Курс «Глубокое обучение в компьютерном зрении»

Урок 5. Детектирование объектов

Практическое задание 5

Обучить детектор объектов с помощью TensorFlow Object Detection API Библиотеки: [Python, Tensorflow]

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Sea Turtles Dataset

Ссылка на датасет: https://github.com/danielc92/oidv4-sea-turtles (https://github.com/danielc92/oidv4-sea-turtles)

Keras RetinaNet – Sea Turtle, Training & Detection

B [1]:
```
!git clone https://github.com/danielc92/oidv4-sea-turtles.git
```

```
Cloning into 'oidv4-sea-turtles'...
remote: Enumerating objects: 2668, done.
remote: Total 2668 (delta 0), reused 0 (delta 0), pack-reused 2668
Receiving objects: 100% (2668/2668), 276.85 MiB | 27.96 MiB/s, done.
Resolving deltas: 100% (881/881), done.
Checking out files: 100% (2655/2655), done.
```

Preparing RetinaNet Environment

В [2]:
```
# Upload данных
if 1:
    # Клонируем рипозиторий
    !git clone https://github.com/fizyr/keras-retinanet.git

%cd keras-retinanet/

!pip install .

!python setup.py build_ext --inplace
```

```
Cloning into 'keras-retinanet'...
remote: Enumerating objects: 6220, done.
remote: Counting objects: 100% (15/15), done.
remote: Compressing objects: 100% (13/13), done.
remote: Total 6220 (delta 5), reused 6 (delta 2), pack-reused 6205
Receiving objects: 100% (6220/6220), 13.48 MiB | 26.00 MiB/s, done.
Resolving deltas: 100% (4205/4205), done.
/content/keras-retinanet
Looking in indexes: https://pypi.org/simple, (https://pypi.org/simple,) https://us-python.pkg.dev/colab-wheels/public/simple/ (https://us-python.pkg.dev/colab-wheels/public/simple/)
Processing /content/keras-retinanet
  DEPRECATION: A future pip version will change local packages to be built in-place without first copying to a temporary directory. We recommend you use --use-feature=in-tree-build to test your packages with this new behavior before it becomes the default.
   pip 21.3 will remove support for this functionality. You can find discussion regarding this at https://github.com/pypa/pip/issues/7555. (https://github.com/pypa/pip/issues/7555.)
Collecting keras-resnet==0.2.0
  Downloading keras-resnet-0.2.0.tar.gz (9.3 kB)
Requirement already satisfied: six in /usr/local/lib/python3.7/dist-packages (from keras-retinanet==1.0.0) (1.15.0)
Requirement already satisfied: numpy in /usr/local/lib/python3.7/dist-packages (from keras-retinanet==1.0.0) (1.21.6)
Requirement already satisfied: cython in /usr/local/lib/python3.7/dist-packages (from keras-retinanet==1.0.0) (0.29.32)
Requirement already satisfied: Pillow in /usr/local/lib/python3.7/dist-packages (from keras-retinanet==1.0.0) (7.1.2)
Requirement already satisfied: opencv-python in /usr/local/lib/python3.7/dist-packages (from keras-retinanet==1.0.0) (4.6.0.66)
Requirement already satisfied: progressbar2 in /usr/local/lib/python3.7/dist-packages (from keras-retinanet==1.0.0) (3.38.0)
Requirement already satisfied: keras>=2.2.4 in /usr/local/lib/python3.7/dist-packages (from keras-resnet==0.2.0->keras-retinanet==1.0.0) (2.8.0)
Requirement already satisfied: python-utils>=2.3.0 in /usr/local/lib/python3.7/dist-packages (from progressbar2->keras-retinanet==1.0.0) (3.3.3)
Building wheels for collected packages: keras-retinanet, keras-resnet
  Building wheel for keras-retinanet (setup.py) ... done
  Created wheel for keras-retinanet: filename=keras_retinanet-1.0.0-cp37-cp37m-linux_x86_64.whl size=169549 sha256=e1006730289b0f08b2afc5b9b7ed14511dd2ff6287746e3c5096404e4b154c55
  Stored in directory: /root/.cache/pip/wheels/32/29/34/9b33c07f08b1be9e77607c1fc6b08c679489aa7ddaed329652
  Building wheel for keras-resnet (setup.py) ... done
  Created wheel for keras-resnet: filename=keras_resnet-0.2.0-py2.py3-none-any.whl size=20486 sha256=83bc69bf0500cff6ba3ed900b30ad358d99e2711a7a98e8743ab921ea955ec0c
  Stored in directory: /root/.cache/pip/wheels/bd/ef/06/5d65f696360436c3a423020c4b7fd8c558c09ef264a0e6c575
Successfully built keras-retinanet keras-resnet
Installing collected packages: keras-resnet, keras-retinanet
Successfully installed keras-resnet-0.2.0 keras-retinanet-1.0.0
running build_ext
cythoning keras_retinanet/utils/compute_overlap.pyx to keras_retinanet/utils/compute_overlap.c
/usr/local/lib/python3.7/dist-packages/Cython/Compiler/Main.py:369: FutureWarning: Cython directive 'language_level' not set, using 2 for now (Py2). This will change in a later release! File: /content/keras-retinanet/keras_retinanet/utils/compute_overlap.pyx
  tree = Parsing.p_module(s, pxd, full_module_name)
building 'keras_retinanet.utils.compute_overlap' extension
creating build
creating build/temp.linux-x86_64-3.7
creating build/temp.linux-x86_64-3.7/keras_retinanet
creating build/temp.linux-x86_64-3.7/keras_retinanet/utils
x86_64-linux-gnu-gcc -pthread -Wno-unused-result -Wsign-compare -DNDEBUG -g -fwrapv -O2 -Wall -g -fstack-protector-strong -Wformat -Werror=format-security -g -fwrapv -O2 -g -fstack-protector-strong -Wformat -Werror=format-security -Wdate-time -D_FORTIFY_SOURCE=2 -fPIC -I/usr/include/python3.7m -I/usr/local/lib/python3.7/dist-packages/numpy/core/include -c keras_retinanet/utils/compute_overlap.c -o build/temp.linux-x86_64-3.7/keras_retinanet/utils/compute_overlap.o
In file included from /usr/local/lib/python3.7/dist-packages/numpy/core/include/numpy/ndarraytypes.h:1969:0,
                 from /usr/local/lib/python3.7/dist-packages/numpy/core/include/numpy/ndarrayobject.h:12,
                 from /usr/local/lib/python3.7/dist-packages/numpy/core/include/numpy/arrayobject.h:4,
                 from keras_retinanet/utils/compute_overlap.c:746:
/usr/local/lib/python3.7/dist-packages/numpy/core/include/numpy/npy_1_7_deprecated_api.h:17:2: warning: #warning "Using deprecated NumPy API, disable it with " "#define NPY_NO_DEPRECATED_API NPY_1_7_API_VERSION" [-Wcpp]
 #warning "Using deprecated NumPy API, disable it with " \
  ^~~~~~~
creating build/lib.linux-x86_64-3.7
creating build/lib.linux-x86_64-3.7/keras_retinanet
creating build/lib.linux-x86_64-3.7/keras_retinanet/utils
x86_64-linux-gnu-gcc -pthread -shared -Wl,-O1 -Wl,-Bsymbolic-functions -Wl,-Bsymbolic-functions -g -fwrapv -O2 -Wl,-Bsymbolic-functions -g -fwrapv -O2 -g -fstack-protector-strong -Wformat -Werror=format-security -Wdate-time -D_FORTIFY_SOURCE=2 build/temp.linux-x86_64-3.7/keras_retinanet/utils/compute_overlap.o -o build/lib.linux-x86_64-3.7/keras_retinanet/utils/compute_overlap.cpython-37m-x86_64-linux-gnu.so
copying build/lib.linux-x86_64-3.7/keras_retinanet/utils/compute_overlap.cpython-37m-x86_64-linux-gnu.so -> keras_retinanet/utils
```

Generating annotations/classes file

B [3]:
```
import os
import shutil
import urllib
import xml.etree.ElementTree as ET
import numpy as np
import csv
import pandas

DATASET_DIR = '/content/oidv4-sea-turtles/TRAIN/'
ANNOTATIONS_FILE = 'annotations.csv'
CLASSES_FILE = 'classes.csv'

annotations = []
classes = set([])

for xml_file in [f for f in os.listdir(DATASET_DIR) if f.endswith(".xml")]:
  tree = ET.parse(os.path.join(DATASET_DIR, xml_file))
  root = tree.getroot()

file_name = None

for elem in root:
  if elem.tag == 'filename':
    file_name = os.path.join(DATASET_DIR, elem.text)

if elem.tag == 'object':
  obj_name = None

coords = []
for subelem in elem:
  if subelem.tag == 'name':
    obj_name = subelem.text

  if subelem.tag == 'bndbox':
    for subsubelem in subelem:
      coords.append(subsubelem.text)

item = [file_name] + coords + [obj_name]
annotations.append(item)
classes.add(obj_name)

with open(ANNOTATIONS_FILE, 'w') as f:
  writer = csv.writer(f)
  writer.writerows(annotations)

with open(CLASSES_FILE, 'w') as f:
  for i, line in enumerate(classes):
    f.write('{},{}\n'.format(line,i))
```

Training the model

B [4]:
```
# Скачиваем веса предобученной модели
!wget "https://github.com/fizyr/keras-retinanet/releases/download/0.5.1/resnet50_coco_best_v2.1.0.h5"
```

```
--2022-08-05 13:35:59--  https://github.com/fizyr/keras-retinanet/releases/download/0.5.1/resnet50_coco_best_v2.1.0.h5
 (https://github.com/fizyr/keras-retinanet/releases/download/0.5.1/resnet50_coco_best_v2.1.0.h5)
Resolving github.com (github.com)... 192.30.255.113
Connecting to github.com (github.com)|192.30.255.113|:443... connected.
HTTP request sent, awaiting response... 302 Found
Location: https://objects.githubusercontent.com/github-production-release-asset-2e65be/100249425/b7184a80-9350-11e9-9cc
2-454f5c616394?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWNJYAX4CSVEH53A%2F20220805%2Fus-east-1%2Fs3%2Faws
4_request&X-Amz-Date=20220805T133559Z&X-Amz-Expires=300&X-Amz-Signature=2f55bf4bef45b0deb1138e5e0d93e688d4cec331d03acd1
99a3bcf804efc975e&X-Amz-SignedHeaders=host&actor_id=0&key_id=0&repo_id=100249425&response-content-disposition=attachmen
t%3B%20filename%3Dresnet50_coco_best_v2.1.0.h5&response-content-type=application%2Foctet-stream (https://objects.github
usercontent.com/github-production-release-asset-2e65be/100249425/b7184a80-9350-11e9-9cc2-454f5c616394?X-Amz-Algorithm=A
WS4-HMAC-SHA256&X-Amz-Credential=AKIAIWNJYAX4CSVEH53A%2F20220805%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20220805T13
3559Z&X-Amz-Expires=300&X-Amz-Signature=2f55bf4bef45b0deb1138e5e0d93e688d4cec331d03acd199a3bcf804efc975e&X-Amz-SignedHe
aders=host&actor_id=0&key_id=0&repo_id=100249425&response-content-disposition=attachment%3B%20filename%3Dresnet50_coco_
best_v2.1.0.h5&response-content-type=application%2Foctet-stream) [following]
--2022-08-05 13:35:59--  https://objects.githubusercontent.com/github-production-release-asset-2e65be/100249425/b7184a8
0-9350-11e9-9cc2-454f5c616394?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWNJYAX4CSVEH53A%2F20220805%2Fus-ea
st-1%2Fs3%2Faws4_request&X-Amz-Date=20220805T133559Z&X-Amz-Expires=300&X-Amz-Signature=2f55bf4bef45b0deb1138e5e0d93e688
d4cec331d03acd199a3bcf804efc975e&X-Amz-SignedHeaders=host&actor_id=0&key_id=0&repo_id=100249425&response-content-dispos
ition=attachment%3B%20filename%3Dresnet50_coco_best_v2.1.0.h5&response-content-type=application%2Foctet-stream (http
s://objects.githubusercontent.com/github-production-release-asset-2e65be/100249425/b7184a80-9350-11e9-9cc2-454f5c61639
4?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWNJYAX4CSVEH53A%2F20220805%2Fus-east-1%2Fs3%2Faws4_request&X-A
mz-Date=20220805T133559Z&X-Amz-Expires=300&X-Amz-Signature=2f55bf4bef45b0deb1138e5e0d93e688d4cec331d03acd199a3bcf804efc
975e&X-Amz-SignedHeaders=host&actor_id=0&key_id=0&repo_id=100249425&response-content-disposition=attachment%3B%20filena
me%3Dresnet50_coco_best_v2.1.0.h5&response-content-type=application%2Foctet-stream)
Resolving objects.githubusercontent.com (objects.githubusercontent.com)... 185.199.111.133, 185.199.110.133, 185.199.10
8.133, ...
Connecting to objects.githubusercontent.com (objects.githubusercontent.com)|185.199.111.133|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 152662144 (146M) [application/octet-stream]
Saving to: ‘resnet50_coco_best_v2.1.0.h5’

resnet50_coco_best_ 100%[===================>] 145.59M  33.2MB/s    in 5.1s

2022-08-05 13:36:05 (28.3 MB/s) - ‘resnet50_coco_best_v2.1.0.h5’ saved [152662144/152662144]
```

B [34]:
```
!pwd
!ls
```

```
/content/keras-retinanet
annotations.csv  examples         README.md                    setup.cfg
build            images           requirements.txt             setup.py
classes.csv      keras_retinanet  resnet50_coco_best_v2.1.0.h5  snapshots
CONTRIBUTORS.md  LICENSE          resnet50_csv_01.h5           tests
```

B [40]:
```
!ls '/content/keras-retinanet/snapshots'
```

```
_pretrained_model.h5  resnet50_csv_01.h5
```

B [52]:
```
import urllib.request

PRETRAINED_MODEL = '_pretrained_model.h5'
# PRETRAINED_MODEL = 'resnet50_csv_01.h5'

URL_MODEL = 'https://github.com/fizyr/keras-retinanet/releases/download/0.5.1/resnet50_coco_best_v2.1.0.h5'

urllib.request.urlretrieve(URL_MODEL, PRETRAINED_MODEL)

!keras_retinanet/bin/train.py \
  --freeze-backbone \
  --random-transform \
  --weights {PRETRAINED_MODEL} \
  --batch-size 8 \
  --steps 1000 \
  --epochs 30 \
   csv annotations.csv classes.csv

# !python keras_retinanet/bin/train.py \
#     --random-transform \
#     --weights {PRETRAINED_MODEL} \
#     --steps 100 \
#     --epochs 20 \
#     csv annotations.csv classes.csv
```

```
Creating model, this may take a second...
2022-08-05 14:34:22.581940: E tensorflow/stream_executor/cuda/cuda_driver.cc:271] failed call to cuInit: CUDA_ERROR_NO_
DEVICE: no CUDA-capable device is detected
WARNING:tensorflow:Skipping loading weights for layer #212 (named classification_submodel) due to mismatch in shape for
weight pyramid_classification/kernel:0. Weight expects shape (3, 3, 256, 9). Received saved weight with shape (720, 25
6, 3, 3)
WARNING:tensorflow:Skipping loading weights for layer #212 (named classification_submodel) due to mismatch in shape for
weight pyramid_classification/bias:0. Weight expects shape (9,). Received saved weight with shape (720,)
/usr/local/lib/python3.7/dist-packages/keras/optimizer_v2/adam.py:105: UserWarning: The `lr` argument is deprecated, us
e `learning_rate` instead.
  super(Adam, self).__init__(name, **kwargs)
Model: "retinanet"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_1 (InputLayer)           [(None, None, None,  0           []
                                 3)]

 conv1 (Conv2D)                 (None, None, None,   9408        ['input_1[0][0]']
                                64)

 bn_conv1 (BatchNormalization)  (None, None, None,   256         ['conv1[0][0]']
                                64)

 conv1_relu (Activation)        (None, None, None,   0           ['bn_conv1[0][0]']
                                64)

 pool1 (MaxPooling2D)           (None, None, None,   0           ['conv1_relu[0][0]']
                                64)

 res2a_branch2a (Conv2D)        (None, None, None,   4096        ['pool1[0][0]']
                                64)

 bn2a_branch2a (BatchNormalizat  (None, None, None,   256        ['res2a_branch2a[0][0]']
 ion)                           64)

 res2a_branch2a_relu (Activatio  (None, None, None,   0          ['bn2a_branch2a[0][0]']
 n)                             64)

 padding2a_branch2b (ZeroPaddin  (None, None, None,   0          ['res2a_branch2a_relu[0][0]']
 g2D)                           64)

 res2a_branch2b (Conv2D)        (None, None, None,   36864       ['padding2a_branch2b[0][0]']
                                64)

 bn2a_branch2b (BatchNormalizat  (None, None, None,   256        ['res2a_branch2b[0][0]']
 ion)                           64)

 res2a_branch2b_relu (Activatio  (None, None, None,   0          ['bn2a_branch2b[0][0]']
 n)                             64)

 res2a_branch2c (Conv2D)        (None, None, None,   16384       ['res2a_branch2b_relu[0][0]']
                                256)

 res2a_branch1 (Conv2D)         (None, None, None,   16384       ['pool1[0][0]']
                                256)

 bn2a_branch2c (BatchNormalizat  (None, None, None,   1024       ['res2a_branch2c[0][0]']
 ion)                           256)

 bn2a_branch1 (BatchNormalizati  (None, None, None,   1024       ['res2a_branch1[0][0]']
 on)                            256)
```

```
res2a (Add)                    (None, None, None,   0          ['bn2a_branch2c[0][0]',
                               256)                             'bn2a_branch1[0][0]']

res2a_relu (Activation)        (None, None, None,   0          ['res2a[0][0]']
                               256)

res2b_branch2a (Conv2D)        (None, None, None,   16384      ['res2a_relu[0][0]']
                               64)

bn2b_branch2a (BatchNormalizat  (None, None, None,   256       ['res2b_branch2a[0][0]']
ion)                           64)

res2b_branch2a_relu (Activatio  (None, None, None,   0         ['bn2b_branch2a[0][0]']
n)                             64)

padding2b_branch2b (ZeroPaddin  (None, None, None,   0         ['res2b_branch2a_relu[0][0]']
g2D)                           64)

res2b_branch2b (Conv2D)        (None, None, None,   36864      ['padding2b_branch2b[0][0]']
                               64)

bn2b_branch2b (BatchNormalizat  (None, None, None,   256       ['res2b_branch2b[0][0]']
ion)                           64)

res2b_branch2b_relu (Activatio  (None, None, None,   0         ['bn2b_branch2b[0][0]']
n)                             64)

res2b_branch2c (Conv2D)        (None, None, None,   16384      ['res2b_branch2b_relu[0][0]']
                               256)

bn2b_branch2c (BatchNormalizat  (None, None, None,   1024      ['res2b_branch2c[0][0]']
ion)                           256)

res2b (Add)                    (None, None, None,   0          ['bn2b_branch2c[0][0]',
                               256)                             'res2a_relu[0][0]']

res2b_relu (Activation)        (None, None, None,   0          ['res2b[0][0]']
                               256)

res2c_branch2a (Conv2D)        (None, None, None,   16384      ['res2b_relu[0][0]']
                               64)

bn2c_branch2a (BatchNormalizat  (None, None, None,   256       ['res2c_branch2a[0][0]']
ion)                           64)

res2c_branch2a_relu (Activatio  (None, None, None,   0         ['bn2c_branch2a[0][0]']
n)                             64)

padding2c_branch2b (ZeroPaddin  (None, None, None,   0         ['res2c_branch2a_relu[0][0]']
g2D)                           64)

res2c_branch2b (Conv2D)        (None, None, None,   36864      ['padding2c_branch2b[0][0]']
                               64)

bn2c_branch2b (BatchNormalizat  (None, None, None,   256       ['res2c_branch2b[0][0]']
ion)                           64)

res2c_branch2b_relu (Activatio  (None, None, None,   0         ['bn2c_branch2b[0][0]']
n)                             64)

res2c_branch2c (Conv2D)        (None, None, None,   16384      ['res2c_branch2b_relu[0][0]']
                               256)

bn2c_branch2c (BatchNormalizat  (None, None, None,   1024      ['res2c_branch2c[0][0]']
ion)                           256)

res2c (Add)                    (None, None, None,   0          ['bn2c_branch2c[0][0]',
                               256)                             'res2b_relu[0][0]']

res2c_relu (Activation)        (None, None, None,   0          ['res2c[0][0]']
                               256)

res3a_branch2a (Conv2D)        (None, None, None,   32768      ['res2c_relu[0][0]']
                               128)

bn3a_branch2a (BatchNormalizat  (None, None, None,   512       ['res3a_branch2a[0][0]']
ion)                           128)

res3a_branch2a_relu (Activatio  (None, None, None,   0         ['bn3a_branch2a[0][0]']
n)                             128)

padding3a_branch2b (ZeroPaddin  (None, None, None,   0         ['res3a_branch2a_relu[0][0]']
g2D)                           128)

res3a_branch2b (Conv2D)        (None, None, None,   147456     ['padding3a_branch2b[0][0]']
                               128)

bn3a_branch2b (BatchNormalizat  (None, None, None,   512       ['res3a_branch2b[0][0]']
```

```
ion)                           128)

res3a_branch2b_relu (Activatio  (None, None, None,   0          ['bn3a_branch2b[0][0]']
n)                             128)

res3a_branch2c (Conv2D)        (None, None, None,   65536      ['res3a_branch2b_relu[0][0]']
                               512)

res3a_branch1 (Conv2D)         (None, None, None,   131072     ['res2c_relu[0][0]']
                               512)

bn3a_branch2c (BatchNormalizat  (None, None, None,   2048       ['res3a_branch2c[0][0]']
ion)                           512)

bn3a_branch1 (BatchNormalizati  (None, None, None,   2048       ['res3a_branch1[0][0]']
on)                            512)

res3a (Add)                    (None, None, None,   0          ['bn3a_branch2c[0][0]',
                               512)                             'bn3a_branch1[0][0]']

res3a_relu (Activation)        (None, None, None,   0          ['res3a[0][0]']
                               512)

res3b_branch2a (Conv2D)        (None, None, None,   65536      ['res3a_relu[0][0]']
                               128)

bn3b_branch2a (BatchNormalizat  (None, None, None,   512        ['res3b_branch2a[0][0]']
ion)                           128)

res3b_branch2a_relu (Activatio  (None, None, None,   0          ['bn3b_branch2a[0][0]']
n)                             128)

padding3b_branch2b (ZeroPaddin  (None, None, None,   0          ['res3b_branch2a_relu[0][0]']
g2D)                           128)

res3b_branch2b (Conv2D)        (None, None, None,   147456     ['padding3b_branch2b[0][0]']
                               128)

bn3b_branch2b (BatchNormalizat  (None, None, None,   512        ['res3b_branch2b[0][0]']
ion)                           128)

res3b_branch2b_relu (Activatio  (None, None, None,   0          ['bn3b_branch2b[0][0]']
n)                             128)

res3b_branch2c (Conv2D)        (None, None, None,   65536      ['res3b_branch2b_relu[0][0]']
                               512)

bn3b_branch2c (BatchNormalizat  (None, None, None,   2048       ['res3b_branch2c[0][0]']
ion)                           512)

res3b (Add)                    (None, None, None,   0          ['bn3b_branch2c[0][0]',
                               512)                             'res3a_relu[0][0]']

res3b_relu (Activation)        (None, None, None,   0          ['res3b[0][0]']
                               512)

res3c_branch2a (Conv2D)        (None, None, None,   65536      ['res3b_relu[0][0]']
                               128)

bn3c_branch2a (BatchNormalizat  (None, None, None,   512        ['res3c_branch2a[0][0]']
ion)                           128)

res3c_branch2a_relu (Activatio  (None, None, None,   0          ['bn3c_branch2a[0][0]']
n)                             128)

padding3c_branch2b (ZeroPaddin  (None, None, None,   0          ['res3c_branch2a_relu[0][0]']
g2D)                           128)

res3c_branch2b (Conv2D)        (None, None, None,   147456     ['padding3c_branch2b[0][0]']
                               128)

bn3c_branch2b (BatchNormalizat  (None, None, None,   512        ['res3c_branch2b[0][0]']
ion)                           128)

res3c_branch2b_relu (Activatio  (None, None, None,   0          ['bn3c_branch2b[0][0]']
n)                             128)

res3c_branch2c (Conv2D)        (None, None, None,   65536      ['res3c_branch2b_relu[0][0]']
                               512)

bn3c_branch2c (BatchNormalizat  (None, None, None,   2048       ['res3c_branch2c[0][0]']
ion)                           512)

res3c (Add)                    (None, None, None,   0          ['bn3c_branch2c[0][0]',
                               512)                             'res3b_relu[0][0]']

res3c_relu (Activation)        (None, None, None,   0          ['res3c[0][0]']
                               512)
```

```
res3d_branch2a (Conv2D)        (None, None, None,   65536       ['res3c_relu[0][0]']
                               128)

bn3d_branch2a (BatchNormalizat  (None, None, None,   512        ['res3d_branch2a[0][0]']
ion)                           128)

res3d_branch2a_relu (Activatio  (None, None, None,   0          ['bn3d_branch2a[0][0]']
n)                             128)

padding3d_branch2b (ZeroPaddin  (None, None, None,   0          ['res3d_branch2a_relu[0][0]']
g2D)                           128)

res3d_branch2b (Conv2D)        (None, None, None,   147456      ['padding3d_branch2b[0][0]']
                               128)

bn3d_branch2b (BatchNormalizat  (None, None, None,   512        ['res3d_branch2b[0][0]']
ion)                           128)

res3d_branch2b_relu (Activatio  (None, None, None,   0          ['bn3d_branch2b[0][0]']
n)                             128)

res3d_branch2c (Conv2D)        (None, None, None,   65536       ['res3d_branch2b_relu[0][0]']
                               512)

bn3d_branch2c (BatchNormalizat  (None, None, None,   2048       ['res3d_branch2c[0][0]']
ion)                           512)

res3d (Add)                    (None, None, None,   0           ['bn3d_branch2c[0][0]',
                               512)                              'res3c_relu[0][0]']

res3d_relu (Activation)        (None, None, None,   0           ['res3d[0][0]']
                               512)

res4a_branch2a (Conv2D)        (None, None, None,   131072      ['res3d_relu[0][0]']
                               256)

bn4a_branch2a (BatchNormalizat  (None, None, None,   1024       ['res4a_branch2a[0][0]']
ion)                           256)

res4a_branch2a_relu (Activatio  (None, None, None,   0          ['bn4a_branch2a[0][0]']
n)                             256)

padding4a_branch2b (ZeroPaddin  (None, None, None,   0          ['res4a_branch2a_relu[0][0]']
g2D)                           256)

res4a_branch2b (Conv2D)        (None, None, None,   589824      ['padding4a_branch2b[0][0]']
                               256)

bn4a_branch2b (BatchNormalizat  (None, None, None,   1024       ['res4a_branch2b[0][0]']
ion)                           256)

res4a_branch2b_relu (Activatio  (None, None, None,   0          ['bn4a_branch2b[0][0]']
n)                             256)

res4a_branch2c (Conv2D)        (None, None, None,   262144      ['res4a_branch2b_relu[0][0]']
                               1024)

res4a_branch1 (Conv2D)         (None, None, None,   524288      ['res3d_relu[0][0]']
                               1024)

bn4a_branch2c (BatchNormalizat  (None, None, None,   4096       ['res4a_branch2c[0][0]']
ion)                           1024)

bn4a_branch1 (BatchNormalizati  (None, None, None,   4096       ['res4a_branch1[0][0]']
on)                            1024)

res4a (Add)                    (None, None, None,   0           ['bn4a_branch2c[0][0]',
                               1024)                             'bn4a_branch1[0][0]']

res4a_relu (Activation)        (None, None, None,   0           ['res4a[0][0]']
                               1024)

res4b_branch2a (Conv2D)        (None, None, None,   262144      ['res4a_relu[0][0]']
                               256)

bn4b_branch2a (BatchNormalizat  (None, None, None,   1024       ['res4b_branch2a[0][0]']
ion)                           256)

res4b_branch2a_relu (Activatio  (None, None, None,   0          ['bn4b_branch2a[0][0]']
n)                             256)

padding4b_branch2b (ZeroPaddin  (None, None, None,   0          ['res4b_branch2a_relu[0][0]']
g2D)                           256)

res4b_branch2b (Conv2D)        (None, None, None,   589824      ['padding4b_branch2b[0][0]']
                               256)
```

```
bn4b_branch2b (BatchNormalizat  (None, None, None,   1024       ['res4b_branch2b[0][0]']
ion)                            256)

res4b_branch2b_relu (Activatio  (None, None, None,   0          ['bn4b_branch2b[0][0]']
n)                              256)

res4b_branch2c (Conv2D)         (None, None, None,   262144     ['res4b_branch2b_relu[0][0]']
                                1024)

bn4b_branch2c (BatchNormalizat  (None, None, None,   4096       ['res4b_branch2c[0][0]']
ion)                            1024)

res4b (Add)                     (None, None, None,   0          ['bn4b_branch2c[0][0]',
                                1024)                            'res4a_relu[0][0]']

res4b_relu (Activation)         (None, None, None,   0          ['res4b[0][0]']
                                1024)

res4c_branch2a (Conv2D)         (None, None, None,   262144     ['res4b_relu[0][0]']
                                256)

bn4c_branch2a (BatchNormalizat  (None, None, None,   1024       ['res4c_branch2a[0][0]']
ion)                            256)

res4c_branch2a_relu (Activatio  (None, None, None,   0          ['bn4c_branch2a[0][0]']
n)                              256)

padding4c_branch2b (ZeroPaddin  (None, None, None,   0          ['res4c_branch2a_relu[0][0]']
g2D)                            256)

res4c_branch2b (Conv2D)         (None, None, None,   589824     ['padding4c_branch2b[0][0]']
                                256)

bn4c_branch2b (BatchNormalizat  (None, None, None,   1024       ['res4c_branch2b[0][0]']
ion)                            256)

res4c_branch2b_relu (Activatio  (None, None, None,   0          ['bn4c_branch2b[0][0]']
n)                              256)

res4c_branch2c (Conv2D)         (None, None, None,   262144     ['res4c_branch2b_relu[0][0]']
                                1024)

bn4c_branch2c (BatchNormalizat  (None, None, None,   4096       ['res4c_branch2c[0][0]']
ion)                            1024)

res4c (Add)                     (None, None, None,   0          ['bn4c_branch2c[0][0]',
                                1024)                            'res4b_relu[0][0]']

res4c_relu (Activation)         (None, None, None,   0          ['res4c[0][0]']
                                1024)

res4d_branch2a (Conv2D)         (None, None, None,   262144     ['res4c_relu[0][0]']
                                256)

bn4d_branch2a (BatchNormalizat  (None, None, None,   1024       ['res4d_branch2a[0][0]']
ion)                            256)

res4d_branch2a_relu (Activatio  (None, None, None,   0          ['bn4d_branch2a[0][0]']
n)                              256)

padding4d_branch2b (ZeroPaddin  (None, None, None,   0          ['res4d_branch2a_relu[0][0]']
g2D)                            256)

res4d_branch2b (Conv2D)         (None, None, None,   589824     ['padding4d_branch2b[0][0]']
                                256)

bn4d_branch2b (BatchNormalizat  (None, None, None,   1024       ['res4d_branch2b[0][0]']
ion)                            256)

res4d_branch2b_relu (Activatio  (None, None, None,   0          ['bn4d_branch2b[0][0]']
n)                              256)

res4d_branch2c (Conv2D)         (None, None, None,   262144     ['res4d_branch2b_relu[0][0]']
                                1024)

bn4d_branch2c (BatchNormalizat  (None, None, None,   4096       ['res4d_branch2c[0][0]']
ion)                            1024)

res4d (Add)                     (None, None, None,   0          ['bn4d_branch2c[0][0]',
                                1024)                            'res4c_relu[0][0]']

res4d_relu (Activation)         (None, None, None,   0          ['res4d[0][0]']
                                1024)

res4e_branch2a (Conv2D)         (None, None, None,   262144     ['res4d_relu[0][0]']
                                256)

bn4e_branch2a (BatchNormalizat  (None, None, None,   1024       ['res4e_branch2a[0][0]']
```

```
ion)                           256)

res4e_branch2a_relu (Activatio  (None, None, None,   0          ['bn4e_branch2a[0][0]']
n)                             256)

padding4e_branch2b (ZeroPaddin  (None, None, None,   0          ['res4e_branch2a_relu[0][0]']
g2D)                           256)

res4e_branch2b (Conv2D)        (None, None, None,   589824      ['padding4e_branch2b[0][0]']
                               256)

bn4e_branch2b (BatchNormalizat  (None, None, None,   1024       ['res4e_branch2b[0][0]']
ion)                           256)

res4e_branch2b_relu (Activatio  (None, None, None,   0          ['bn4e_branch2b[0][0]']
n)                             256)

res4e_branch2c (Conv2D)        (None, None, None,   262144      ['res4e_branch2b_relu[0][0]']
                               1024)

bn4e_branch2c (BatchNormalizat  (None, None, None,   4096       ['res4e_branch2c[0][0]']
ion)                           1024)

res4e (Add)                    (None, None, None,   0           ['bn4e_branch2c[0][0]',
                               1024)                             'res4d_relu[0][0]']

res4e_relu (Activation)        (None, None, None,   0           ['res4e[0][0]']
                               1024)

res4f_branch2a (Conv2D)        (None, None, None,   262144      ['res4e_relu[0][0]']
                               256)

bn4f_branch2a (BatchNormalizat  (None, None, None,   1024       ['res4f_branch2a[0][0]']
ion)                           256)

res4f_branch2a_relu (Activatio  (None, None, None,   0          ['bn4f_branch2a[0][0]']
n)                             256)

padding4f_branch2b (ZeroPaddin  (None, None, None,   0          ['res4f_branch2a_relu[0][0]']
g2D)                           256)

res4f_branch2b (Conv2D)        (None, None, None,   589824      ['padding4f_branch2b[0][0]']
                               256)

bn4f_branch2b (BatchNormalizat  (None, None, None,   1024       ['res4f_branch2b[0][0]']
ion)                           256)

res4f_branch2b_relu (Activatio  (None, None, None,   0          ['bn4f_branch2b[0][0]']
n)                             256)

res4f_branch2c (Conv2D)        (None, None, None,   262144      ['res4f_branch2b_relu[0][0]']
                               1024)

bn4f_branch2c (BatchNormalizat  (None, None, None,   4096       ['res4f_branch2c[0][0]']
ion)                           1024)

res4f (Add)                    (None, None, None,   0           ['bn4f_branch2c[0][0]',
                               1024)                             'res4e_relu[0][0]']

res4f_relu (Activation)        (None, None, None,   0           ['res4f[0][0]']
                               1024)

res5a_branch2a (Conv2D)        (None, None, None,   524288      ['res4f_relu[0][0]']
                               512)

bn5a_branch2a (BatchNormalizat  (None, None, None,   2048       ['res5a_branch2a[0][0]']
ion)                           512)

res5a_branch2a_relu (Activatio  (None, None, None,   0          ['bn5a_branch2a[0][0]']
n)                             512)

padding5a_branch2b (ZeroPaddin  (None, None, None,   0          ['res5a_branch2a_relu[0][0]']
g2D)                           512)

res5a_branch2b (Conv2D)        (None, None, None,   2359296     ['padding5a_branch2b[0][0]']
                               512)

bn5a_branch2b (BatchNormalizat  (None, None, None,   2048       ['res5a_branch2b[0][0]']
ion)                           512)

res5a_branch2b_relu (Activatio  (None, None, None,   0          ['bn5a_branch2b[0][0]']
n)                             512)

res5a_branch2c (Conv2D)        (None, None, None,   1048576     ['res5a_branch2b_relu[0][0]']
                               2048)

res5a_branch1 (Conv2D)         (None, None, None,   2097152     ['res4f_relu[0][0]']
                               2048)
```

```
bn5a_branch2c (BatchNormalizat  (None, None, None,   8192       ['res5a_branch2c[0][0]']
ion)                            2048)

bn5a_branch1 (BatchNormalizati  (None, None, None,   8192       ['res5a_branch1[0][0]']
on)                             2048)

res5a (Add)                     (None, None, None,   0          ['bn5a_branch2c[0][0]',
                                2048)                            'bn5a_branch1[0][0]']

res5a_relu (Activation)         (None, None, None,   0          ['res5a[0][0]']
                                2048)

res5b_branch2a (Conv2D)         (None, None, None,   1048576    ['res5a_relu[0][0]']
                                512)

bn5b_branch2a (BatchNormalizat  (None, None, None,   2048       ['res5b_branch2a[0][0]']
ion)                            512)

res5b_branch2a_relu (Activatio  (None, None, None,   0          ['bn5b_branch2a[0][0]']
n)                              512)

padding5b_branch2b (ZeroPaddin  (None, None, None,   0          ['res5b_branch2a_relu[0][0]']
g2D)                            512)

res5b_branch2b (Conv2D)         (None, None, None,   2359296    ['padding5b_branch2b[0][0]']
                                512)

bn5b_branch2b (BatchNormalizat  (None, None, None,   2048       ['res5b_branch2b[0][0]']
ion)                            512)

res5b_branch2b_relu (Activatio  (None, None, None,   0          ['bn5b_branch2b[0][0]']
n)                              512)

res5b_branch2c (Conv2D)         (None, None, None,   1048576    ['res5b_branch2b_relu[0][0]']
                                2048)

bn5b_branch2c (BatchNormalizat  (None, None, None,   8192       ['res5b_branch2c[0][0]']
ion)                            2048)

res5b (Add)                     (None, None, None,   0          ['bn5b_branch2c[0][0]',
                                2048)                            'res5a_relu[0][0]']

res5b_relu (Activation)         (None, None, None,   0          ['res5b[0][0]']
                                2048)

res5c_branch2a (Conv2D)         (None, None, None,   1048576    ['res5b_relu[0][0]']
                                512)

bn5c_branch2a (BatchNormalizat  (None, None, None,   2048       ['res5c_branch2a[0][0]']
ion)                            512)

res5c_branch2a_relu (Activatio  (None, None, None,   0          ['bn5c_branch2a[0][0]']
n)                              512)

padding5c_branch2b (ZeroPaddin  (None, None, None,   0          ['res5c_branch2a_relu[0][0]']
g2D)                            512)

res5c_branch2b (Conv2D)         (None, None, None,   2359296    ['padding5c_branch2b[0][0]']
                                512)

bn5c_branch2b (BatchNormalizat  (None, None, None,   2048       ['res5c_branch2b[0][0]']
ion)                            512)

res5c_branch2b_relu (Activatio  (None, None, None,   0          ['bn5c_branch2b[0][0]']
n)                              512)

res5c_branch2c (Conv2D)         (None, None, None,   1048576    ['res5c_branch2b_relu[0][0]']
                                2048)

bn5c_branch2c (BatchNormalizat  (None, None, None,   8192       ['res5c_branch2c[0][0]']
ion)                            2048)

res5c (Add)                     (None, None, None,   0          ['bn5c_branch2c[0][0]',
                                2048)                            'res5b_relu[0][0]']

res5c_relu (Activation)         (None, None, None,   0          ['res5c[0][0]']
                                2048)

C5_reduced (Conv2D)             (None, None, None,   524544     ['res5c_relu[0][0]']
                                256)

P5_upsampled (UpsampleLike)     (None, None, None,   0          ['C5_reduced[0][0]',
                                256)                             'res4f_relu[0][0]']

C4_reduced (Conv2D)             (None, None, None,   262400     ['res4f_relu[0][0]']
                                256)
```

```
P4_merged (Add)                 (None, None, None,   0          ['P5_upsampled[0][0]',
                                256)                             'C4_reduced[0][0]']

P4_upsampled (UpsampleLike)     (None, None, None,   0          ['P4_merged[0][0]',
                                256)                             'res3d_relu[0][0]']

C3_reduced (Conv2D)             (None, None, None,   131328     ['res3d_relu[0][0]']
                                256)

P6 (Conv2D)                     (None, None, None,   4718848    ['res5c_relu[0][0]']
                                256)

P3_merged (Add)                 (None, None, None,   0          ['P4_upsampled[0][0]',
                                256)                             'C3_reduced[0][0]']

C6_relu (Activation)            (None, None, None,   0          ['P6[0][0]']
                                256)

P3 (Conv2D)                     (None, None, None,   590080     ['P3_merged[0][0]']
                                256)

P4 (Conv2D)                     (None, None, None,   590080     ['P4_merged[0][0]']
                                256)

P5 (Conv2D)                     (None, None, None,   590080     ['C5_reduced[0][0]']
                                256)

P7 (Conv2D)                     (None, None, None,   590080     ['C6_relu[0][0]']
                                256)

regression_submodel (Functiona  (None, None, 4)      2443300    ['P3[0][0]',
l)                                                               'P4[0][0]',
                                                                 'P5[0][0]',
                                                                 'P6[0][0]',
                                                                 'P7[0][0]']

classification_submodel (Funct  (None, None, 1)      2381065    ['P3[0][0]',
ional)                                                           'P4[0][0]',
                                                                 'P5[0][0]',
                                                                 'P6[0][0]',
                                                                 'P7[0][0]']

regression (Concatenate)        (None, None, 4)      0          ['regression_submodel[0][0]',
                                                                 'regression_submodel[1][0]',
                                                                 'regression_submodel[2][0]',
                                                                 'regression_submodel[3][0]',
                                                                 'regression_submodel[4][0]']

classification (Concatenate)    (None, None, 1)      0          ['classification_submodel[0][0]',
                                                                 'classification_submodel[1][0]',
                                                                 'classification_submodel[2][0]',
                                                                 'classification_submodel[3][0]',
                                                                 'classification_submodel[4][0]']

==================================================================================================
Total params: 36,382,957
Trainable params: 12,821,805
Non-trainable params: 23,561,152
__________________________________________________________________________________________________
None
keras_retinanet/bin/train.py:548: UserWarning: `Model.fit_generator` is deprecated and will be removed in a future vers
ion. Please use `Model.fit`, which supports generators.
  initial_epoch=args.initial_epoch
Epoch 1/30
   1/1000 [..............................] - ETA: 32:17:36 - loss: 1.8227 - regression_loss: 0.8511 - classification_lo
ss: 0.9716WARNING:tensorflow:Your input ran out of data; interrupting training. Make sure that your dataset or generato
r can generate at least `steps_per_epoch * epochs` batches (in this case, 30000 batches). You may need to use the repea
t() function when building your dataset.

Epoch 1: saving model to ./snapshots/resnet50_csv_01.h5
1000/1000 [==============================] - 117s 1ms/step - loss: 1.8227 - regression_loss: 0.8511 - classification_lo
ss: 0.9716 - lr: 1.0000e-05
```

Making Predictions

I modified the bounding box code to get clearer texts with better contrast, as the original was a bit hard to see. It involved a bit of tinkering in cv2, but it was worth it.

B [43]:
```
THRES_SCORE = 0.5

# show images inline
%matplotlib inline

# automatically reload modules when they have changed
%reload_ext autoreload
%autoreload 2

# import keras
import keras

# import keras_retinanet
from keras_retinanet import models
from keras_retinanet.utils.image import read_image_bgr, preprocess_image, resize_image
from keras_retinanet.utils.visualization import draw_box, draw_caption
from keras_retinanet.utils.colors import label_color

# import miscellaneous modules
import matplotlib.pyplot as plt
import cv2
import os
import numpy as np
import time

# set tf backend to allow memory to grow, instead of claiming everything
import tensorflow as tf

def get_session():
  config = tf.ConfigProto()
  config.gpu_options.allow_growth = True
  return tf.Session(config=config)
```

B [44]:
```
if 0:
  from keras import backend as K
  # use this environment flag to change which GPU to use
  os.environ["CUDA_VISIBLE_DEVICES"] = "1"

  # set the modified tf session as backend in keras
  # keras.backend.tensorflow_backend.set_session(get_session())
  K.set_session(get_session())
```

B [45]:
```
!pwd
# !ls DATASET_DIR
# PRETRAINED_MODEL
```

```
/content/keras-retinanet
```

B [18]:
```
# !python keras-retinanet/keras_retinanet/bin/convert_model.py \
#   'snapshots/resnet50_csv_01.h5' \
#   'snapshots/inference_model.h5'
```

```
/content/keras-retinanet
2022-08-05 13:47:36.120057: E tensorflow/stream_executor/cuda/cuda_driver.cc:271] failed call to cuInit: CUDA_ERROR_NO_
DEVICE: no CUDA-capable device is detected
Traceback (most recent call last):
  File "./keras_retinanet/bin/convert_model.py", line 100, in <module>
    main()
  File "./keras_retinanet/bin/convert_model.py", line 77, in main
    model = models.load_model(args.model_in, backbone_name=args.backbone)
  File "./keras_retinanet/bin/../../keras_retinanet/models/__init__.py", line 87, in load_model
    return keras.models.load_model(filepath, custom_objects=backbone(backbone_name).custom_objects)
  File "/usr/local/lib/python3.7/dist-packages/keras/utils/traceback_utils.py", line 67, in error_handler
    raise e.with_traceback(filtered_tb) from None
  File "/usr/local/lib/python3.7/dist-packages/keras/saving/save.py", line 204, in load_model
    raise IOError(f'No file or directory found at {filepath_str}')
OSError: No file or directory found at ../snapshots/resnet50_csv_01.h5
```

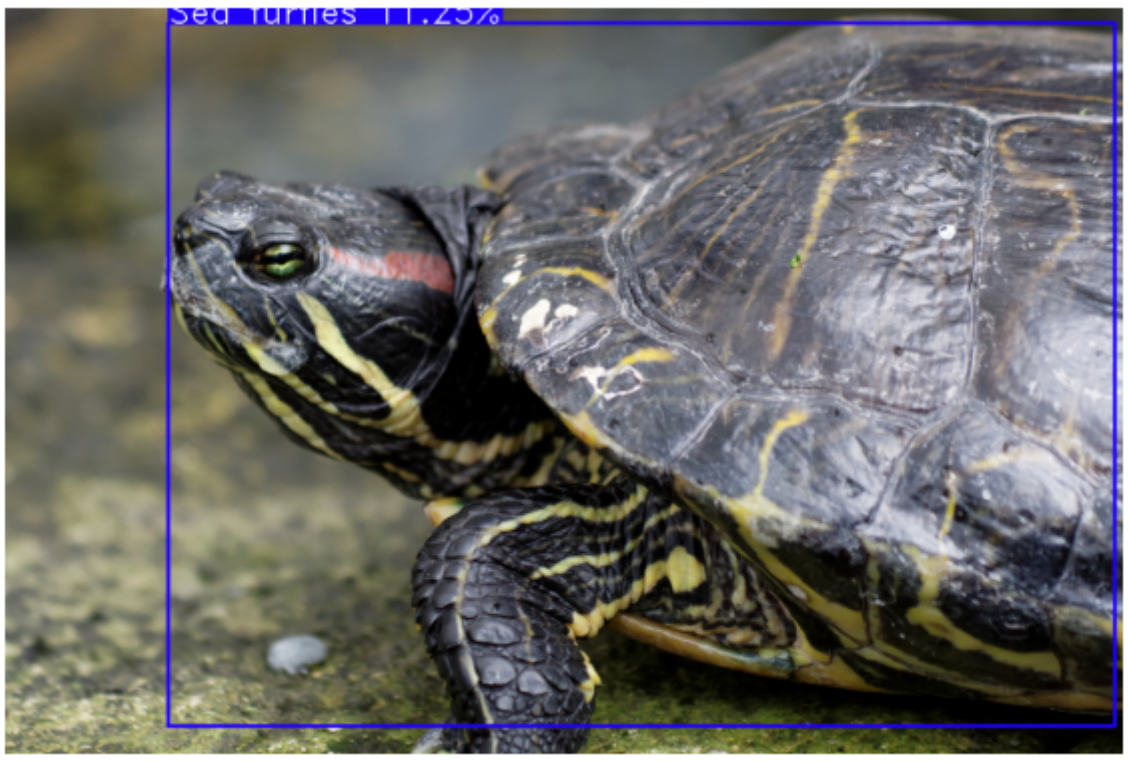
B [56]:
```
THRES_SCORE = 0.1
# THRES_SCORE = 0.5

model_path = './snapshots/resnet50_csv_01.h5'

# load retinanet model
model = models.load_model(model_path, backbone_name='resnet50')
model = models.convert_model(model)

# load label to names mapping for visualization purposes
labels_to_names = pandas.read_csv(CLASSES_FILE,header=None).T.loc[0].to_dict()

def modified_draw_caption(image, box, caption, color):
  """ Draws a caption above the box in an image."""
  b = np.array(box).astype(int)

  text_size = cv2.getTextSize(caption, cv2.FONT_HERSHEY_DUPLEX, 1, 1)
  text_length = text_size[0][0]
  text_height = text_size[0][1]

  print(text_size)

  cv2.rectangle(image,
                (b[0], b[1] - text_height),
                (b[0] + text_length, b[1]),
                color,
                -1)

  cv2.putText(image, caption, (b[0], b[1]), cv2.FONT_HERSHEY_DUPLEX, 1, (255, 255, 255), 1)

def img_inference(img_path):
  image = read_image_bgr(img_path)

  # copy to draw on
  draw = image.copy()
  draw = cv2.cvtColor(draw, cv2.COLOR_BGR2RGB)

  # preprocess image for network
  image = preprocess_image(image)
  image, scale = resize_image(image)

  # process image
  start = time.time()
  boxes, scores, labels = model.predict_on_batch(np.expand_dims(image, axis=0))

  # correct for image scale
  boxes /= scale

  # visualize detections
  for box, score, label in zip(boxes[0], scores[0], labels[0]):
    # scores are sorted so we can break
    if score < THRES_SCORE:
      # print('Found a bounding box at {0:.2%}. Box did not meet threshold'.format(score))
      # Найден ограничивающий прямоугольник на уровне 17,34%. Коробка не достигла порога
      break
    else:
      print("processing time: ", time.time() - start)
      print(box, label)
      print('Found a bounding box at {0:.2%}. Box met threshold'.format(score))
      color = label_color(label)
      b = box.astype(int)
      print(b)
      draw_box(draw, b, color=color)

      caption = "{} {:.2%}".format(labels_to_names[label], score)
      modified_draw_caption(draw, b, caption, color)

      # Отрисовка
      plt.figure(figsize=(10, 10))
      plt.axis('off')
      plt.imshow(draw)

      plt.show()

# validation_path = '/content/oidv4-sea-turtles/TEST'
validation_path = '/content/oidv4-sea-turtles/VALIDATION'
test_images = [os.path.join(validation_path, f) for f in os.listdir(validation_path) if f.endswith('.jpg')]

# i=4
# print(test_images[i])
# for path in [test_images[i]]:
#   # print(path)
#   img_inference(path)

for i in range(15):
  for path in [test_images[i]]:
    # print( '\n', i, path)
```

```
    img_inference(path)
```

```
processing time:  11.21749496459961
[ 101.51761   45.6552  1022.79254  677.42   ] 0
Found a bounding box at 10.00%. Box met threshold
[ 101   45 1022  677]
((306, 22), 10)
```


```
processing time:  5.594956398010254
[ 32.770344  74.08858  955.6254   688.3102  ] 0
Found a bounding box at 10.63%. Box met threshold
[ 32  74 955 688]
((306, 22), 10)
```

```
processing time:  6.319045543670654
[ 149.14569    15.188963 1016.6629    657.2312  ] 0
Found a bounding box at 11.25%. Box met threshold
[ 149   15 1016  657]
((306, 22), 10)
```




```
processing time:  5.669989824295044
[ 46.57031 291.84064 665.0165  544.89496] 0
Found a bounding box at 10.40%. Box met threshold
[ 46 291 665 544]
((306, 22), 10)
```

```
processing time:  6.333439350128174
[ 79.628456 104.64392  866.24475  643.048   ] 0
Found a bounding box at 14.27%. Box met threshold
[ 79 104 866 643]
((306, 22), 10)
```

Вывод:

Google Colab дал обучиться только на 1-й эпохе.
Несмотря на это модель определяет объекты.

Для более качественного решения задачи детектирования объектов, требуется дообучение модели.

```
B [ ]:
```