class', 'xmin', 'ymin', 'xmax', 'ymax']
    xml_df = pd.DataFrame(xml_list, columns=column_name)
    return xml_df


def convert():
    '''
    for directory in ['train','testing']:
        image_path = os.path.join(os.getcwd(), 'images/{}'.format(directory).format(directory))
        xml_df = xml_to_csv(image_path)
        xml_df.to_csv('data/{}_labels.csv'.format(directory), index=None)
        print('Successfully converted xml to csv.')
    '''
```

```
    image_path = os.path.join(os.getcwd(), 'data/train/annotations')
    xml_df = xml_to_csv(image_path)
    xml_df.to_csv('data/train_labels.csv', index=None)

    image_path = os.path.join(os.getcwd(), 'data/test/annotations')
    xml_df = xml_to_csv(image_path)
    xml_df.to_csv('data/test_labels.csv', index=None)

    image_path = os.path.join(os.getcwd(), 'data/validation/annotations')
    xml_df = xml_to_csv(image_path)
    xml_df.to_csv('data/val_labels.csv', index=None)



for file in ['train_labels.csv', 'test_labels.csv', 'val_labels.csv']:
    file_path = pathlib.Path(data_dir) / file
    print("Removing", file_path)
    if file_path.exists():
        file_path.unlink()

convert()
```

```
Removing data\train_labels.csv
Removing data\test_labels.csv
Removing data\val_labels.csv
```

Check that images are loaded correctly

In [7]:

```
train_path = glob.glob(os.path.join(train_dir, '*.jpg'))

# Show the first 3 images
for img_path in train_path[:3]:
    img = Image.open(img_path)
    plt.imshow(img)
    plt.axis('off')
    plt.show()
```

Now we have successfully loaded the data. Next really important task is to convert our pictures for TFRecord format. TFRecord is binary fileformat of TensorFlow, which able us to load data more faster and effienctly, without that all images and annotations needs to be loaded separetally.

TFRecord Conversion

These following functions are based on following file, but just modified to work here:
https://gist.github.com/iKhushPatel/5614a36f26cf6459cc49c8248e8b5b48

In [8]:
```
# Function to map class names to integer labels
def class_text_to_int(row_label):
    label_map = {
        'pedestrian': 1,
        'bicycle': 2,
        'car': 3,
        'motorcycle': 4,
        'trafficlight': 5,
        'trafficsign': 6,
        'bus': 7,
        'trashbin': 8
    }
    return label_map.get(row_label, 0)

# Function to split dataframe by filename
def split(df, group):
    data = namedtuple('data', ['filename', 'object'])
    gb = df.groupby(group)
    return [data(filename, gb.get_group(x)) for filename, x in zip(gb.groups.keys(), gb.groups)]

# Function to create TFRecord example
def create_tf_example(group, image_dir):
    image_path = os.path.join(image_dir, group.filename)
    with tf.io.gfile.GFile(image_path, 'rb') as fid:
        encoded_jpg = fid.read()
    image = Image.open(io.BytesIO(encoded_jpg))
    width, height = image.size

    filename = group.filename.encode('utf8')
    image_format = b'jpg'
    xmins, xmaxs, ymins, ymaxs, classes_text, classes = [], [], [], [], [], []

    for _, row in group.object.iterrows():
        xmins.append(row['xmin'] / width)
        xmaxs.append(row['xmax'] / width)
        ymins.append(row['ymin'] / height)
        ymaxs.append(row['ymax'] / height)
        classes_text.append(row['class'].encode('utf8'))
        classes.append(class_text_to_int(row['class']))

    tf_example = tf.train.Example(features=tf.train.Features(feature={
        'image/height': tf.train.Feature(int64_list=tf.train.Int64List(value=[height])),
        'image/width': tf.train.Feature(int64_list=tf.train.Int64List(value=[width])),
        'image/filename': tf.train.Feature(bytes_list=tf.train.BytesList(value=[filename])),
        'image/source_id': tf.train.Feature(bytes_list=tf.train.BytesList(value=[filename])),
        'image/encoded': tf.train.Feature(bytes_list=tf.train.BytesList(value=[encoded_jpg])),
```

```
        'image/format': tf.train.Feature(bytes_list=tf.train.BytesList(value=[image_format])),
        'image/object/bbox/xmin': tf.train.Feature(float_list=tf.train.FloatList(value=xmins)),
        'image/object/bbox/xmax': tf.train.Feature(float_list=tf.train.FloatList(value=xmaxs)),
        'image/object/bbox/ymin': tf.train.Feature(float_list=tf.train.FloatList(value=ymins)),
        'image/object/bbox/ymax': tf.train.Feature(float_list=tf.train.FloatList(value=ymaxs)),
        'image/object/class/text': tf.train.Feature(bytes_list=tf.train.BytesList(value=classes_text)),
        'image/object/class/label': tf.train.Feature(int64_list=tf.train.Int64List(value=classes)),
    }))
    return tf_example

# Function to generate TFRecord
def create_tfrecord(csv_input, image_dir, output_path):
    writer = tf.io.TFRecordWriter(output_path)
    df = pd.read_csv(csv_input)
    grouped = split(df, 'filename')

    for group in grouped:
        tf_example = create_tf_example(group, image_dir)
        writer.write(tf_example.SerializeToString())

    writer.close()
    print(f'Successfully created TFRecord file: {output_path}')
```

In [9]:
```
label_map = label_map_util.load_labelmap('data/label_map.pbtxt')
categories = label_map_util.convert_label_map_to_categories(label_map, max_num_classes=8, use_display_name=True
category_index = label_map_util.create_category_index(categories)


# Create the TFRecord files
create_tfrecord('data/train_labels.csv', 'data/train', 'train.record')
create_tfrecord('data/val_labels.csv', 'data/validation', 'validation.record')
create_tfrecord('data/test_labels.csv', 'data/test', 'test.record')
```

```
Successfully created TFRecord file: train.record
Successfully created TFRecord file: validation.record
Successfully created TFRecord file: test.record
```

Model preparation

Loading label map

Label maps map indices to category names, so that when our convolution network predicts `5`, we know that this corresponds to `airplane`. Here we use internal utility functions, but anything that returns a dictionary mapping integers to appropriate string labels would be fine

We have created the label_map.pbtx file which looks like this:

label_map.pbtxt item { id: 1 name: "pedestrian" } item { id: 2 name: "bicycle" } item { id: 3 name: "traffic" } item { id: 4 name: "motorcycle" } item { id: 5 name: "car" } item { id: 6 name: "bus" } item { id: 7 name: "traffic sign" } item { id: 8 name: "trashbin" }

In [11]:
```
# List of the strings that is used to add correct label for each box.
PATH_TO_LABELS = 'data/label_map.pbtxt'
category_index = label_map_util.create_category_index_from_labelmap(PATH_TO_LABELS, use_display_name=True)
```

In [12]:
```
categories= []
for key in category_index:
    categories.append(category_index[key])
```

In [13]:
```
# If you want to test the code with your images, just add path to the images to the TEST_IMAGE_PATHS.
PATH_TO_TEST_IMAGES_DIR = pathlib.Path('data/test')
TEST_IMAGE_PATHS = sorted(list(PATH_TO_TEST_IMAGES_DIR.glob("*.jpg")))
TEST_IMAGE_PATHS
```

Out[13]:
```
[WindowsPath('data/test/bike_20.jpg'),
 WindowsPath('data/test/bike_8.jpg'),
 WindowsPath('data/test/bin_11.jpg'),
 WindowsPath('data/test/bin_13.jpg'),
 WindowsPath('data/test/bin_14.jpg'),
 WindowsPath('data/test/bin_4.jpg'),
 WindowsPath('data/test/bus_12.jpg'),
 WindowsPath('data/test/bus_14.jpg'),
 WindowsPath('data/test/bus_22.jpg'),
 WindowsPath('data/test/bus_23.jpg'),
 WindowsPath('data/test/bus_3.jpg'),
 WindowsPath('data/test/bus_5.jpg'),
 WindowsPath('data/test/car_15.jpg'),
 WindowsPath('data/test/car_16.jpg'),
 WindowsPath('data/test/car_23.jpg'),
 WindowsPath('data/test/car_4.jpg'),
 WindowsPath('data/test/moto_2.jpg'),
 WindowsPath('data/test/moto_22.jpg'),
 WindowsPath('data/test/moto_8.jpg'),
 WindowsPath('data/test/pedestrian_1.jpg'),
 WindowsPath('data/test/pedestrian_14.jpg'),
 WindowsPath('data/test/pedestrian_19.jpg'),
 WindowsPath('data/test/pedestrian_4.jpg'),
 WindowsPath('data/test/signs_1.jpg'),
 WindowsPath('data/test/signs_15.jpg'),
 WindowsPath('data/test/signs_23.jpg'),
 WindowsPath('data/test/t_lights_2.jpg'),
 WindowsPath('data/test/t_lights_23.jpg'),
 WindowsPath('data/test/t_lights_24.jpg'),
 WindowsPath('data/test/t_lights_7.jpg')]
```

In [14]:
```
PATH_TO_TEST_LABELS_DIR = pathlib.Path('data/test/annotations')
TEST_LABEL_PATHS = sorted(list(PATH_TO_TEST_LABELS_DIR.glob("*.xml")))
TEST_LABEL_PATHS
```

Out[14]:
```
[WindowsPath('data/test/annotations/bike_20.xml'),
 WindowsPath('data/test/annotations/bike_8.xml'),
 WindowsPath('data/test/annotations/bin_11.xml'),
 WindowsPath('data/test/annotations/bin_13.xml'),
 WindowsPath('data/test/annotations/bin_14.xml'),
 WindowsPath('data/test/annotations/bin_4.xml'),
 WindowsPath('data/test/annotations/bus_12.xml'),
 WindowsPath('data/test/annotations/bus_14.xml'),
 WindowsPath('data/test/annotations/bus_22.xml'),
 WindowsPath('data/test/annotations/bus_23.xml'),
 WindowsPath('data/test/annotations/bus_3.xml'),
 WindowsPath('data/test/annotations/bus_5.xml'),
 WindowsPath('data/test/annotations/car_15.xml'),
 WindowsPath('data/test/annotations/car_16.xml'),
 WindowsPath('data/test/annotations/car_23.xml'),
 WindowsPath('data/test/annotations/car_4.xml'),
 WindowsPath('data/test/annotations/moto_2.xml'),
 WindowsPath('data/test/annotations/moto_22.xml'),
 WindowsPath('data/test/annotations/moto_8.xml'),
 WindowsPath('data/test/annotations/pedestrian_1.xml'),
 WindowsPath('data/test/annotations/pedestrian_14.xml'),
 WindowsPath('data/test/annotations/pedestrian_19.xml'),
 WindowsPath('data/test/annotations/pedestrian_4.xml'),
 WindowsPath('data/test/annotations/signs_1.xml'),
 WindowsPath('data/test/annotations/signs_15.xml'),
 WindowsPath('data/test/annotations/signs_23.xml'),
 WindowsPath('data/test/annotations/t_lights_2.xml'),
 WindowsPath('data/test/annotations/t_lights_23.xml'),
 WindowsPath('data/test/annotations/t_lights_24.xml'),
 WindowsPath('data/test/annotations/t_lights_7.xml')]
```

Model Loading and Training

Load an object detection model:

In [15]:
```
model_path = 'models/faster_rcnn_resnet101_v1_640x640_coco17_tpu-8/saved_model/'
detection_model = tf.saved_model.load(model_path)
```

Detection

Check the model's input signature, it expects a batch of 3-color images of type uint8:

In [16]:
```
print(detection_model.signatures['serving_default'].inputs)
```

[<tf.Tensor 'input_tensor:0' shape=(1, None, None, 3) dtype=uint8>, <tf.Tensor 'unknown:0' shape=<unknown> dtype
=resource>, <tf.Tensor 'unknown_0:0' shape=<unknown> dtype=resource>, <tf.Tensor 'unknown_1:0' shape=<unknown> d
type=resource>, <tf.Tensor 'unknown_2:0' shape=<unknown> dtype=resource>, <tf.Tensor 'unknown_3:0' shape=<unknow
n> dtype=resource>, <tf.Tensor 'unknown_4:0' shape=<unknown> dtype=resource>, <tf.Tensor 'unknown_5:0' shape=<un
known> dtype=resource>, <tf.Tensor 'unknown_6:0' shape=<unknown> dtype=resource>, <tf.Tensor 'unknown_7:0' shape
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r 'unknown_15:0' shape=<unknown> dtype=resource>, <tf.Tensor 'unknown_16:0' shape=<unknown> dtype=resource>, <tf
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```

And returns several outputs:

In [17]:
```
detection_model.signatures['serving_default'].output_dtypes
```

Out[17]:
```
{'detection_classes': tf.float32,
 'detection_anchor_indices': tf.float32,
 'detection_multiclass_scores': tf.float32,
 'num_detections': tf.float32,
 'detection_scores': tf.float32,
 'raw_detection_boxes': tf.float32,
 'raw_detection_scores': tf.float32,
 'detection_boxes': tf.float32}
```

In [18]:
```
detection_model.signatures['serving_default'].output_shapes
```

Out[18]:
```
{'detection_classes': TensorShape([1, 300]),
 'detection_anchor_indices': TensorShape([1, 300]),
 'detection_multiclass_scores': TensorShape([1, 300, 91]),
 'num_detections': TensorShape([1]),
 'detection_scores': TensorShape([1, 300]),
 'raw_detection_boxes': TensorShape([1, 300, 4]),
 'raw_detection_scores': TensorShape([1, 300, 91]),
 'detection_boxes': TensorShape([1, 300, 4])}
```

Add a wrapper function to call the model, and cleanup the outputs:

In [19]:
```
def run_inference_for_single_image(model, image):
  image = np.asarray(image)
  print(image)
  # The input needs to be a tensor, convert it using `tf.convert_to_tensor`.
  input_tensor = tf.convert_to_tensor(image)
  # The model expects a batch of images, so add an axis with `tf.newaxis`.
  input_tensor = input_tensor[tf.newaxis,...]

  # Run inference
  model_fn = model.signatures['serving_default']
  output_dict = model_fn(input_tensor)

  # All outputs are batches tensors.
  # Convert to numpy arrays, and take index [0] to remove the batch dimension.
  # We're only interested in the first num_detections.
  num_detections = int(output_dict.pop('num_detections'))
  output_dict = {key:value[0, :num_detections].numpy()
                 for key,value in output_dict.items()}
  output_dict['num_detections'] = num_detections
```

```
  # detection_classes should be ints.
  output_dict['detection_classes'] = output_dict['detection_classes'].astype(np.int64)

  # Handle models with masks:
  if 'detection_masks' in output_dict:
    # Reframe the the bbox mask to the image size.
    detection_masks_reframed = utils_ops.reframe_box_masks_to_image_masks(
              output_dict['detection_masks'], output_dict['detection_boxes'],
               image.shape[0], image.shape[1])
    detection_masks_reframed = tf.cast(detection_masks_reframed > 0.5,
                                       tf.uint8)
    output_dict['detection_masks_reframed'] = detection_masks_reframed.numpy()
    print(output_dict['detection_classes'])

  return output_dict
```

Run it on each test image and show the results:

In [20]:
```
def show_inference(model, image_path):
  # the array based representation of the image will be used later in order to prepare the
  # result image with boxes and labels on it.
  image_np = np.array(Image.open(image_path))
  # Actual detection.
  output_dict = run_inference_for_single_image(model, image_np)
  print(output_dict)
  # Visualization of the results of a detection.
  vis_util.visualize_boxes_and_labels_on_image_array(
      image_np,
      output_dict['detection_boxes'],
      output_dict['detection_classes'],
      output_dict['detection_scores'],
      category_index,
      instance_masks=output_dict.get('detection_masks_reframed', None),
      use_normalized_coordinates=True,
      line_thickness=8)

  display(Image.fromarray(image_np))
```

In [21]:
```
for image_path in TEST_IMAGE_PATHS:
  show_inference(detection_model, image_path)
```

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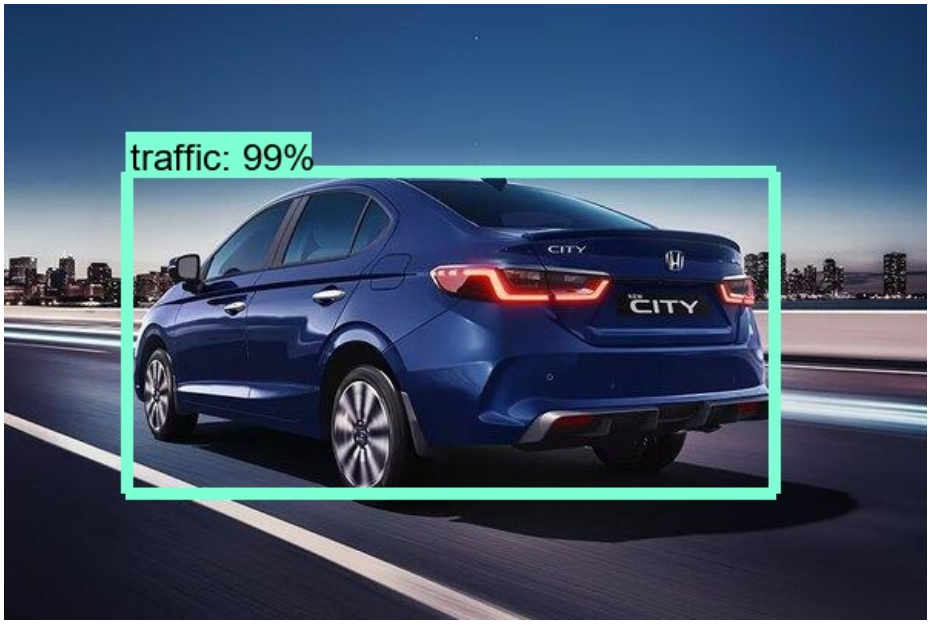


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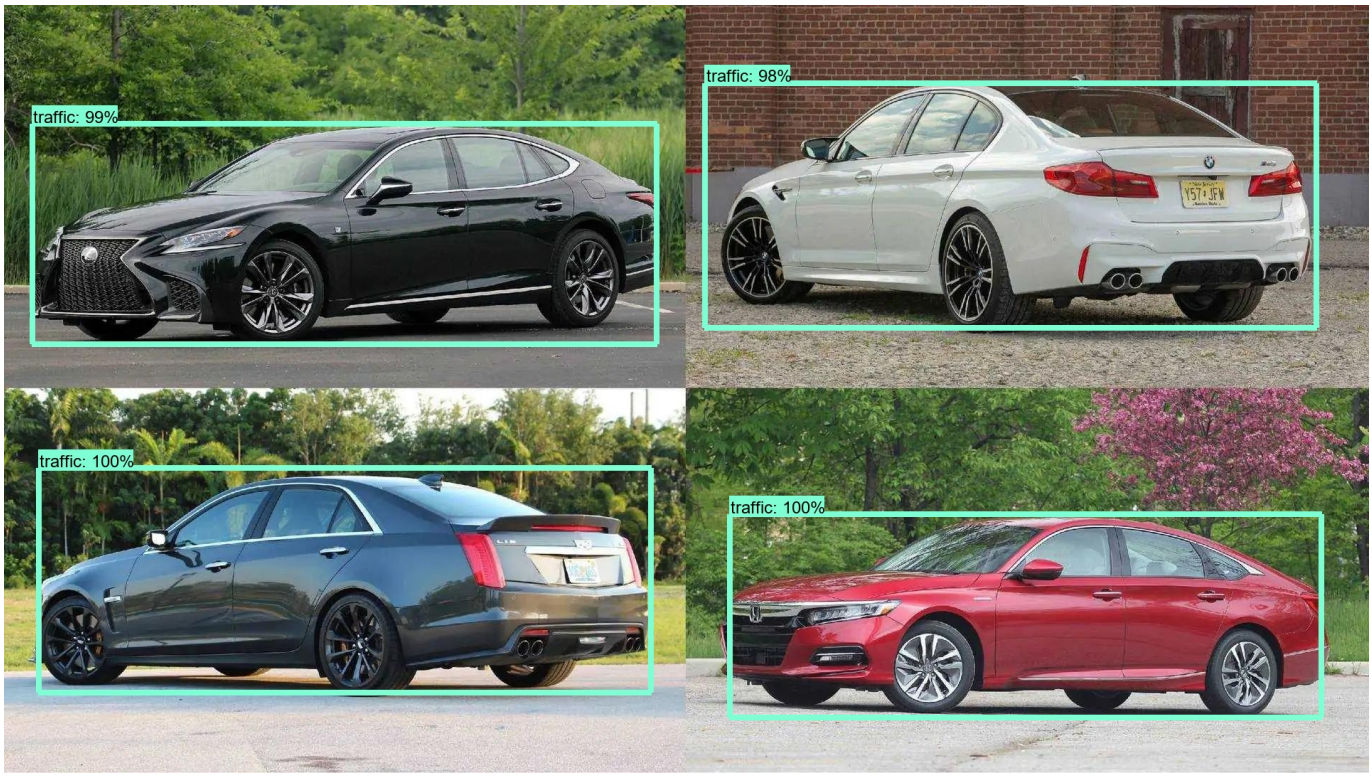


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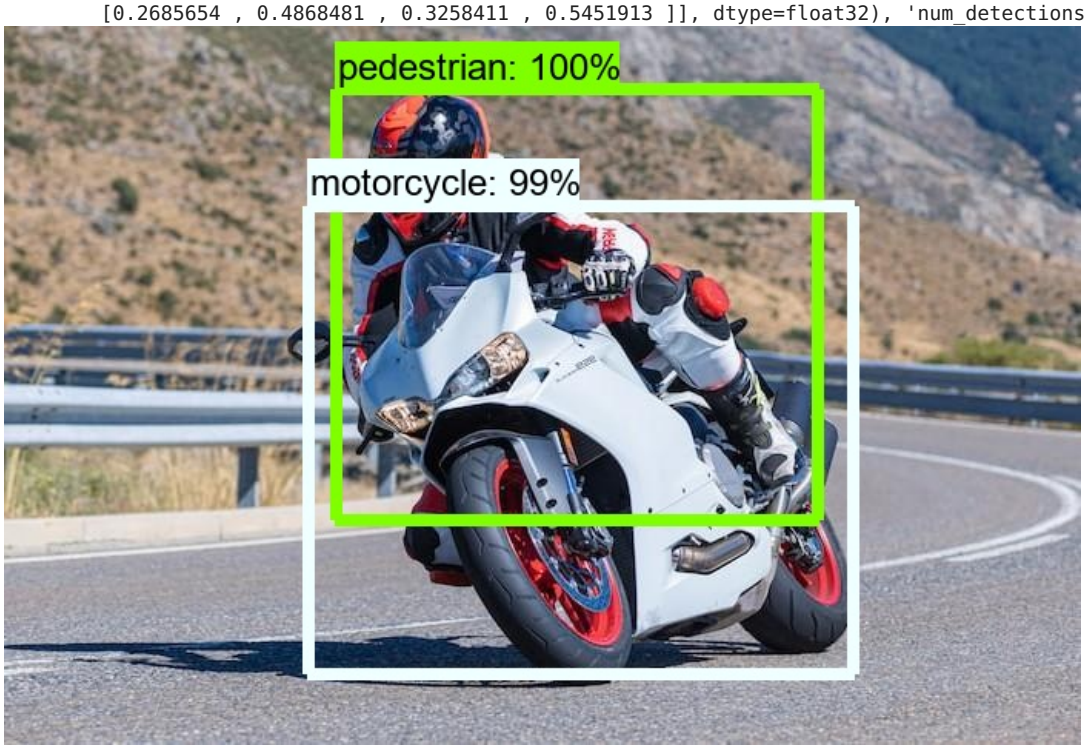


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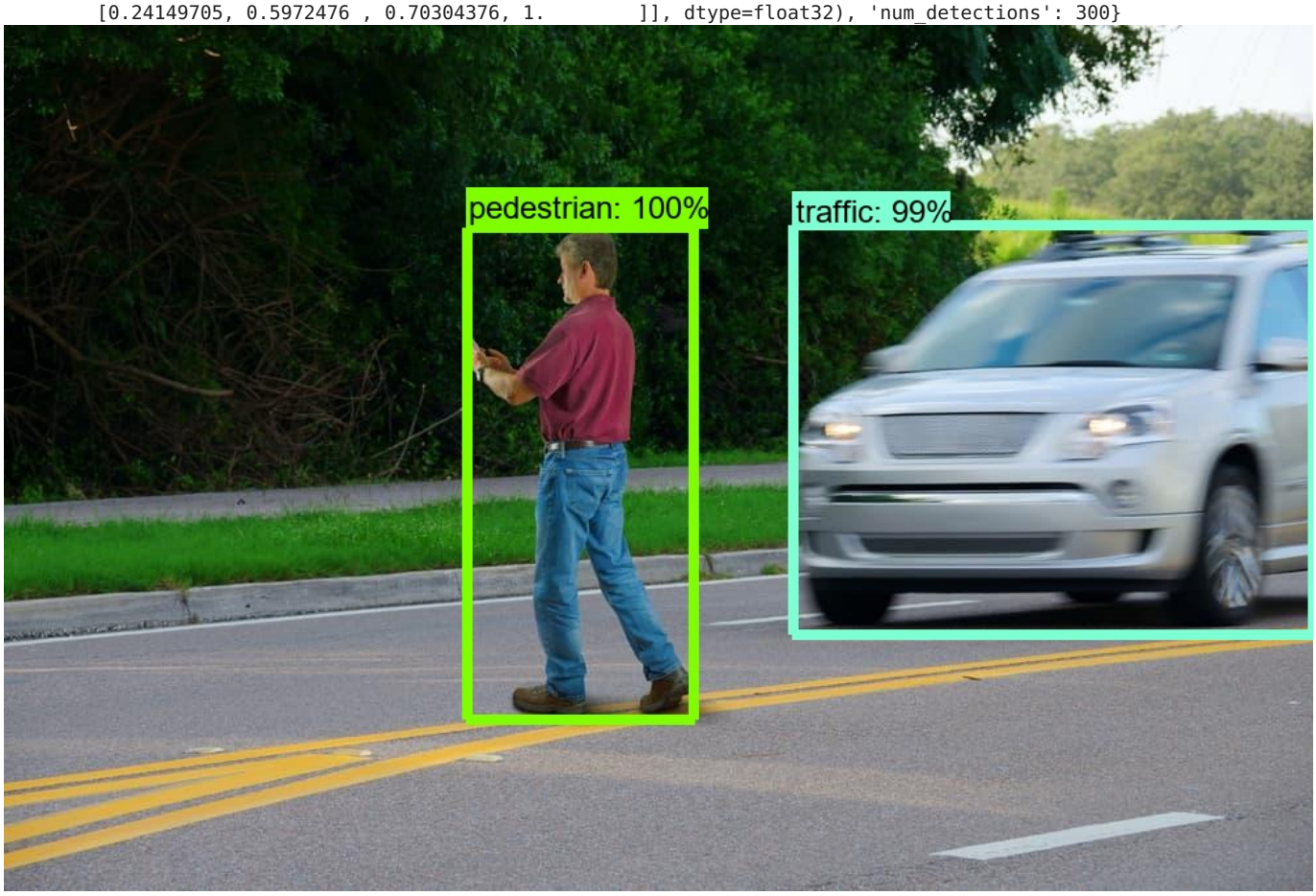


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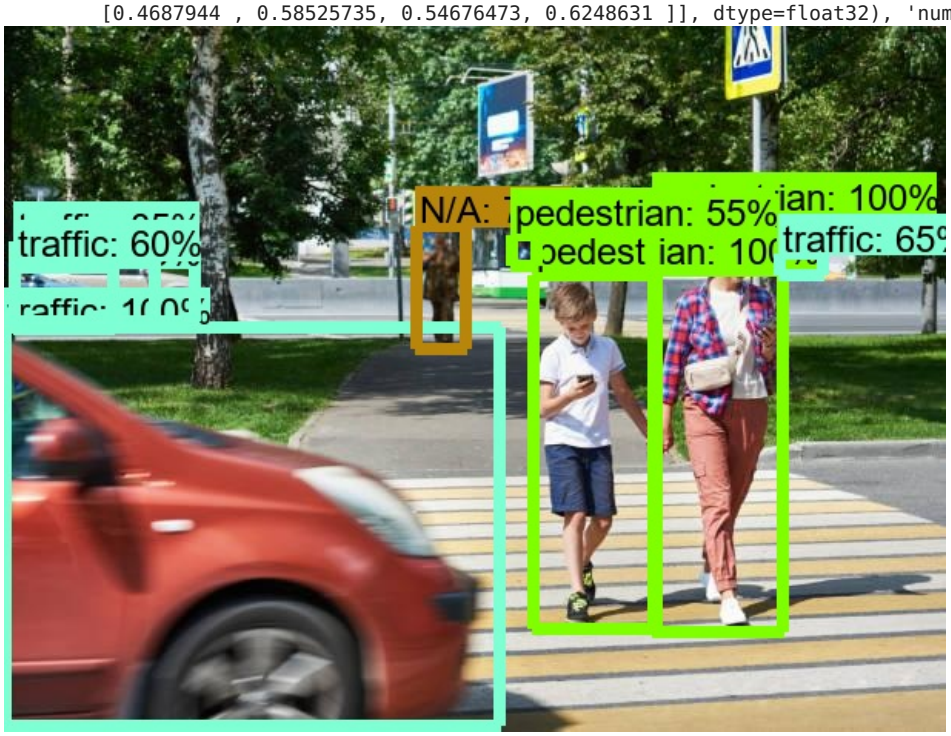


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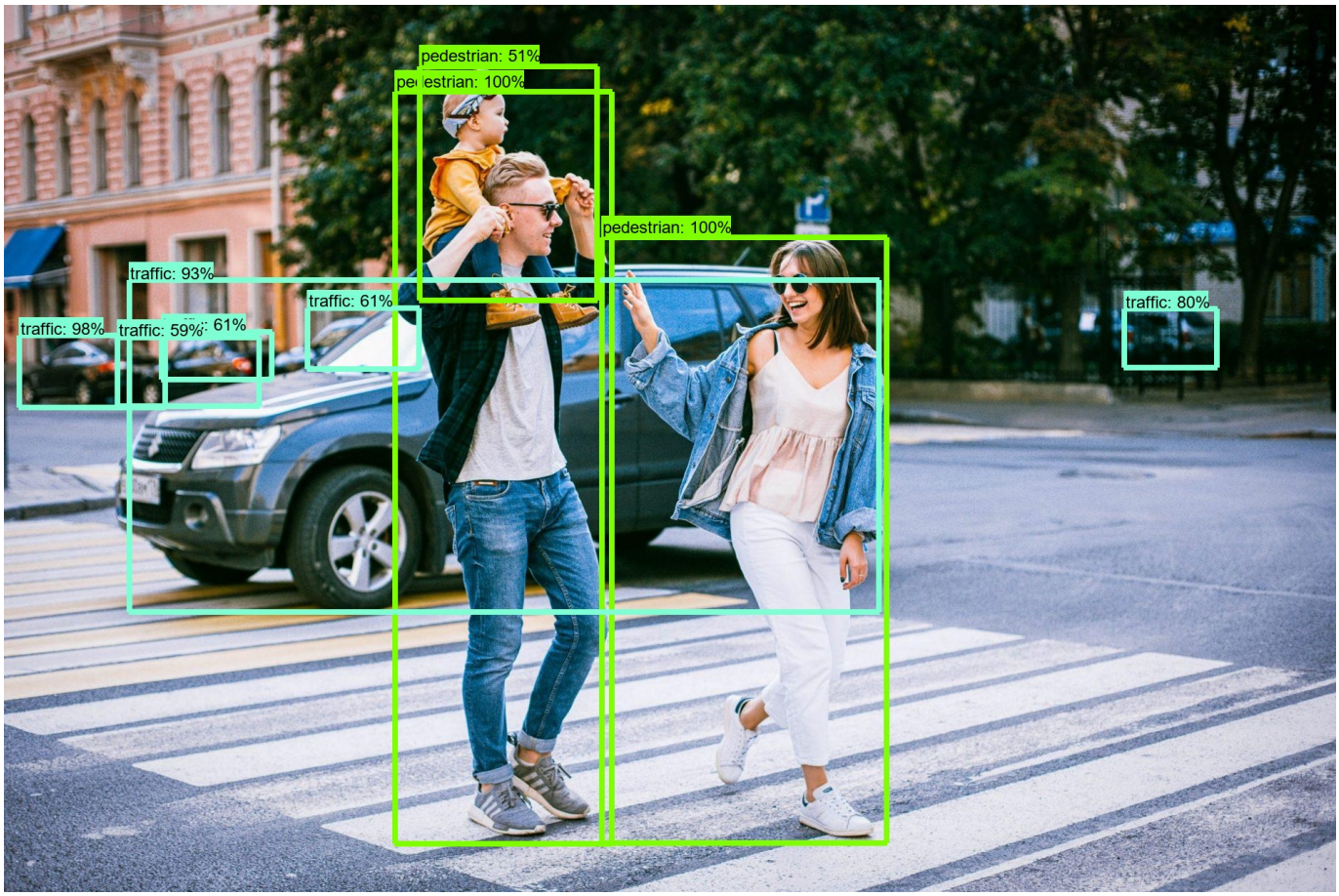


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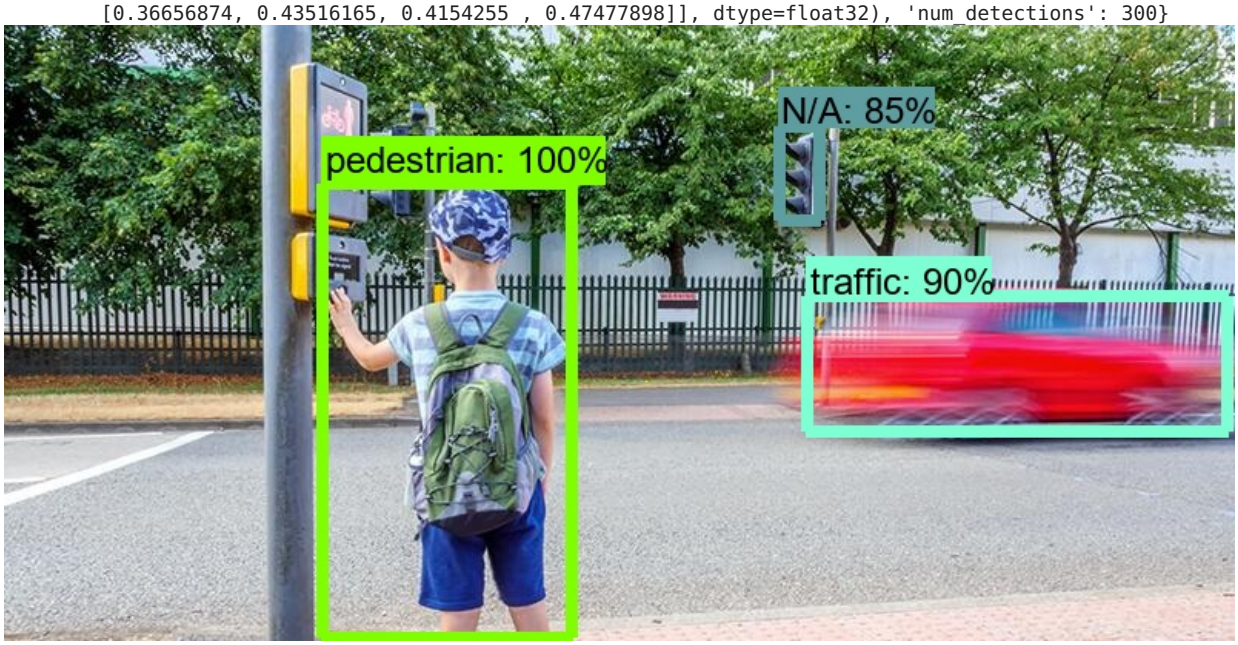


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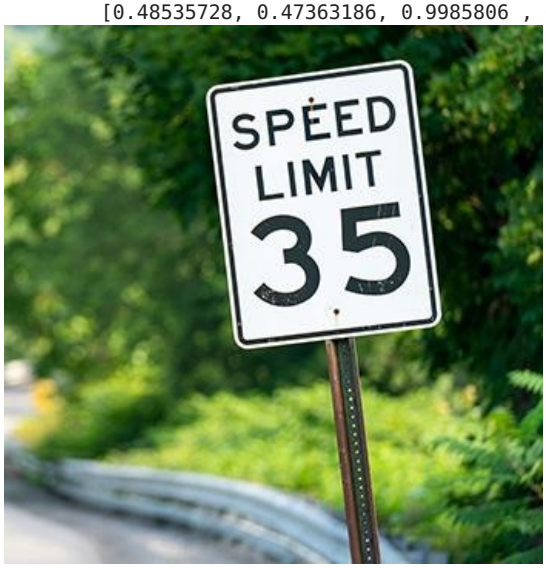


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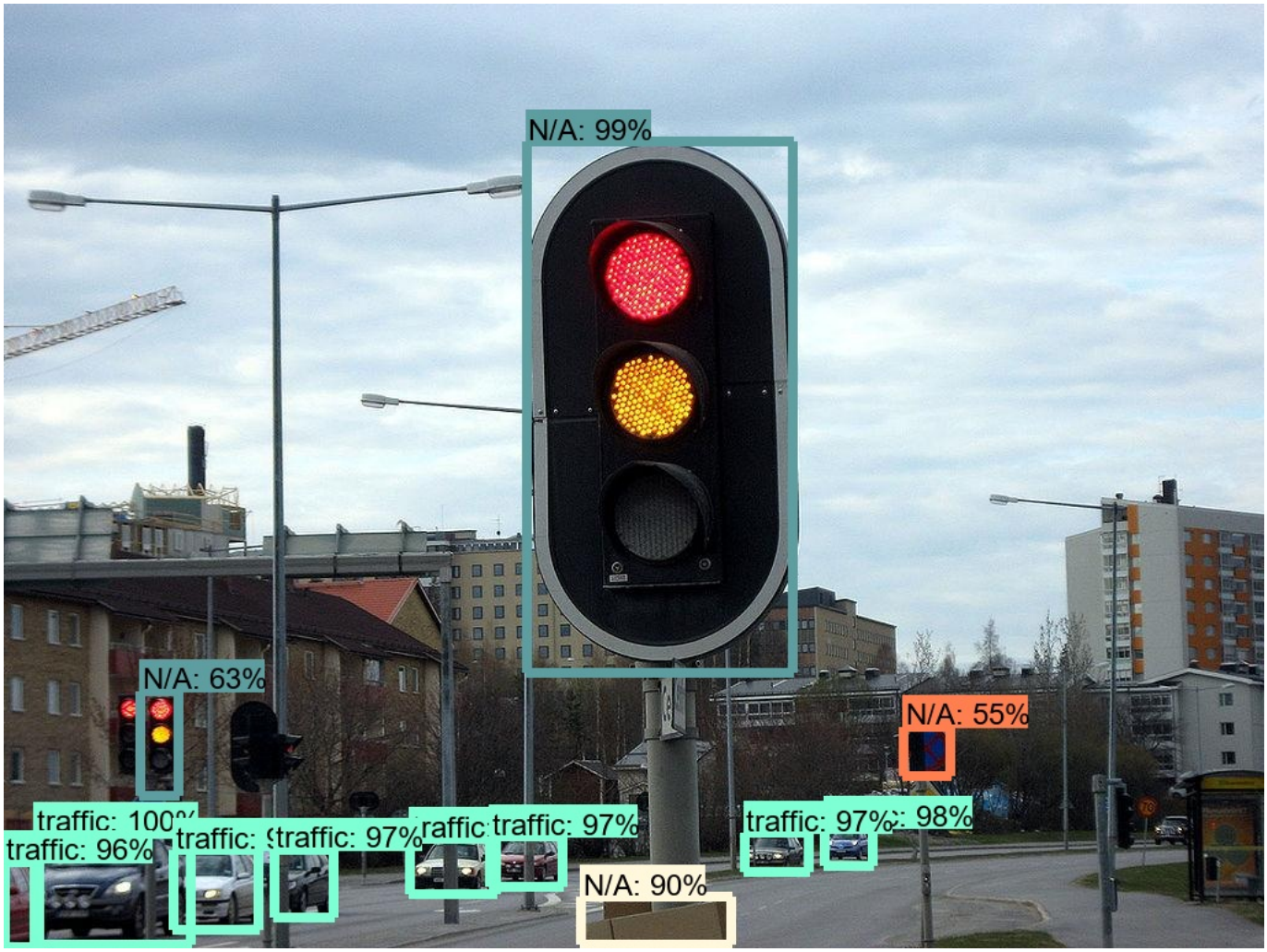


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        2.3381135e-05, 1.5527114e-05],
       ...,
       [9.9999475e-01, 1.0522019e-07, 8.1889278e-09, ..., 5.3977871e-09,
        6.2722889e-09, 1.8400048e-08],
       [9.9993575e-01, 6.0021176e-07, 5.6633784e-08, ..., 2.0661510e-08,
        6.4790044e-08, 1.2011162e-07],
       [9.9827909e-01, 7.9373967e-06, 4.7685194e-07, ..., 1.2429790e-06,
        2.9111951e-07, 7.8049879e-07]], dtype=float32), 'detection_boxes': array([[0.03835287, 0.34130675, 0.930
6127 , 0.7108172 ],
       [0.31390128, 0.35078916, 0.9129862 , 0.68056625],
       [0.02419338, 0.35002548, 0.6132906 , 0.69694704],
       ...,
       [0.10621196, 0.38185292, 0.2893644 , 0.6129455 ],
       [0.5943116 , 0.32431382, 0.9071587 , 0.66731066],
       [0.39892823, 0.41465065, 0.58215386, 0.65359634]], dtype=float32), 'num_detections': 300}
```

Fine-Tuning the Pre-Trained Model

Now we have run the pre-trained model for our dataset, which looks to work well for some of objects, because I noticed we have some same objects labeled that COCO Dataset also contains. We can still see that for example car are not labeled correctly (Because we are talking about cars now, not traffic).

At first what we want to do is modify the pipeline.config of pre-trained model to match with our project.

We want to change following things in the pipeline.config:

We want to modify following from model part:

- Num_classes: Classes we have labeled for the pictures.

model { faster_rcnn { num_classes: 8 # Instead of 90 classes, we want to detect 8 classes now. image_resizer { keep_aspect_ratio_resizer { min_dimension: 640 max_dimension: 640 pad_to_max_dimension: true } } feature_extractor { type: 'faster_rcnn_resnet101_keras' batch_norm_trainable: true } first_stage_anchor_generator { grid_anchor_generator { scales: [0.25, 0.5, 1.0, 2.0] aspect_ratios: [0.5, 1.0, 2.0] height_stride: 16 width_stride: 16 } } first_stage_box_predictor_conv_hyperparams { op: CONV regularizer { l2_regularizer { weight: 0.0 } } initializer { truncated_normal_initializer { stddev: 0.01 } } } first_stage_nms_score_threshold: 0.0 first_stage_nms_iou_threshold: 0.7 first_stage_max_proposals: 300 first_stage_localization_loss_weight: 2.0 first_stage_objectness_loss_weight: 1.0 initial_crop_size: 14 maxpool_kernel_size: 2 maxpool_stride: 2 second_stage_box_predictor { mask_rcnn_box_predictor { use_dropout: false

dropout_keep_probability: 1.0 fc_hyperparams { op: FC regularizer { l2_regularizer { weight: 0.0 } } initializer { variance_scaling_initializer { factor: 1.0 uniform: true mode: FAN_AVG } } share_box_across_classes: true } } second_stage_post_processing { batch_non_max_suppression { score_threshold: 0.0 iou_threshold: 0.6 max_detections_per_class: 100 max_total_detections: 300 } score_converter: SOFTMAX } second_stage_localization_loss_weight: 2.0 second_stage_classification_loss_weight: 1.0 use_static_shapes: true use_matmul_crop_and_resize: true clip_anchors_to_image: true use_static_balanced_label_sampler: true use_matmul_gather_in_matcher: true } }

We want to modify following from train_config part:

- batch_size: The size of each training iteration. I had to use really low sizes of batches because I got memory issues on my GPU with larger than size of 2. This will obviously result more bad quality on the predictions, but now we just have idea to see it the model works or not.
- fine_tune_checkpoint: Here we want to define the path of our pre-trained model checkpoint files, which will be used in training process.
- fine_tune_checkpoint_type: Here we define the fine_tuning type, which is detection instead of classification.
- use_bfloat16: I have no TPU, so I turn this off.

train_config: { # Because I am using a my own GPU for training, # I cannot use a large batch size. Otherwise, # there will be a memory errors. batch_size: 2 sync_replicas: true startup_delay_steps: 0 replicas_to_aggregate: 8 num_steps: 25000 optimizer { momentum_optimizer: { learning_rate: { cosine_decay_learning_rate { learning_rate_base: .04 total_steps: 25000 warmup_learning_rate: .013333 warmup_steps: 2000 } } momentum_optimizer_value: 0.9 } use_moving_average: false } # Here we set the path of pre-trained models checkpoints fine_tune_checkpoint_version: V2 fine_tune_checkpoint: "C:/Users/itane/Documents/GitHub/ComputerVisionAndSensorFunsion/exercises3/models/trainable_model/checkpoint/ckpt-0" fine_tune_checkpoint_type: "detection" # We want to use detection instead of classification data_augmentation_options { random_horizontal_flip { } } max_number_of_boxes: 100 unpad_groundtruth_tensors: false use_bfloat16: false # works only on TPUs }

Now we change the input paths of training input and evaluation input.

We want to modify following from train_config part:

- label_map_path (train_input_reader): We define the path of our label_map.pbtxt file.
- input_path (train_input_reader): Define the input path of training TFRecord file
- label_map_path (eval_input_reader): We define the path of our label_map.pbtxt file.
- input_path (eval_input_reader): Define the input path of validation TFRecord file

train_input_reader: { label_map_path: "C:/Users/itane/Documents/GitHub/ComputerVisionAndSensorFunsion/exercises3/data/label_map.pbtxt" tf_record_input_reader { input_path: "C:/Users/itane/Documents/GitHub/ComputerVisionAndSensorFunsion/exercises3/train.record" } } eval_config: { metrics_set: "coco_detection_metrics" use_moving_averages: false batch_size: 1; } eval_input_reader: { label_map_path: "C:/Users/itane/Documents/GitHub/ComputerVisionAndSensorFunsion/exercises3/data/label_map.pbtxt" shuffle: false num_epochs: 1 tf_record_input_reader { input_path: "C:/Users/itane/Documents/GitHub/ComputerVisionAndSensorFunsion/exercises3/validation.record" } }

Training Process

Now the pipeline.config file have been modified correctly, this file have been saved in models directory in our project, where is the trainable model (Faster R-CNN ResNet101-640x640 model we downloaded from the Tensorflow Model Zoo, but I wanted to create a backup file if something could go wrong and I could still see the differences of original pipeline.config etc.).

Here the first step is use the model_main_tf2.py to train the model by using the pipeline.config we just modified. The model_main_tf2.py is located in our cloned git repository which is donwnloaded from: https://github.com/tensorflow/models

Here I have done many steps in Anaconda Prompt to initialize the Ananconda Environment for us. Here is what I have done:

1. Tensorflow 2.5.0 Installation, I used *pip install tensorflow==2.5.0*
2. I installed https://github.com/tensorflow/models
3. Installed Protocol Buffers from GitHub and defined System PATH for it.
4. Run following command in models/reseach to convert .protofiles to python: *protoc object_detection/protos/*.proto --python_out=.*
5. Then I copied the setup.py from object_detection/packages/tf2/setup.py to research directory and installed it with *python -m pip install .*
6. Then I found out that protobuf have no builder.py file with this version, that comes with object_detection package. So I updated the protobuf for the latest version, copied the builder.py, downgraded the version back to compatible version and finally added the builder.py for protobufs internal folder.
7. Finally I checked that the environment was working with command: *python object_detection/builders/model_builder_tf2_test.py*

Now the environment is working, and we can continue to the training process.

model_main_tf2.py

Here we want to define following parameters:

- --pipeline_config_path: Path of our pre-trained models pipeline config.
- --: Folder where all the checkpoint files will be saved after training.
- --alsologtostderr: Logs will be visible in the terminal
- --num_train_steps: Number of training steps. I kept it low because of performance issues and low amount of data.
- --sample_1_of_n_eval_examples=1: Number of evaluation examples selected during model evaluation.
- --num_eval_steps: Number of evaluation steps.

In [23]:
```
!python "C:/Users/itane/Documents/GitHub/models/research/object_detection/model_main_tf2.py" \
--pipeline_config_path="C:/Users/itane/Documents/GitHub/ComputerVisionAndSensorFunsion/exercises3/models/trainal
--model_dir="C:/Users/itane/Documents/GitHub/ComputerVisionAndSensorFunsion/exercises3/models/trained_model" \
--alsologtostderr \
--num_train_steps=1000 \
--sample_1_of_n_eval_examples=1 \
--num_eval_steps=20
```

```
c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\tensorflow_addons\utils\tfa_eol_msg.py:23: UserW
arning:

TensorFlow Addons (TFA) has ended development and introduction of new features.
TFA has entered a minimal maintenance and release mode until a planned end of life in May 2024.
Please modify downstream libraries to take dependencies from other repositories in our TensorFlow community (e.g
. Keras, Keras-CV, and Keras-NLP).

For more information see: https://github.com/tensorflow/addons/issues/2807

  warnings.warn(
c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\tensorflow_addons\utils\ensure_tf_install.py:53:
UserWarning: Tensorflow Addons supports using Python ops for all Tensorflow versions above or equal to 2.12.0 an
d strictly below 2.15.0 (nightly versions are not supported).
 The versions of TensorFlow you are currently using is 2.10.1 and is not supported.
Some things might work, some things might not.
If you were to encounter a bug, do not file an issue.
If you want to make sure you're using a tested and supported configuration, either change the TensorFlow version
or the TensorFlow Addons's version.
You can find the compatibility matrix in TensorFlow Addon's readme:
https://github.com/tensorflow/addons
  warnings.warn(
2025-03-06 12:36:39.352928: I tensorflow/core/platform/cpu_feature_guard.cc:193] This TensorFlow binary is optim
ized with oneAPI Deep Neural Network Library (oneDNN) to use the following CPU instructions in performance-criti
cal operations:  AVX AVX2
To enable them in other operations, rebuild TensorFlow with the appropriate compiler flags.
2025-03-06 12:36:39.554697: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1616] Created device /job:localho
st/replica:0/task:0/device:GPU:0 with 5280 MB memory:  -> device: 0, name: NVIDIA GeForce RTX 4060, pci bus id:
0000:07:00.0, compute capability: 8.9
INFO:tensorflow:Using MirroredStrategy with devices ('/job:localhost/replica:0/task:0/device:GPU:0',)
I0306 12:36:40.494507 24516 mirrored_strategy.py:374] Using MirroredStrategy with devices ('/job:localhost/repli
ca:0/task:0/device:GPU:0',)
INFO:tensorflow:Maybe overwriting train_steps: 1000
I0306 12:36:40.497218 24516 config_util.py:552] Maybe overwriting train_steps: 1000
INFO:tensorflow:Maybe overwriting use_bfloat16: False
I0306 12:36:40.497218 24516 config_util.py:552] Maybe overwriting use_bfloat16: False
WARNING:tensorflow:From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\object_detection\model_l
ib_v2.py:563: StrategyBase.experimental_distribute_datasets_from_function (from tensorflow.python.distribute.dis
tribute_lib) is deprecated and will be removed in a future version.
Instructions for updating:
rename to distribute_datasets_from_function
W0306 12:36:40.517614 24516 deprecation.py:350] From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-pack
ages\object_detection\model_lib_v2.py:563: StrategyBase.experimental_distribute_datasets_from_function (from ten
sorflow.python.distribute.distribute_lib) is deprecated and will be removed in a future version.
Instructions for updating:
rename to distribute_datasets_from_function
INFO:tensorflow:Reading unweighted datasets: ['C:/Users/itane/Documents/GitHub/ComputerVisionAndSensorFunsion/ex
ercises3/train.record']
I0306 12:36:40.530879 24516 dataset_builder.py:162] Reading unweighted datasets: ['C:/Users/itane/Documents/GitH
ub/ComputerVisionAndSensorFunsion/exercises3/train.record']
INFO:tensorflow:Reading record datasets for input file: ['C:/Users/itane/Documents/GitHub/ComputerVisionAndSenso
rFunsion/exercises3/train.record']
I0306 12:36:40.530879 24516 dataset_builder.py:79] Reading record datasets for input file: ['C:/Users/itane/Docu
ments/GitHub/ComputerVisionAndSensorFunsion/exercises3/train.record']
INFO:tensorflow:Number of filenames to read: 1
I0306 12:36:40.530879 24516 dataset_builder.py:80] Number of filenames to read: 1
WARNING:tensorflow:num_readers has been reduced to 1 to match input file shards.
W0306 12:36:40.530879 24516 dataset_builder.py:86] num_readers has been reduced to 1 to match input file shards.
WARNING:tensorflow:From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\object_detection\builder
s\dataset_builder.py:100: parallel_interleave (from tensorflow.python.data.experimental.ops.interleave_ops) is d
eprecated and will be removed in a future version.
Instructions for updating:
Use `tf.data.Dataset.interleave(map_func, cycle_length, block_length, num_parallel_calls=tf.data.AUTOTUNE)` inst
ead. If sloppy execution is desired, use `tf.data.Options.deterministic`.
```

```
W0306 12:36:40.535826 24516 deprecation.py:350] From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\object_detection\builders\dataset_builder.py:100: parallel_interleave (from tensorflow.python.data.experimental.ops.interleave_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use `tf.data.Dataset.interleave(map_func, cycle_length, block_length, num_parallel_calls=tf.data.AUTOTUNE)` instead. If sloppy execution is desired, use `tf.data.Options.deterministic`.
WARNING:tensorflow:From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\object_detection\builders\dataset_builder.py:235: DatasetV1.map_with_legacy_function (from tensorflow.python.data.ops.dataset_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use `tf.data.Dataset.map()
W0306 12:36:40.547183 24516 deprecation.py:350] From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\object_detection\builders\dataset_builder.py:235: DatasetV1.map_with_legacy_function (from tensorflow.python.data.ops.dataset_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use `tf.data.Dataset.map()
WARNING:tensorflow:From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\tensorflow\python\util\dispatch.py:1176: sparse_to_dense (from tensorflow.python.ops.sparse_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Create a `tf.sparse.SparseTensor` and use `tf.sparse.to_dense` instead.
W0306 12:36:44.672576 24516 deprecation.py:350] From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\tensorflow\python\util\dispatch.py:1176: sparse_to_dense (from tensorflow.python.ops.sparse_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Create a `tf.sparse.SparseTensor` and use `tf.sparse.to_dense` instead.
WARNING:tensorflow:From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\tensorflow\python\util\dispatch.py:1176: to_float (from tensorflow.python.ops.math_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use `tf.cast` instead.
W0306 12:36:46.585480 24516 deprecation.py:350] From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\tensorflow\python\util\dispatch.py:1176: to_float (from tensorflow.python.ops.math_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use `tf.cast` instead.
c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\keras\backend.py:451: UserWarning: `tf.keras.backend.set_learning_phase` is deprecated and will be removed after 2020-10-11. To update it, simply pass a True/False value to the `training` argument of the `__call__` method of your layer or model.
  warnings.warn(
INFO:tensorflow:depth of additional conv before box predictor: 0
I0306 12:36:53.300103  2784 convolutional_keras_box_predictor.py:152] depth of additional conv before box predictor: 0
WARNING:tensorflow:From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\tensorflow\python\autograph\impl\api.py:459: Tensor.experimental_ref (from tensorflow.python.framework.ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use ref() instead.
W0306 12:36:58.096700  2784 deprecation.py:350] From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\tensorflow\python\autograph\impl\api.py:459: Tensor.experimental_ref (from tensorflow.python.framework.ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use ref() instead.
WARNING:tensorflow:From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\tensorflow\python\util\dispatch.py:1176: softmax_cross_entropy_with_logits (from tensorflow.python.ops.nn_ops) is deprecated and will be removed in a future version.
Instructions for updating:

Future major versions of TensorFlow will allow gradients to flow
into the labels input on backprop by default.

See `tf.nn.softmax_cross_entropy_with_logits_v2`.

W0306 12:37:01.221267  2784 deprecation.py:350] From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\tensorflow\python\util\dispatch.py:1176: softmax_cross_entropy_with_logits (from tensorflow.python.ops.nn_ops) is deprecated and will be removed in a future version.
Instructions for updating:

Future major versions of TensorFlow will allow gradients to flow
into the labels input on backprop by default.

See `tf.nn.softmax_cross_entropy_with_logits_v2`.

2025-03-06 12:37:09.170296: I tensorflow/stream_executor/cuda/cuda_dnn.cc:384] Loaded cuDNN version 8907
2025-03-06 12:37:09.385101: I tensorflow/stream_executor/cuda/cuda_blas.cc:1614] TensorFloat-32 will be used for the matrix multiplication. This will only be logged once.
INFO:tensorflow:Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then broadcast to ('/job:localhost/replica:0/task:0/device:CPU:0',).
I0306 12:37:11.703115 24516 cross_device_ops.py:616] Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then broadcast to ('/job:localhost/replica:0/task:0/device:CPU:0',).
INFO:tensorflow:Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then broadcast to ('/job:localhost/replica:0/task:0/device:CPU:0',).
I0306 12:37:11.705116 24516 cross_device_ops.py:616] Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then
```

```
broadcast to ('/job:localhost/replica:0/task:0/device:CPU:0',).
INFO:tensorflow:Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then broadcast to ('/job:localhost/replic
a:0/task:0/device:CPU:0',).
I0306 12:37:11.705916 24516 cross_device_ops.py:616] Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then
broadcast to ('/job:localhost/replica:0/task:0/device:CPU:0',).
INFO:tensorflow:Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then broadcast to ('/job:localhost/replic
a:0/task:0/device:CPU:0',).
I0306 12:37:11.706912 24516 cross_device_ops.py:616] Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then
broadcast to ('/job:localhost/replica:0/task:0/device:CPU:0',).
INFO:tensorflow:Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then broadcast to ('/job:localhost/replic
a:0/task:0/device:CPU:0',).
I0306 12:37:11.707913 24516 cross_device_ops.py:616] Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then
broadcast to ('/job:localhost/replica:0/task:0/device:CPU:0',).
INFO:tensorflow:Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then broadcast to ('/job:localhost/replic
a:0/task:0/device:CPU:0',).
I0306 12:37:11.708914 24516 cross_device_ops.py:616] Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then
broadcast to ('/job:localhost/replica:0/task:0/device:CPU:0',).
INFO:tensorflow:Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then broadcast to ('/job:localhost/replic
a:0/task:0/device:CPU:0',).
I0306 12:37:11.710916 24516 cross_device_ops.py:616] Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then
broadcast to ('/job:localhost/replica:0/task:0/device:CPU:0',).
INFO:tensorflow:Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then broadcast to ('/job:localhost/replic
a:0/task:0/device:CPU:0',).
I0306 12:37:11.710916 24516 cross_device_ops.py:616] Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then
broadcast to ('/job:localhost/replica:0/task:0/device:CPU:0',).
INFO:tensorflow:Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then broadcast to ('/job:localhost/replic
a:0/task:0/device:CPU:0',).
I0306 12:37:11.711917 24516 cross_device_ops.py:616] Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then
broadcast to ('/job:localhost/replica:0/task:0/device:CPU:0',).
INFO:tensorflow:Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then broadcast to ('/job:localhost/replic
a:0/task:0/device:CPU:0',).
I0306 12:37:11.711917 24516 cross_device_ops.py:616] Reduce to /job:localhost/replica:0/task:0/device:CPU:0 then
broadcast to ('/job:localhost/replica:0/task:0/device:CPU:0',).
WARNING:tensorflow:From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\tensorflow\python\util\d
eprecation.py:629: calling map_fn_v2 (from tensorflow.python.ops.map_fn) with dtype is deprecated and will be re
moved in a future version.
Instructions for updating:
Use fn_output_signature instead
W0306 12:37:13.071569 14516 deprecation.py:554] From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-pack
ages\tensorflow\python\util\deprecation.py:629: calling map_fn_v2 (from tensorflow.python.ops.map_fn) with dtype
is deprecated and will be removed in a future version.
Instructions for updating:
Use fn_output_signature instead
INFO:tensorflow:Step 100 per-step time 0.713s
I0306 12:38:24.163617 24516 model_lib_v2.py:705] Step 100 per-step time 0.713s
INFO:tensorflow:{'Loss/BoxClassifierLoss/classification_loss': 0.47434476,
 'Loss/BoxClassifierLoss/localization_loss': 0.556795,
 'Loss/RPNLoss/localization_loss': 0.05348078,
 'Loss/RPNLoss/objectness_loss': 0.15584204,
 'Loss/regularization_loss': 0.0,
 'Loss/total_loss': 1.2404625,
 'learning_rate': 0.014666351}
I0306 12:38:24.163617 24516 model_lib_v2.py:708] {'Loss/BoxClassifierLoss/classification_loss': 0.47434476,
 'Loss/BoxClassifierLoss/localization_loss': 0.556795,
 'Loss/RPNLoss/localization_loss': 0.05348078,
 'Loss/RPNLoss/objectness_loss': 0.15584204,
 'Loss/regularization_loss': 0.0,
 'Loss/total_loss': 1.2404625,
 'learning_rate': 0.014666351}
INFO:tensorflow:Step 200 per-step time 0.351s
I0306 12:38:59.290707 24516 model_lib_v2.py:705] Step 200 per-step time 0.351s
INFO:tensorflow:{'Loss/BoxClassifierLoss/classification_loss': 0.4765444,
 'Loss/BoxClassifierLoss/localization_loss': 0.13473216,
 'Loss/RPNLoss/localization_loss': 0.5419196,
 'Loss/RPNLoss/objectness_loss': 0.17644913,
 'Loss/regularization_loss': 0.0,
 'Loss/total_loss': 1.3296453,
 'learning_rate': 0.0159997}
I0306 12:38:59.290707 24516 model_lib_v2.py:708] {'Loss/BoxClassifierLoss/classification_loss': 0.4765444,
 'Loss/BoxClassifierLoss/localization_loss': 0.13473216,
 'Loss/RPNLoss/localization_loss': 0.5419196,
 'Loss/RPNLoss/objectness_loss': 0.17644913,
 'Loss/regularization_loss': 0.0,
 'Loss/total_loss': 1.3296453,
 'learning_rate': 0.0159997}
INFO:tensorflow:Step 300 per-step time 0.350s
I0306 12:39:34.271248 24516 model_lib_v2.py:705] Step 300 per-step time 0.350s
INFO:tensorflow:{'Loss/BoxClassifierLoss/classification_loss': 0.30629742,
 'Loss/BoxClassifierLoss/localization_loss': 0.3197419,
 'Loss/RPNLoss/localization_loss': 0.17687532,
 'Loss/RPNLoss/objectness_loss': 0.052356686,
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 'Loss/total_loss': 0.85527134,
```

```
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INFO:tensorflow:Step 400 per-step time 0.351s
I0306 12:40:09.322201 24516 model_lib_v2.py:705] Step 400 per-step time 0.351s
INFO:tensorflow:{'Loss/BoxClassifierLoss/classification_loss': 0.14139867,
 'Loss/BoxClassifierLoss/localization_loss': 0.19464995,
 'Loss/RPNLoss/localization_loss': 0.06983039,
 'Loss/RPNLoss/objectness_loss': 0.0731477,
 'Loss/regularization_loss': 0.0,
 'Loss/total_loss': 0.47902673,
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INFO:tensorflow:Step 500 per-step time 0.345s
I0306 12:40:43.833215 24516 model_lib_v2.py:705] Step 500 per-step time 0.345s
INFO:tensorflow:{'Loss/BoxClassifierLoss/classification_loss': 0.07566543,
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 'Loss/RPNLoss/localization_loss': 0.030390752,
 'Loss/RPNLoss/objectness_loss': 0.02747975,
 'Loss/regularization_loss': 0.0,
 'Loss/total_loss': 0.26594248,
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I0306 12:40:43.833215 24516 model_lib_v2.py:708] {'Loss/BoxClassifierLoss/classification_loss': 0.07566543,
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INFO:tensorflow:Step 600 per-step time 0.347s
I0306 12:41:18.540164 24516 model_lib_v2.py:705] Step 600 per-step time 0.347s
INFO:tensorflow:{'Loss/BoxClassifierLoss/classification_loss': 0.20928068,
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 'Loss/RPNLoss/localization_loss': 0.038956746,
 'Loss/RPNLoss/objectness_loss': 0.020063777,
 'Loss/regularization_loss': 0.0,
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INFO:tensorflow:Step 700 per-step time 0.338s
I0306 12:41:52.292173 24516 model_lib_v2.py:705] Step 700 per-step time 0.338s
INFO:tensorflow:{'Loss/BoxClassifierLoss/classification_loss': 0.0861071,
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 'Loss/RPNLoss/localization_loss': 0.02624343,
 'Loss/RPNLoss/objectness_loss': 0.013984928,
 'Loss/regularization_loss': 0.0,
 'Loss/total_loss': 0.21199864,
 'learning_rate': 0.02266645}
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INFO:tensorflow:Step 800 per-step time 0.342s
I0306 12:42:26.467656 24516 model_lib_v2.py:705] Step 800 per-step time 0.342s
INFO:tensorflow:{'Loss/BoxClassifierLoss/classification_loss': 0.26122874,
 'Loss/BoxClassifierLoss/localization_loss': 0.15798913,
 'Loss/RPNLoss/localization_loss': 0.22658902,
 'Loss/RPNLoss/objectness_loss': 0.041425914,
 'Loss/regularization_loss': 0.0,
 'Loss/total_loss': 0.68723285,
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I0306 12:42:26.468496 24516 model_lib_v2.py:708] {'Loss/BoxClassifierLoss/classification_loss': 0.26122874,
 'Loss/BoxClassifierLoss/localization_loss': 0.15798913,
```

```
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 'learning_rate': 0.023999799}
INFO:tensorflow:Step 900 per-step time 0.340s
I0306 12:43:00.439116 24516 model_lib_v2.py:705] Step 900 per-step time 0.340s
INFO:tensorflow:{'Loss/BoxClassifierLoss/classification_loss': 0.11775064,
 'Loss/BoxClassifierLoss/localization_loss': 0.09098248,
 'Loss/RPNLoss/localization_loss': 0.25787717,
 'Loss/RPNLoss/objectness_loss': 0.019792397,
 'Loss/regularization_loss': 0.0,
 'Loss/total_loss': 0.48640272,
 'learning_rate': 0.025333151}
I0306 12:43:00.439116 24516 model_lib_v2.py:708] {'Loss/BoxClassifierLoss/classification_loss': 0.11775064,
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 'Loss/regularization_loss': 0.0,
 'Loss/total_loss': 0.48640272,
 'learning_rate': 0.025333151}
INFO:tensorflow:Step 1000 per-step time 0.338s
I0306 12:43:34.238373 24516 model_lib_v2.py:705] Step 1000 per-step time 0.338s
INFO:tensorflow:{'Loss/BoxClassifierLoss/classification_loss': 0.055283036,
 'Loss/BoxClassifierLoss/localization_loss': 0.13626511,
 'Loss/RPNLoss/localization_loss': 0.018302528,
 'Loss/RPNLoss/objectness_loss': 0.008884367,
 'Loss/regularization_loss': 0.0,
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I0306 12:43:34.238373 24516 model_lib_v2.py:708] {'Loss/BoxClassifierLoss/classification_loss': 0.055283036,
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```

Now the model has been trained. The next step is to export the model through the checkpoints, and then we have a final usable fine-tuned model.

This exporting can be done by using object_detection's exporter_main_v2.py. Here we also want to define couple of parameters while running the command in python. Parameters are following:

- --input_type: Here we define the type of input, where I will use image_tensor, which uses single image's tensors as input.
- --pipeline_config_path: Here we again define the pipeline.config of our downloaded pre-trained model.
- --trained_checkpoint_dir: Here we define the path of our just trained model's checkpoints.
- --output_directory: Here we define the output directory where the final fine-tune model will be saved.

In [24]:
```
!python "C:/Users/itane/Documents/GitHub/models/research/object_detection/exporter_main_v2.py" \
--input_type=image_tensor \
--pipeline_config_path="C:/Users/itane/Documents/GitHub/ComputerVisionAndSensorFunsion/exercises3/models/trainal
--trained_checkpoint_dir="C:/Users/itane/Documents/GitHub/ComputerVisionAndSensorFunsion/exercises3/models/trai
--output_directory="C:/Users/itane/Documents/GitHub/ComputerVisionAndSensorFunsion/exercises3/models/fine_tuned_
```

```
2025-03-06 12:53:46.436076: I tensorflow/core/platform/cpu_feature_guard.cc:193] This TensorFlow binary is optim
ized with oneAPI Deep Neural Network Library (oneDNN) to use the following CPU instructions in performance-criti
cal operations:  AVX AVX2
To enable them in other operations, rebuild TensorFlow with the appropriate compiler flags.
2025-03-06 12:53:46.609564: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1616] Created device /job:localho
st/replica:0/task:0/device:GPU:0 with 5563 MB memory:  -> device: 0, name: NVIDIA GeForce RTX 4060, pci bus id:
0000:07:00.0, compute capability: 8.9
WARNING:tensorflow:From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\tensorflow\python\autogr
aph\impl\api.py:458: calling map_fn_v2 (from tensorflow.python.ops.map_fn) with back_prop=False is deprecated an
d will be removed in a future version.
Instructions for updating:
back_prop=False is deprecated. Consider using tf.stop_gradient instead.
Instead of:
results = tf.map_fn(fn, elems, back_prop=False)
Use:
results = tf.nest.map_structure(tf.stop_gradient, tf.map_fn(fn, elems))
W0306 12:53:46.947436 13836 deprecation.py:623] From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-pack
ages\tensorflow\python\autograph\impl\api.py:458: calling map_fn_v2 (from tensorflow.python.ops.map_fn) with bac
k_prop=False is deprecated and will be removed in a future version.
Instructions for updating:
back_prop=False is deprecated. Consider using tf.stop_gradient instead.
Instead of:
results = tf.map_fn(fn, elems, back_prop=False)
Use:
results = tf.nest.map_structure(tf.stop_gradient, tf.map_fn(fn, elems))
INFO:tensorflow:depth of additional conv before box predictor: 0
I0306 12:53:51.089432 13836 convolutional_keras_box_predictor.py:152] depth of additional conv before box predic
tor: 0
WARNING:tensorflow:From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-packages\tensorflow\python\autogr
aph\impl\api.py:459: Tensor.experimental_ref (from tensorflow.python.framework.ops) is deprecated and will be re
moved in a future version.
Instructions for updating:
Use ref() instead.
W0306 12:53:55.366652 13836 deprecation.py:350] From c:\Users\itane\anaconda3\envs\ObjectDetection\lib\site-pack
ages\tensorflow\python\autograph\impl\api.py:459: Tensor.experimental_ref (from tensorflow.python.framework.ops)
is deprecated and will be removed in a future version.
Instructions for updating:
Use ref() instead.
WARNING:tensorflow:Skipping full serialization of Keras layer <object_detection.meta_architectures.faster_rcnn_m
eta_arch.FasterRCNNMetaArch object at 0x000001F8BB1F7130>, because it is not built.
W0306 12:54:04.270467 13836 save_impl.py:66] Skipping full serialization of Keras layer <object_detection.meta_a
rchitectures.faster_rcnn_meta_arch.FasterRCNNMetaArch object at 0x000001F8BB1F7130>, because it is not built.
W0306 12:54:16.801283 13836 save.py:269] Found untraced functions such as FirstStageBoxPredictor_layer_call_fn,
FirstStageBoxPredictor_layer_call_and_return_conditional_losses, mask_rcnn_keras_box_predictor_layer_call_fn, ma
sk_rcnn_keras_box_predictor_layer_call_and_return_conditional_losses, _jit_compiled_convolution_op while saving
(showing 5 of 135). These functions will not be directly callable after loading.
INFO:tensorflow:Assets written to: C:/Users/itane/Documents/GitHub/ComputerVisionAndSensorFunsion/exercises3/mod
els/fine_tuned_model\saved_model\assets
I0306 12:54:22.364616 13836 builder_impl.py:779] Assets written to: C:/Users/itane/Documents/GitHub/ComputerVisi
onAndSensorFunsion/exercises3/models/fine_tuned_model\saved_model\assets
INFO:tensorflow:Writing pipeline config file to C:/Users/itane/Documents/GitHub/ComputerVisionAndSensorFunsion/e
xercises3/models/fine_tuned_model\pipeline.config
I0306 12:54:23.393785 13836 config_util.py:253] Writing pipeline config file to C:/Users/itane/Documents/GitHub/
ComputerVisionAndSensorFunsion/exercises3/models/fine_tuned_model\pipeline.config
```

Now we have finally trained and exported our new fine-tuned model. Next step is to put it in work and see how it performs.

Predictions with our new model

In [25]:
```
model_path = 'models/fine_tuned_model/saved_model/'
detection_model = tf.saved_model.load(model_path)
```

In [26]:
```
print(detection_model.signatures['serving_default'].inputs)
```

```
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In [27]:
```
detection_model.signatures['serving_default'].output_dtypes
```

Out[27]:
```
{'raw_detection_scores': tf.float32,
 'raw_detection_boxes': tf.float32,
 'detection_anchor_indices': tf.float32,
 'num_detections': tf.float32,
 'detection_boxes': tf.float32,
 'detection_multiclass_scores': tf.float32,
 'detection_scores': tf.float32,
 'detection_classes': tf.float32}
```

In [28]:
```
detection_model.signatures['serving_default'].output_shapes
```

Out[28]:
```
{'raw_detection_scores': TensorShape([1, 300, 9]),
 'raw_detection_boxes': TensorShape([1, 300, 4]),
 'detection_anchor_indices': TensorShape([1, 300]),
 'num_detections': TensorShape([1]),
 'detection_boxes': TensorShape([1, 300, 4]),
 'detection_multiclass_scores': TensorShape([1, 300, 9]),
 'detection_scores': TensorShape([1, 300]),
 'detection_classes': TensorShape([1, 300])}
```

In [29]:
```
for image_path in TEST_IMAGE_PATHS:
  show_inference(detection_model, image_path)
```

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       [2.7852647e-02, 1.1594364e-02, 8.6842883e-01, ..., 1.5745983e-02,
        2.5794985e-02, 8.4226290e-03],
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       ...,
       [9.9999964e-01, 6.9341858e-08, 2.2426249e-08, ..., 3.5822609e-09,
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       [9.2229348e-01, 9.9677721e-04, 3.4519969e-03, ..., 1.3506030e-04,
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       ...,
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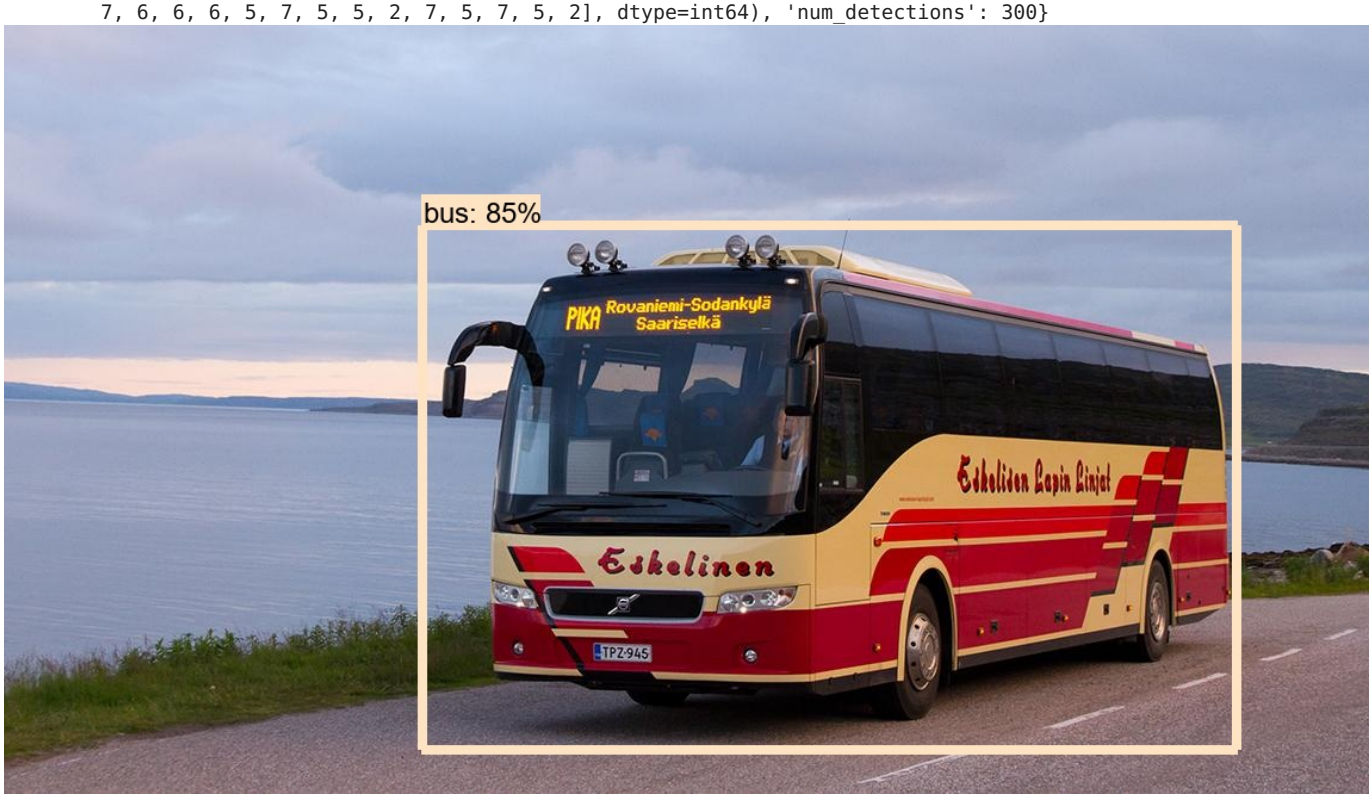


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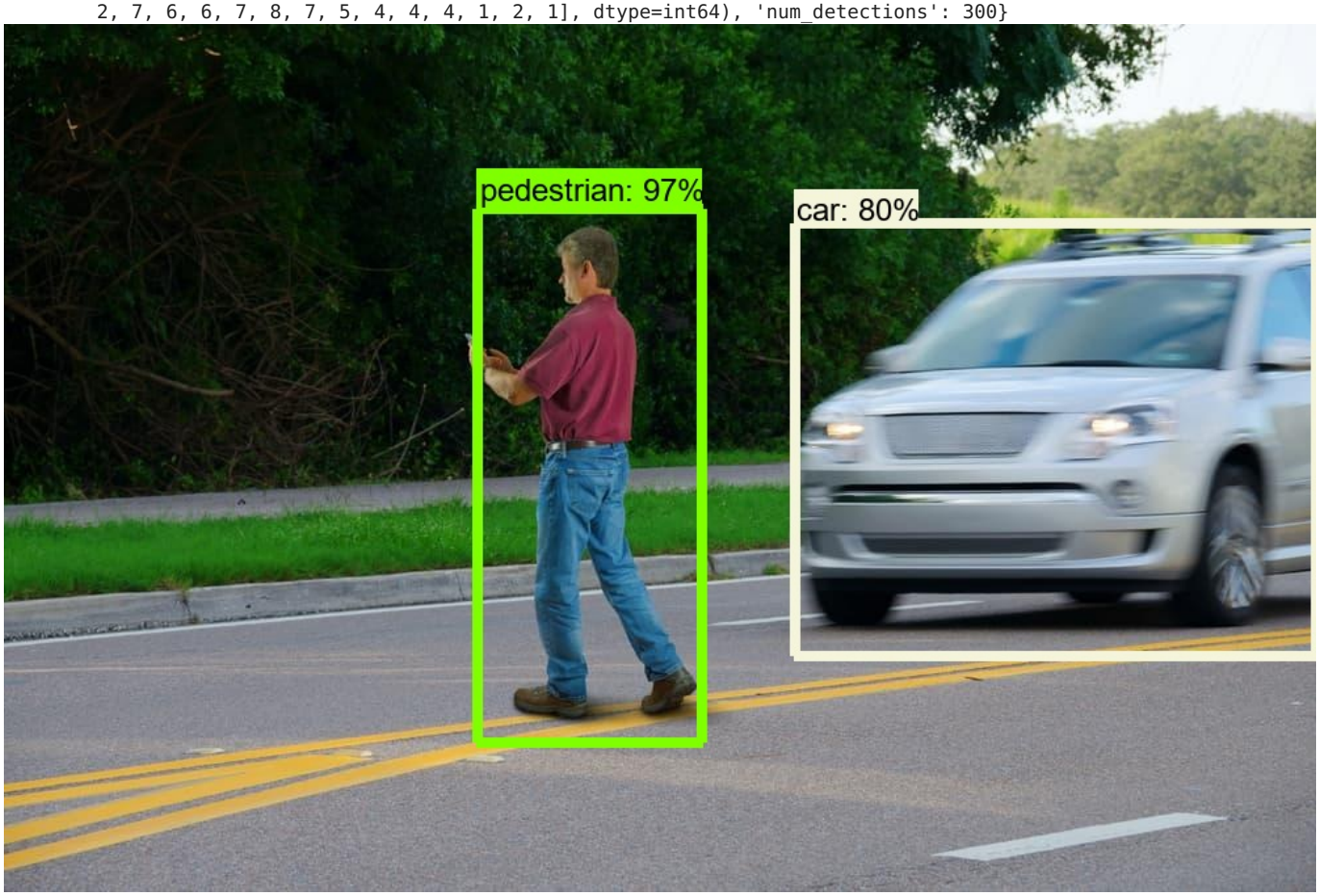


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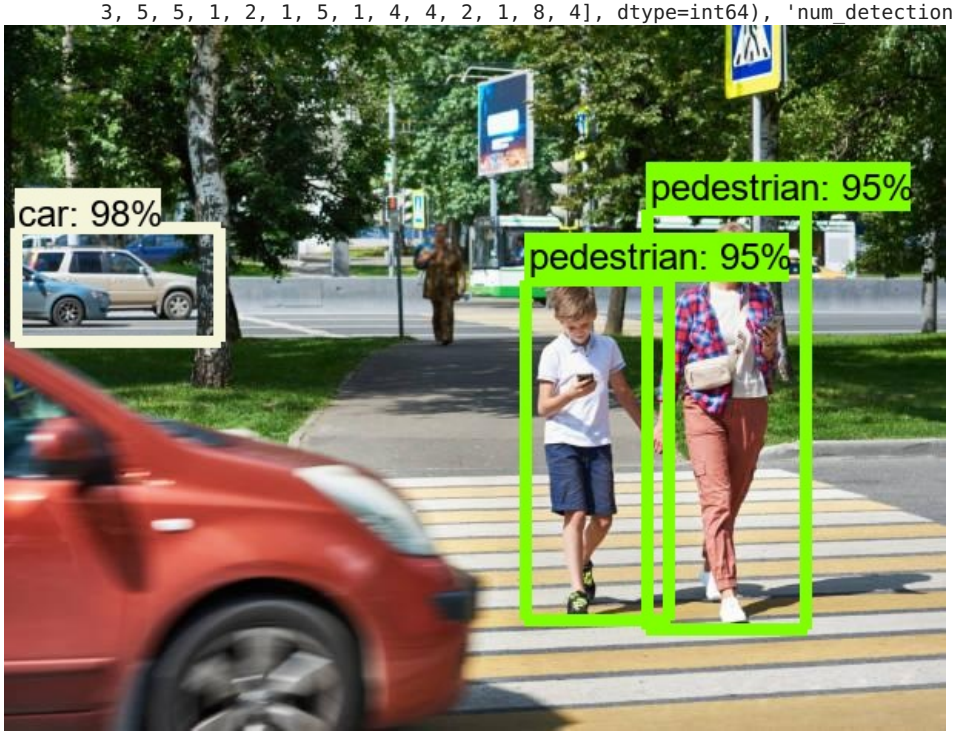


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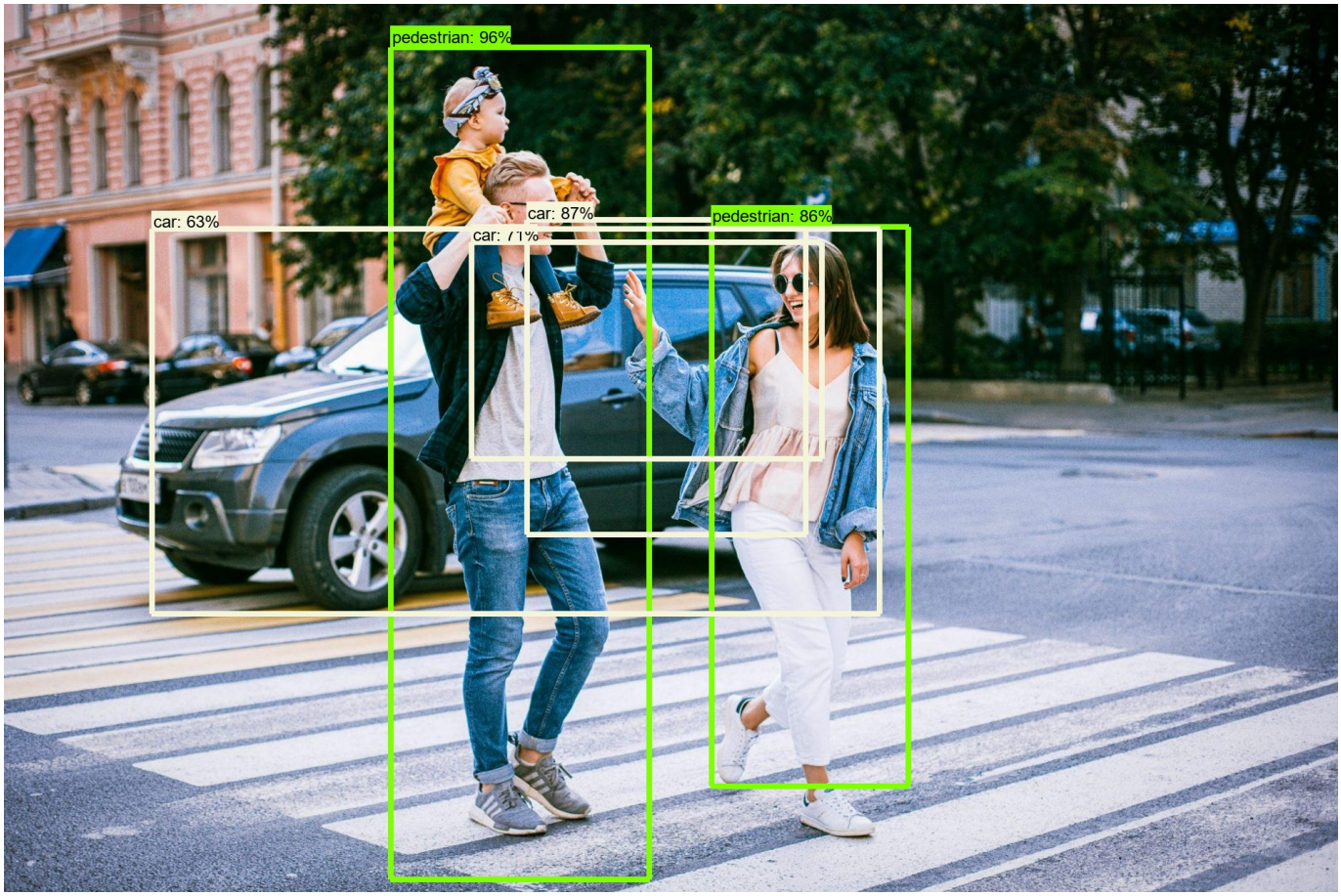


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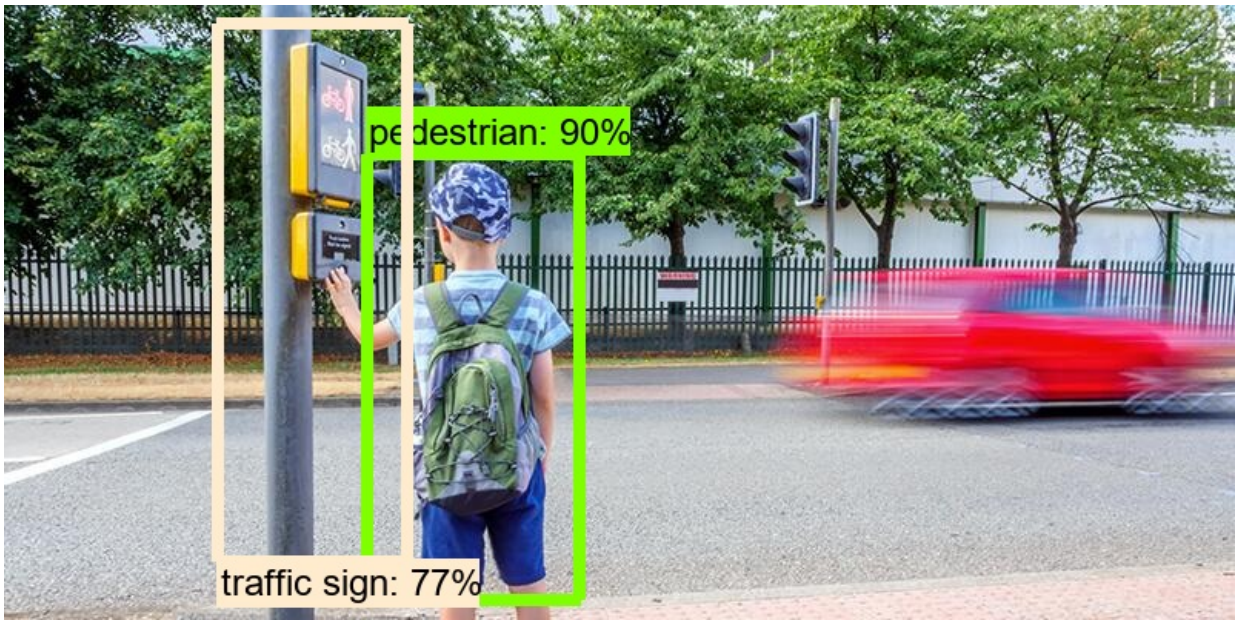


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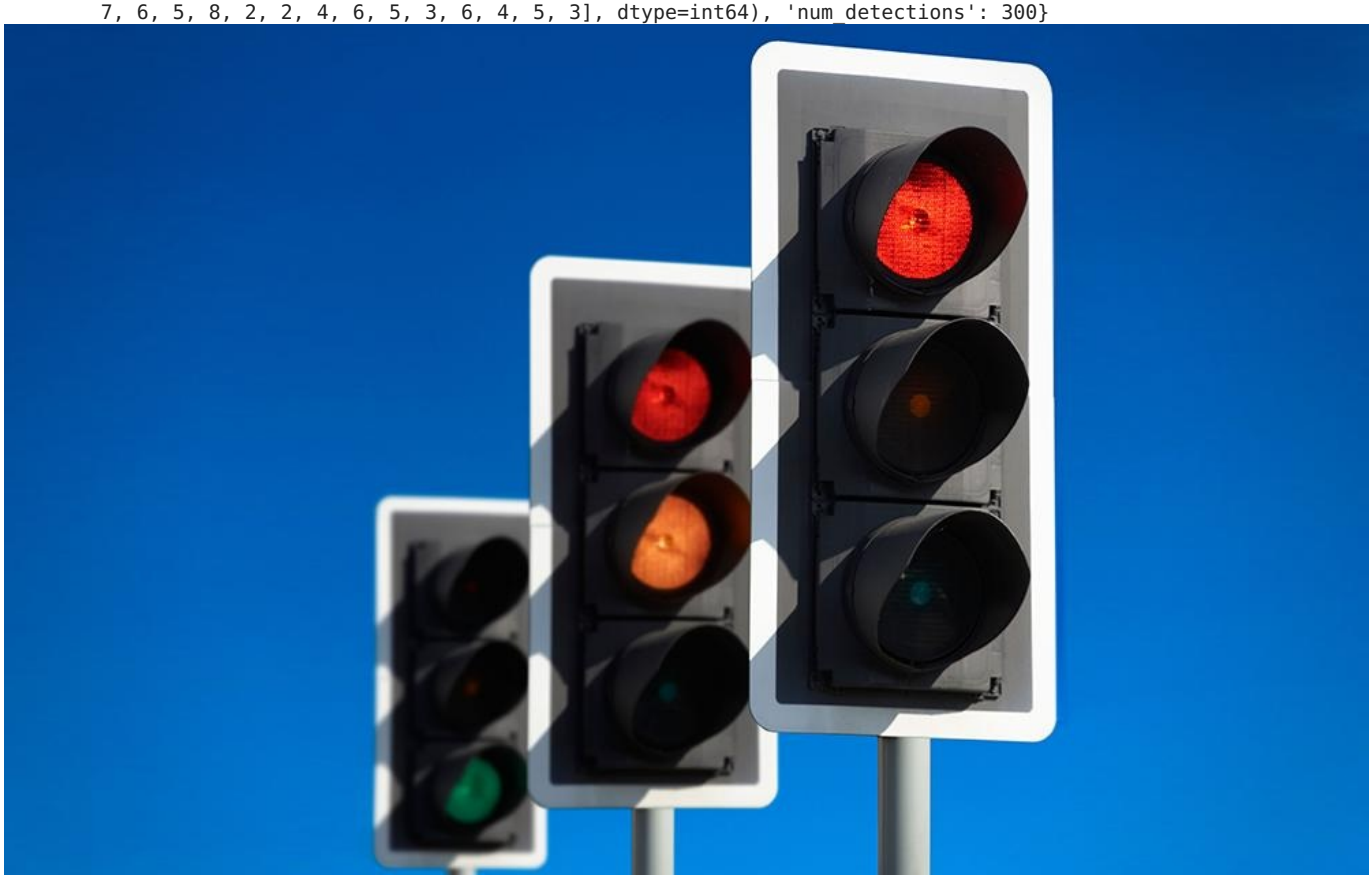

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Final Observations and Conclusion

As we can see from the results of final prints, our model is now having better labeling information is somewhere, but we can clearly see that the model is not trained enough yet. To make much more reliable prediction, we should gain the amount of data, but also tune the parameters we have used in our training commands and config files.

For instance, we can see that trash bins are not detected basicly at all, but this may be caused, because all the trashbins we have may vary with their colors and shapes. It is really hard to models predict these without a large amount of data or harded training.