dt_object_detection_training

December 31, 2023

1 First, let us set up a few dependencies

Don't forget to switch to a GPU-enabled colab runtime!

`Runtime -> Change Runtime Type -> GPU`

```python
import os
import contextlib
@contextlib.contextmanager
def directory(name):
  ret = os.getcwd()
  os.chdir(name)
  yield None
  os.chdir(ret)


import subprocess
def run(input, exception_on_failure=False):
  try:
    program_output = subprocess.check_output(f"{input}", shell=True,
  ↪universal_newlines=True, stderr=subprocess.STDOUT)
  except Exception as e:
    if exception_on_failure:
      raise e
    program_output = e.output

    return program_output
def prun(input, exception_on_failure=False):
  x = run(input, exception_on_failure)
  print(x)
  return x
```

2 This mounts your google drive to this notebook. You might have to change the path to fit with your dataset folder inside your drive.

Read the instruction output by the cell bellow carefully!

```python
# Create a temporary workspace
import tempfile


SESSION_WORKSPACE = tempfile.mkdtemp()
print(f"Session workspace created at: {SESSION_WORKSPACE}")
```

Session workspace created at: /tmp/tmpm1vock2i

```python
# Mount the drive
from google.colab import drive
drive.mount('/content/drive')
DRIVE_PATH = "/content/drive/My Drive"
```

Mounted at /content/drive

```python
# Unzip the dataset
import shutil
import os


DATASET_DIR_NAME = "duckietown_object_detection_dataset"
DATASET_ZIP_NAME = f"{DATASET_DIR_NAME}.zip"
DATASET_DIR_PATH = os.path.join(SESSION_WORKSPACE, DATASET_DIR_NAME)
TRAIN_DIR = "train"
VALIDATION_DIR = "val"
IMAGES_DIR = "images"
LABELS_DIR = "labels"


def show_info(base_path: str):
  for l1 in [TRAIN_DIR, VALIDATION_DIR]:
    for l2 in [IMAGES_DIR, LABELS_DIR]:
      p = os.path.join(base_path, l1, l2)
      print(f"#Files in {l1}/{l2}: {len(os.listdir(p))}")


def unzip_dataset():
  # check zipped file
  zip_path = os.path.join(DRIVE_PATH, DATASET_ZIP_NAME)
  assert os.path.exists(zip_path), f"No zipped dataset found at {zip_path}!␣
  ↪Abort!"

  # unzip the data
  print("Unpacking zipped data...")
  shutil.unpack_archive(zip_path, DATASET_DIR_PATH)
  print(f"Zipped dataset unpacked to {DATASET_DIR_PATH}")
```

```
    # show some info
    show_info(DATASET_DIR_PATH)


unzip_dataset()
```

Unpacking zipped data…
Zipped dataset unpacked to /tmp/tmpm1vock2i/duckietown_object_detection_dataset
#Files in train/images: 964
#Files in train/labels: 964
#Files in val/images: 242
#Files in val/labels: 242

```
[ ]: # change  working directory to the session workspace
     os.chdir(SESSION_WORKSPACE)
     print(f"PWD: {os.getcwd()}")

     # install pytorch and torchvision
     !pip3 install torch==1.13.0 torchvision==0.14.0
```

PWD: /tmp/tmpm1vock2i
Collecting torch==1.13.0
   Downloading torch-1.13.0-cp310-cp310-manylinux1_x86_64.whl (890.1 MB)
                              890.1/890.1

MB 705.3 kB/s eta 0:00:00
Collecting torchvision==0.14.0
   Downloading torchvision-0.14.0-cp310-cp310-manylinux1_x86_64.whl (24.3 MB)
                              24.3/24.3 MB
21.8 MB/s eta 0:00:00
Requirement already satisfied: typing-extensions in
/usr/local/lib/python3.10/dist-packages (from torch==1.13.0) (4.5.0)
Collecting nvidia-cuda-runtime-cu11==11.7.99 (from torch==1.13.0)
   Downloading nvidia_cuda_runtime_cu11-11.7.99-py3-none-manylinux1_x86_64.whl
(849 kB)
                              849.3/849.3

kB 28.1 MB/s eta 0:00:00
Collecting nvidia-cudnn-cu11==8.5.0.96 (from torch==1.13.0)
   Downloading nvidia_cudnn_cu11-8.5.0.96-2-py3-none-manylinux1_x86_64.whl (557.1
MB)
                              557.1/557.1

MB 2.6 MB/s eta 0:00:00
Collecting nvidia-cublas-cu11==11.10.3.66 (from torch==1.13.0)
   Downloading nvidia_cublas_cu11-11.10.3.66-py3-none-manylinux1_x86_64.whl
(317.1 MB)
                              317.1/317.1

MB 2.7 MB/s eta 0:00:00
```

```
Collecting nvidia-cuda-nvrtc-cu11==11.7.99 (from torch==1.13.0)
  Downloading nvidia_cuda_nvrtc_cu11-11.7.99-2-py3-none-manylinux1_x86_64.whl
(21.0 MB)
                              21.0/21.0 MB
38.1 MB/s eta 0:00:00
Requirement already satisfied: numpy in /usr/local/lib/python3.10/dist-
packages (from torchvision==0.14.0) (1.23.5)
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-
packages (from torchvision==0.14.0) (2.31.0)
Requirement already satisfied: pillow!=8.3.*,>=5.3.0 in
/usr/local/lib/python3.10/dist-packages (from torchvision==0.14.0) (9.4.0)
Requirement already satisfied: setuptools in /usr/local/lib/python3.10/dist-
packages (from nvidia-cublas-cu11==11.10.3.66->torch==1.13.0) (67.7.2)
Requirement already satisfied: wheel in /usr/local/lib/python3.10/dist-packages
(from nvidia-cublas-cu11==11.10.3.66->torch==1.13.0) (0.42.0)
Requirement already satisfied: charset-normalizer<4,>=2 in
/usr/local/lib/python3.10/dist-packages (from requests->torchvision==0.14.0)
(3.3.2)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-
packages (from requests->torchvision==0.14.0) (3.6)
Requirement already satisfied: urllib3<3,>=1.21.1 in
/usr/local/lib/python3.10/dist-packages (from requests->torchvision==0.14.0)
(2.0.7)
Requirement already satisfied: certifi>=2017.4.17 in
/usr/local/lib/python3.10/dist-packages (from requests->torchvision==0.14.0)
(2023.11.17)
Installing collected packages: nvidia-cuda-runtime-cu11, nvidia-cuda-nvrtc-cu11,
nvidia-cublas-cu11, nvidia-cudnn-cu11, torch, torchvision
  Attempting uninstall: torch
    Found existing installation: torch 2.1.0+cu121
    Uninstalling torch-2.1.0+cu121:
      Successfully uninstalled torch-2.1.0+cu121
  Attempting uninstall: torchvision
    Found existing installation: torchvision 0.16.0+cu121
    Uninstalling torchvision-0.16.0+cu121:
      Successfully uninstalled torchvision-0.16.0+cu121
```

Successfully installed nvidia-cublas-cu11-11.10.3.66 nvidia-cuda-nvrtc-cu11-11.7.99 nvidia-cuda-runtime-cu11-11.7.99 nvidia-cudnn-cu11-8.5.0.96 torch-1.13.0 torchvision-0.14.0

3   Next, we will clone Yolov5

```
[ ]: !rm -rf ./yolov5
     !git clone https://github.com/ultralytics/yolov5.git -b v7.0
     !cd yolov5 && pip3 install -r requirements.txt
```

Cloning into 'yolov5'…
remote: Enumerating objects: 16117, done.
remote: Counting objects: 100% (28/28), done.
remote: Compressing objects: 100% (27/27), done.
remote: Total 16117 (delta 9), reused 11 (delta 1), pack-reused 16089
Receiving objects: 100% (16117/16117), 14.86 MiB | 21.02 MiB/s, done.
Resolving deltas: 100% (11032/11032), done.
Note: switching to '915bbf294bb74c859f0b41f1c23bc395014ea679'.

You are in 'detached HEAD' state. You can look around, make experimental
changes and commit them, and you can discard any commits you make in this
state without impacting any branches by switching back to a branch.

If you want to create a new branch to retain commits you create, you may
do so (now or later) by using -c with the switch command. Example:

  git switch -c <new-branch-name>

Or undo this operation with:

  git switch -

Turn off this advice by setting config variable advice.detachedHead to false

```
Collecting gitpython (from -r requirements.txt (line 5))
  Downloading GitPython-3.1.40-py3-none-any.whl (190 kB)
                         190.6/190.6

kB 1.7 MB/s eta 0:00:00
Requirement already satisfied: ipython in /usr/local/lib/python3.10/dist-
packages (from -r requirements.txt (line 6)) (7.34.0)
Requirement already satisfied: matplotlib>=3.2.2 in
/usr/local/lib/python3.10/dist-packages (from -r requirements.txt (line 7))
(3.7.1)
Requirement already satisfied: numpy>=1.18.5 in /usr/local/lib/python3.10/dist-
packages (from -r requirements.txt (line 8)) (1.23.5)
Requirement already satisfied: opencv-python>=4.1.1 in
/usr/local/lib/python3.10/dist-packages (from -r requirements.txt (line 9))
(4.8.0.76)
Requirement already satisfied: Pillow>=7.1.2 in /usr/local/lib/python3.10/dist-
packages (from -r requirements.txt (line 10)) (9.4.0)
Requirement already satisfied: psutil in /usr/local/lib/python3.10/dist-packages
(from -r requirements.txt (line 11)) (5.9.5)
Requirement already satisfied: PyYAML>=5.3.1 in /usr/local/lib/python3.10/dist-
packages (from -r requirements.txt (line 12)) (6.0.1)
Requirement already satisfied: requests>=2.23.0 in
/usr/local/lib/python3.10/dist-packages (from -r requirements.txt (line 13))
(2.31.0)
Requirement already satisfied: scipy>=1.4.1 in /usr/local/lib/python3.10/dist-
packages (from -r requirements.txt (line 14)) (1.11.4)
Collecting thop>=0.1.1 (from -r requirements.txt (line 15))
  Downloading thop-0.1.1.post2209072238-py3-none-any.whl (15 kB)
Requirement already satisfied: torch>=1.7.0 in /usr/local/lib/python3.10/dist-
packages (from -r requirements.txt (line 16)) (1.13.0)
Requirement already satisfied: torchvision>=0.8.1 in
/usr/local/lib/python3.10/dist-packages (from -r requirements.txt (line 17))
(0.14.0)
Requirement already satisfied: tqdm>=4.64.0 in /usr/local/lib/python3.10/dist-
packages (from -r requirements.txt (line 18)) (4.66.1)
Requirement already satisfied: tensorboard>=2.4.1 in
/usr/local/lib/python3.10/dist-packages (from -r requirements.txt (line 22))
(2.15.1)
Requirement already satisfied: pandas>=1.1.4 in /usr/local/lib/python3.10/dist-
packages (from -r requirements.txt (line 27)) (1.5.3)
Requirement already satisfied: seaborn>=0.11.0 in
/usr/local/lib/python3.10/dist-packages (from -r requirements.txt (line 28))
(0.12.2)
Collecting gitdb<5,>=4.0.1 (from gitpython->-r requirements.txt (line 5))
  Downloading gitdb-4.0.11-py3-none-any.whl (62 kB)
                         62.7/62.7 kB
8.4 MB/s eta 0:00:00
Requirement already satisfied: setuptools>=18.5 in
```

/usr/local/lib/python3.10/dist-packages (from ipython->-r requirements.txt (line 6)) (67.7.2)
Collecting jedi>=0.16 (from ipython->-r requirements.txt (line 6))
  Downloading jedi-0.19.1-py2.py3-none-any.whl (1.6 MB)
                              1.6/1.6 MB
13.1 MB/s eta 0:00:00
Requirement already satisfied: decorator in
/usr/local/lib/python3.10/dist-packages (from ipython->-r requirements.txt (line 6)) (4.4.2)
Requirement already satisfied: pickleshare in /usr/local/lib/python3.10/dist-packages (from ipython->-r requirements.txt (line 6)) (0.7.5)
Requirement already satisfied: traitlets>=4.2 in /usr/local/lib/python3.10/dist-packages (from ipython->-r requirements.txt (line 6)) (5.7.1)
Requirement already satisfied: prompt-toolkit!=3.0.0,!=3.0.1,<3.1.0,>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from ipython->-r requirements.txt (line 6)) (3.0.43)
Requirement already satisfied: pygments in /usr/local/lib/python3.10/dist-packages (from ipython->-r requirements.txt (line 6)) (2.16.1)
Requirement already satisfied: backcall in /usr/local/lib/python3.10/dist-packages (from ipython->-r requirements.txt (line 6)) (0.2.0)
Requirement already satisfied: matplotlib-inline in
/usr/local/lib/python3.10/dist-packages (from ipython->-r requirements.txt (line 6)) (0.1.6)
Requirement already satisfied: pexpect>4.3 in /usr/local/lib/python3.10/dist-packages (from ipython->-r requirements.txt (line 6)) (4.9.0)
Requirement already satisfied: contourpy>=1.0.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.2.2->-r requirements.txt (line 7)) (1.2.0)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.10/dist-packages (from matplotlib>=3.2.2->-r requirements.txt (line 7)) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.2.2->-r requirements.txt (line 7)) (4.46.0)
Requirement already satisfied: kiwisolver>=1.0.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.2.2->-r requirements.txt (line 7)) (1.4.5)
Requirement already satisfied: packaging>=20.0 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.2.2->-r requirements.txt (line 7)) (23.2)
Requirement already satisfied: pyparsing>=2.3.1 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.2.2->-r requirements.txt (line 7)) (3.1.1)
Requirement already satisfied: python-dateutil>=2.7 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=3.2.2->-r requirements.txt (line 7)) (2.8.2)
Requirement already satisfied: charset-normalizer<4,>=2 in
/usr/local/lib/python3.10/dist-packages (from requests>=2.23.0->-r requirements.txt (line 13)) (3.3.2)

Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests>=2.23.0->-r requirements.txt (line 13)) (3.6)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests>=2.23.0->-r requirements.txt (line 13)) (2.0.7)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests>=2.23.0->-r requirements.txt (line 13)) (2023.11.17)
Requirement already satisfied: typing-extensions in /usr/local/lib/python3.10/dist-packages (from torch>=1.7.0->-r requirements.txt (line 16)) (4.5.0)
Requirement already satisfied: nvidia-cuda-runtime-cu11==11.7.99 in /usr/local/lib/python3.10/dist-packages (from torch>=1.7.0->-r requirements.txt (line 16)) (11.7.99)
Requirement already satisfied: nvidia-cudnn-cu11==8.5.0.96 in /usr/local/lib/python3.10/dist-packages (from torch>=1.7.0->-r requirements.txt (line 16)) (8.5.0.96)
Requirement already satisfied: nvidia-cublas-cu11==11.10.3.66 in /usr/local/lib/python3.10/dist-packages (from torch>=1.7.0->-r requirements.txt (line 16)) (11.10.3.66)
Requirement already satisfied: nvidia-cuda-nvrtc-cu11==11.7.99 in /usr/local/lib/python3.10/dist-packages (from torch>=1.7.0->-r requirements.txt (line 16)) (11.7.99)
Requirement already satisfied: wheel in /usr/local/lib/python3.10/dist-packages (from nvidia-cublas-cu11==11.10.3.66->torch>=1.7.0->-r requirements.txt (line 16)) (0.42.0)
Requirement already satisfied: absl-py>=0.4 in /usr/local/lib/python3.10/dist-packages (from tensorboard>=2.4.1->-r requirements.txt (line 22)) (1.4.0)
Requirement already satisfied: grpcio>=1.48.2 in /usr/local/lib/python3.10/dist-packages (from tensorboard>=2.4.1->-r requirements.txt (line 22)) (1.60.0)
Requirement already satisfied: google-auth<3,>=1.6.3 in /usr/local/lib/python3.10/dist-packages (from tensorboard>=2.4.1->-r requirements.txt (line 22)) (2.17.3)
Requirement already satisfied: google-auth-oauthlib<2,>=0.5 in /usr/local/lib/python3.10/dist-packages (from tensorboard>=2.4.1->-r requirements.txt (line 22)) (1.2.0)
Requirement already satisfied: markdown>=2.6.8 in /usr/local/lib/python3.10/dist-packages (from tensorboard>=2.4.1->-r requirements.txt (line 22)) (3.5.1)
Requirement already satisfied: protobuf<4.24,>=3.19.6 in /usr/local/lib/python3.10/dist-packages (from tensorboard>=2.4.1->-r requirements.txt (line 22)) (3.20.3)
Requirement already satisfied: six>1.9 in /usr/local/lib/python3.10/dist-packages (from tensorboard>=2.4.1->-r requirements.txt (line 22)) (1.16.0)
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in /usr/local/lib/python3.10/dist-packages (from tensorboard>=2.4.1->-r requirements.txt (line 22)) (0.7.2)
Requirement already satisfied: werkzeug>=1.0.1 in

/usr/local/lib/python3.10/dist-packages (from tensorboard>=2.4.1->-r
requirements.txt (line 22)) (3.0.1)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-
packages (from pandas>=1.1.4->-r requirements.txt (line 27)) (2023.3.post1)
Collecting smmap<6,>=3.0.1 (from gitdb<5,>=4.0.1->gitpython->-r requirements.txt
(line 5))
  Downloading smmap-5.0.1-py3-none-any.whl (24 kB)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in
/usr/local/lib/python3.10/dist-packages (from google-
auth<3,>=1.6.3->tensorboard>=2.4.1->-r requirements.txt (line 22)) (5.3.2)
Requirement already satisfied: pyasn1-modules>=0.2.1 in
/usr/local/lib/python3.10/dist-packages (from google-
auth<3,>=1.6.3->tensorboard>=2.4.1->-r requirements.txt (line 22)) (0.3.0)
Requirement already satisfied: rsa<5,>=3.1.4 in /usr/local/lib/python3.10/dist-
packages (from google-auth<3,>=1.6.3->tensorboard>=2.4.1->-r requirements.txt
(line 22)) (4.9)
Requirement already satisfied: requests-oauthlib>=0.7.0 in
/usr/local/lib/python3.10/dist-packages (from google-auth-
oauthlib<2,>=0.5->tensorboard>=2.4.1->-r requirements.txt (line 22)) (1.3.1)
Requirement already satisfied: parso<0.9.0,>=0.8.3 in
/usr/local/lib/python3.10/dist-packages (from jedi>=0.16->ipython->-r
requirements.txt (line 6)) (0.8.3)
Requirement already satisfied: ptyprocess>=0.5 in
/usr/local/lib/python3.10/dist-packages (from pexpect>4.3->ipython->-r
requirements.txt (line 6)) (0.7.0)
Requirement already satisfied: wcwidth in /usr/local/lib/python3.10/dist-
packages (from prompt-toolkit!=3.0.0,!=3.0.1,<3.1.0,>=2.0.0->ipython->-r
requirements.txt (line 6)) (0.2.12)
Requirement already satisfied: MarkupSafe>=2.1.1 in
/usr/local/lib/python3.10/dist-packages (from
werkzeug>=1.0.1->tensorboard>=2.4.1->-r requirements.txt (line 22)) (2.1.3)
Requirement already satisfied: pyasn1<0.6.0,>=0.4.6 in
/usr/local/lib/python3.10/dist-packages (from pyasn1-modules>=0.2.1->google-
auth<3,>=1.6.3->tensorboard>=2.4.1->-r requirements.txt (line 22)) (0.5.1)
Requirement already satisfied: oauthlib>=3.0.0 in
/usr/local/lib/python3.10/dist-packages (from requests-oauthlib>=0.7.0->google-
auth-oauthlib<2,>=0.5->tensorboard>=2.4.1->-r requirements.txt (line 22))
(3.2.2)
Installing collected packages: smmap, jedi, gitdb, gitpython, thop
Successfully installed gitdb-4.0.11 gitpython-3.1.40 jedi-0.19.1 smmap-5.0.1
thop-0.1.1.post2209072238

4 We now inform the training process of the format and location of our dataset

```
[ ]: %%writefile ./yolov5/data/duckietown.yaml

     # train and val data as 1) directory: path/images/, 2) file: path/images.txt,
     ↪or 3) list: [path1/images/, path2/images/]
     train: ../duckietown_object_detection_dataset/train
     val: ../duckietown_object_detection_dataset/val

     # number of classes
     nc: 4

     # class names
     names: [ 'duckie', 'cone', 'truck', 'bus' ]
```

Writing ./yolov5/data/duckietown.yaml

5 And we're ready to train! This step will take about 5 minutes.

Notice that we're only training for 10 epochs. That's probably not enough!

```
[ ]: !cd yolov5 && python3 train.py --cfg ./models/yolov5n.yaml --img 416 --batch 32
     ↪--epochs 10 --data duckietown.yaml --weights yolov5n.pt
```

train: weights=yolov5n.pt, cfg=./models/yolov5n.yaml,
data=duckietown.yaml, hyp=data/hyps/hyp.scratch-low.yaml, epochs=10,
batch_size=32, imgsz=416, rect=False, resume=False, nosave=False, noval=False,
noautoanchor=False, noplots=False, evolve=None, bucket=, cache=None,
image_weights=False, device=, multi_scale=False, single_cls=False,
optimizer=SGD, sync_bn=False, workers=8, project=runs/train, name=exp,
exist_ok=False, quad=False, cos_lr=False, label_smoothing=0.0, patience=100,
freeze=[0], save_period=-1, seed=0, local_rank=-1, entity=None,
upload_dataset=False, bbox_interval=-1, artifact_alias=latest
github: YOLOv5 is out of date by 254 commits. Use `git pull` or
`git clone https://github.com/ultralytics/yolov5` to update.
YOLOv5   v7.0-0-g915bbf2 Python-3.10.12 torch-1.13.0+cu117 CUDA:0 (Tesla T4,
15102MiB)

hyperparameters: lr0=0.01, lrf=0.01, momentum=0.937,
weight_decay=0.0005, warmup_epochs=3.0, warmup_momentum=0.8, warmup_bias_lr=0.1,
box=0.05, cls=0.5, cls_pw=1.0, obj=1.0, obj_pw=1.0, iou_t=0.2, anchor_t=4.0,
fl_gamma=0.0, hsv_h=0.015, hsv_s=0.7, hsv_v=0.4, degrees=0.0, translate=0.1,
scale=0.5, shear=0.0, perspective=0.0, flipud=0.0, fliplr=0.5, mosaic=1.0,
mixup=0.0, copy_paste=0.0
ClearML: run 'pip install clearml' to automatically track,
visualize and remotely train YOLOv5   in ClearML
Comet: run 'pip install comet_ml' to automatically track and

visualize YOLOv5 runs in Comet
TensorBoard: Start with 'tensorboard --logdir runs/train', view at
http://localhost:6006/
2023-12-31 17:40:32.017915: E
external/local_xla/xla/stream_executor/cuda/cuda_dnn.cc:9261] Unable to register
cuDNN factory: Attempting to register factory for plugin cuDNN when one has
already been registered
2023-12-31 17:40:32.018029: E
external/local_xla/xla/stream_executor/cuda/cuda_fft.cc:607] Unable to register
cuFFT factory: Attempting to register factory for plugin cuFFT when one has
already been registered
2023-12-31 17:40:32.135164: E
external/local_xla/xla/stream_executor/cuda/cuda_blas.cc:1515] Unable to
register cuBLAS factory: Attempting to register factory for plugin cuBLAS when
one has already been registered
2023-12-31 17:40:32.386202: I tensorflow/core/platform/cpu_feature_guard.cc:182]
This TensorFlow binary is optimized to use available CPU instructions in
performance-critical operations.
To enable the following instructions: AVX2 FMA, in other operations, rebuild
TensorFlow with the appropriate compiler flags.
2023-12-31 17:40:34.680389: W
tensorflow/compiler/tf2tensorrt/utils/py_utils.cc:38] TF-TRT Warning: Could not
find TensorRT
Downloading https://ultralytics.com/assets/Arial.ttf to
/root/.config/Ultralytics/Arial.ttf…
100% 755k/755k [00:00<00:00, 17.9MB/s]
Downloading
https://github.com/ultralytics/yolov5/releases/download/v7.0/yolov5n.pt to
yolov5n.pt…
100% 3.87M/3.87M [00:00<00:00, 59.4MB/s]

Overriding model.yaml nc=80 with nc=4

```
                 from  n    params  module
arguments
  0               -1  1      1760  models.common.Conv                    [3,
16, 6, 2, 2]
  1               -1  1      4672  models.common.Conv                    [16,
32, 3, 2]
  2               -1  1      4800  models.common.C3                      [32,
32, 1]
  3               -1  1     18560  models.common.Conv                    [32,
64, 3, 2]
  4               -1  2     29184  models.common.C3                      [64,
64, 2]
  5               -1  1     73984  models.common.Conv                    [64,
128, 3, 2]
  6               -1  3    156928  models.common.C3
```

```
[128, 128, 3]
  7                 -1  1     295424  models.common.Conv
[128, 256, 3, 2]
  8                 -1  1     296448  models.common.C3
[256, 256, 1]
  9                 -1  1     164608  models.common.SPPF
[256, 256, 5]
 10                 -1  1      33024  models.common.Conv
[256, 128, 1, 1]
 11                 -1  1          0  torch.nn.modules.upsampling.Upsample
[None, 2, 'nearest']
 12            [-1, 6]  1          0  models.common.Concat                    [1]
 13                 -1  1      90880  models.common.C3
[256, 128, 1, False]
 14                 -1  1       8320  models.common.Conv
[128, 64, 1, 1]
 15                 -1  1          0  torch.nn.modules.upsampling.Upsample
[None, 2, 'nearest']
 16            [-1, 4]  1          0  models.common.Concat                    [1]
 17                 -1  1      22912  models.common.C3
[128, 64, 1, False]
 18                 -1  1      36992  models.common.Conv                      [64,
64, 3, 2]
 19           [-1, 14]  1          0  models.common.Concat                    [1]
 20                 -1  1      74496  models.common.C3
[128, 128, 1, False]
 21                 -1  1     147712  models.common.Conv
[128, 128, 3, 2]
 22           [-1, 10]  1          0  models.common.Concat                    [1]
 23                 -1  1     296448  models.common.C3
[256, 256, 1, False]
 24      [17, 20, 23]  1      12177  models.yolo.Detect                      [4,
[[10, 13, 16, 30, 33, 23], [30, 61, 62, 45, 59, 119], [116, 90, 156, 198, 373,
326]], [64, 128, 256]]
YOLOv5n summary: 214 layers, 1769329 parameters, 1769329 gradients, 4.2 GFLOPs

Transferred 342/349 items from yolov5n.pt
AMP: checks passed
optimizer: SGD(lr=0.01) with parameter groups 57 weight(decay=0.0),
60 weight(decay=0.0005), 60 bias
albumentations: Blur(p=0.01, blur_limit=(3, 7)), MedianBlur(p=0.01,
blur_limit=(3, 7)), ToGray(p=0.01), CLAHE(p=0.01, clip_limit=(1, 4.0),
tile_grid_size=(8, 8))
train: Scanning
/tmp/tmpm1vock2i/duckietown_object_detection_dataset/train/labels… 964 images,
43 backgrounds, 0 corrupt: 100% 964/964 [00:02<00:00, 396.97it/s]
train: New cache created:
/tmp/tmpm1vock2i/duckietown_object_detection_dataset/train/labels.cache
```

Scanning
/tmp/tmpm1vock2i/duckietown_object_detection_dataset/val/labels… 242 images, 5
backgrounds, 0 corrupt: 100% 242/242 [00:00<00:00, 357.13it/s]
New cache created:
/tmp/tmpm1vock2i/duckietown_object_detection_dataset/val/labels.cache

4.89 anchors/target, 0.994 Best Possible Recall (BPR).
Current anchors are a good fit to dataset
Plotting labels to runs/train/exp/labels.jpg…
Image sizes 416 train, 416 val
Using 2 dataloader workers
Logging results to **runs/train/exp**
Starting training for 10 epochs…

```
      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances       Size
        0/9      1.57G     0.1245    0.01648     0.0321         25       416:
100% 31/31 [00:20<00:00,  1.51it/s]
                 Class      Images  Instances          P          R      mAP50
mAP50-95: 100% 4/4 [00:05<00:00,  1.33s/it]
                   all        242        627     0.0013      0.301     0.0019
0.000445


      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances       Size
        1/9      1.94G    0.09396    0.01847    0.01341         18       416:
100% 31/31 [00:17<00:00,  1.81it/s]
                 Class      Images  Instances          P          R      mAP50
mAP50-95: 100% 4/4 [00:05<00:00,  1.31s/it]
                   all        242        627      0.856      0.118      0.108
0.0343


      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances       Size
        2/9      1.94G    0.08235    0.01709     0.0111          7       416:
100% 31/31 [00:15<00:00,  1.95it/s]
                 Class      Images  Instances          P          R      mAP50
mAP50-95: 100% 4/4 [00:02<00:00,  1.45it/s]
                   all        242        627      0.844      0.108      0.153
0.0363


      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances       Size
        3/9      1.94G    0.07206    0.01681   0.008152         12       416:
100% 31/31 [00:15<00:00,  2.01it/s]
                 Class      Images  Instances          P          R      mAP50
mAP50-95: 100% 4/4 [00:04<00:00,  1.15s/it]
                   all        242        627      0.358      0.621      0.431
0.166


      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances       Size
        4/9      1.94G    0.06605    0.01632    0.00699         13       416:
```

```
100% 31/31 [00:15<00:00,  2.00it/s]
                Class     Images  Instances          P          R      mAP50
mAP50-95: 100% 4/4 [00:03<00:00,  1.06it/s]
                  all        242        627      0.686      0.621      0.618
0.308

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances       Size
        5/9      1.94G    0.05746    0.01581   0.006323          4       416:
100% 31/31 [00:16<00:00,  1.93it/s]
                Class     Images  Instances          P          R      mAP50
mAP50-95: 100% 4/4 [00:02<00:00,  1.42it/s]
                  all        242        627      0.559      0.553      0.627
0.234

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances       Size
        6/9      1.94G    0.05156    0.01478   0.004606         16       416:
100% 31/31 [00:16<00:00,  1.92it/s]
                Class     Images  Instances          P          R      mAP50
mAP50-95: 100% 4/4 [00:02<00:00,  1.51it/s]
                  all        242        627      0.518      0.627      0.609
0.288

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances       Size
        7/9      1.94G     0.0467    0.01409   0.004122         18       416:
100% 31/31 [00:16<00:00,  1.93it/s]
                Class     Images  Instances          P          R      mAP50
mAP50-95: 100% 4/4 [00:02<00:00,  1.51it/s]
                  all        242        627       0.77      0.665      0.748
0.387

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances       Size
        8/9      1.94G    0.04248    0.01339   0.003558          7       416:
100% 31/31 [00:15<00:00,  1.94it/s]
                Class     Images  Instances          P          R      mAP50
mAP50-95: 100% 4/4 [00:03<00:00,  1.13it/s]
                  all        242        627      0.872      0.671      0.802
0.46

      Epoch    GPU_mem   box_loss   obj_loss   cls_loss  Instances       Size
        9/9      1.94G    0.03865    0.01267   0.002999          9       416:
100% 31/31 [00:15<00:00,  1.97it/s]
                Class     Images  Instances          P          R      mAP50
mAP50-95: 100% 4/4 [00:04<00:00,  1.10s/it]
                  all        242        627      0.761      0.852      0.833
0.492

10 epochs completed in 0.057 hours.
Optimizer stripped from runs/train/exp/weights/last.pt, 3.8MB
```

```
Optimizer stripped from runs/train/exp/weights/best.pt, 3.8MB

Validating runs/train/exp/weights/best.pt…
Fusing layers…
YOLOv5n summary: 157 layers, 1764577 parameters, 0 gradients, 4.1 GFLOPs
                Class     Images  Instances          P          R      mAP50
mAP50-95: 100% 4/4 [00:05<00:00,  1.43s/it]
                  all        242        627      0.748      0.836      0.832
0.491
               duckie        242        494      0.783      0.849      0.857
0.495
                 cone        242        103      0.817       0.66      0.722
0.36
                truck        242         12      0.634      0.833      0.836
0.613
                  bus        242         18      0.759          1      0.914
0.494
Results saved to runs/train/exp
```

```python
import numpy as np

all_exps = os.listdir("yolov5/runs/train")
all_exps_filtered = map(lambda x: int(x.replace("exp", "1")), filter(lambda x:
 ↪x.startswith("exp"), all_exps))
all_exps_filtered = np.array(list(all_exps))
latest_exp_index = np.argmax(all_exps)
latest_exp = all_exps[latest_exp_index]
print(f"Latest exp is {latest_exp}")

prun(f"cp yolov5/runs/train/{latest_exp}/weights/best.pt yolov5/best.pt")
print(f"Marked the model from the latest run ({latest_exp}) as yolov5/best.pt.")
```

```
Latest exp is exp
None
Marked the model from the latest run (exp) as yolov5/best.pt.
```

6 Next, we can upload your model to Duckietown's cloud!

We will need our token to access our personal cloud space.

```python
# TODO: Fill in the duckietown token here
YOUR_DT_TOKEN =
 ↪"dt1-3nT7FDbT7NLPrXykNJW6pwvofokYQzZeC8eNrAXJqeVCqtQ-43dzqWFnWd8KBa1yev1g3UKnzVxZkkTbfg7g62
```

Then, we chose the location of the trained model on disk and its name once uploaded to our cloud
space. You should not change these values, or the robots will not be able to find the model to
download.

```python
import sys
sys.path.insert(0, './yolov5')

# DO NOT CHANGE THESE
model_name = "yolov5n"
model_local_path = "./yolov5/best.pt"
model_remote_path = f"courses/mooc/objdet/data/nn_models/{model_name}.pt"

# install DCSS client
!pip3 install dt-data-api-daffy
```

```
Collecting dt-data-api-daffy
  Downloading dt-data-api-daffy-1.2.0.tar.gz (12 kB)
  Preparing metadata (setup.py) … done
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-
packages (from dt-data-api-daffy) (2.31.0)
Requirement already satisfied: beautifulsoup4 in /usr/local/lib/python3.10/dist-
packages (from dt-data-api-daffy) (4.11.2)
Requirement already satisfied: lxml in /usr/local/lib/python3.10/dist-packages
(from dt-data-api-daffy) (4.9.3)
Collecting dt-authentication-daffy (from dt-data-api-daffy)
  Downloading dt-authentication-daffy-0.1.16.tar.gz (3.3 kB)
  Preparing metadata (setup.py) … done
Requirement already satisfied: soupsieve>1.2 in /usr/local/lib/python3.10/dist-
packages (from beautifulsoup4->dt-data-api-daffy) (2.5)
Collecting base58 (from dt-authentication-daffy->dt-data-api-daffy)
  Downloading base58-2.1.1-py3-none-any.whl (5.6 kB)
Collecting ecdsa (from dt-authentication-daffy->dt-data-api-daffy)
  Downloading ecdsa-0.18.0-py2.py3-none-any.whl (142 kB)
                             142.9/142.9

kB 1.6 MB/s eta 0:00:00
Requirement already satisfied: charset-normalizer<4,>=2 in
/usr/local/lib/python3.10/dist-packages (from requests->dt-data-api-daffy)
(3.3.2)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-
packages (from requests->dt-data-api-daffy) (3.6)
Requirement already satisfied: urllib3<3,>=1.21.1 in
/usr/local/lib/python3.10/dist-packages (from requests->dt-data-api-daffy)
(2.0.7)
Requirement already satisfied: certifi>=2017.4.17 in
/usr/local/lib/python3.10/dist-packages (from requests->dt-data-api-daffy)
(2023.11.17)
Requirement already satisfied: six>=1.9.0 in /usr/local/lib/python3.10/dist-
packages (from ecdsa->dt-authentication-daffy->dt-data-api-daffy) (1.16.0)
Building wheels for collected packages: dt-data-api-daffy, dt-authentication-
daffy
  Building wheel for dt-data-api-daffy (setup.py) … done
```

```
   Created wheel for dt-data-api-daffy:
filename=dt_data_api_daffy-1.2.0-py3-none-any.whl size=14284
sha256=b890db9a7085181501a989f027d141852c2d262226137500402f5190a814acd8
   Stored in directory: /root/.cache/pip/wheels/74/53/2a/80f68075691d924b254fc10c
2fd5de630705daadab01c961b4
   Building wheel for dt-authentication-daffy (setup.py) … done
   Created wheel for dt-authentication-daffy:
filename=dt_authentication_daffy-0.1.16-py3-none-any.whl size=3140
sha256=78f6b016867689eb36e98da412858bd438584c0404cc3e55602f9cb86dd319e2
   Stored in directory: /root/.cache/pip/wheels/a1/02/64/f1edbb576157ed7ec13aa57e
824ce80df9ab24080f3a0d8e37
Successfully built dt-data-api-daffy dt-authentication-daffy
Installing collected packages: ecdsa, base58, dt-authentication-daffy, dt-data-
api-daffy
Successfully installed base58-2.1.1 dt-authentication-daffy-0.1.16 dt-data-api-
daffy-1.2.0 ecdsa-0.18.0
```

We now open a pointer to our cloud space and upload the model.

```python
import torch
from dt_data_api import DataClient, Storage

# open a pointer to our personal duckietown cloud space
client = DataClient(YOUR_DT_TOKEN)
storage = client.storage("user")

# upload model
upload = storage.upload(model_local_path, model_remote_path)
upload.join()
```

7   Done!

We're done training! You can now close this tab and go back to the Training notebook