Contributed by: MANISH SONI

Github Repository:[https://github.com/thewitking/billing-system (https://github.com/thewitking/billing-system)](https://github.com/thewitking/billing-system)

Billing system based on Image segmentation or product detection

This Jupyter notebook implements a transfer learning approach using an already pretrained deep neural network. Consider that an entity serving their customers different kind of packaged food products, uses such approach to generate bills for all the purchased item using just a picture of such items.

Deep Neural network used for segmentation: Retinanet [Fizyr implementation (https://github.com/fizyr/keras-retinanet)](https://github.com/fizyr/keras-retinanet) of RetinaNet in Keras.

It requires product image dataset with proper annotations.

Tools used: Tensorflow, keras, python3, Jupyter notebook, Platform for model training: GPU enabled GCP instance

Initial Setup

In [1]:

```
!git clone https://github.com/fizyr/keras-retinanet.git
```

```
fatal: destination path 'keras-retinanet' already exists and is not
an empty directory.
```

In [2]:

```
%cd keras-retinanet/

!pip3 install .
```

```
/home/ms11313/exp3/objdet_fizyr_colab/keras-retinanet
Processing /home/ms11313/exp3/objdet_fizyr_colab/keras-retinanet
Collecting keras (from keras-retinanet===0.5.0)
  Using cached https://files.pythonhosted.org/packages/5e/10/aa32dad
071ce52b5502266b5c659451cfd6ffcbf14e6c8c4f16c0ff5aaab/Keras-2.2.4-py
2.py3-none-any.whl
Collecting keras-resnet (from keras-retinanet===0.5.0)
Collecting six (from keras-retinanet===0.5.0)
  Using cached https://files.pythonhosted.org/packages/73/fb/00a976f
728d0d1fecfe898238ce23f502a721c0ac0ecfedb80e0d88c64e9/six-1.12.0-py2
.py3-none-any.whl
```

```
Collecting scipy (from keras-retinanet===0.5.0)
  Using cached https://files.pythonhosted.org/packages/14/49/8f13fa2
15e10a7ab0731cc95b0e9bb66cf83c6a98260b154cfbd0b55fb19/scipy-1.3.0-cp
35-cp35m-manylinux1_x86_64.whl
Collecting cython (from keras-retinanet===0.5.0)
  Using cached https://files.pythonhosted.org/packages/e7/bd/5905453
4d09830394470c14e4dd4a2e8fa64ac14559095a044208bf34c18/Cython-0.29.7-
cp35-cp35m-manylinux1_x86_64.whl
Collecting Pillow (from keras-retinanet===0.5.0)
  Using cached https://files.pythonhosted.org/packages/de/62/6358ccd
27b9e340affaa29e3e678b5d93a4b17f6bd7533fd6e6e87930b12/Pillow-6.0.0-c
p35-cp35m-manylinux1_x86_64.whl
Collecting opencv-python (from keras-retinanet===0.5.0)
  Using cached https://files.pythonhosted.org/packages/fe/c8/421eeac
942ebc89552a5c90c2141b936be9cfde24dc3c6eeb472c62d1f8e/opencv_python-
4.1.0.25-cp35-cp35m-manylinux1_x86_64.whl
Collecting progressbar2 (from keras-retinanet===0.5.0)
  Using cached https://files.pythonhosted.org/packages/fb/89/d90f9ff
03285d8eb56994e8cec1b73a4d0dc9bb529c1f8e8e10b1b663843/progressbar2-3
.39.3-py2.py3-none-any.whl
Collecting pyyaml (from keras->keras-retinanet===0.5.0)
Collecting keras-preprocessing>=1.0.5 (from keras->keras-retinanet==
=0.5.0)
  Using cached https://files.pythonhosted.org/packages/c0/bf/0315ef6
a9fd3fc2346e85b0ff1f5f83ca17073f2c31ac719ab2e4da0d4a3/Keras_Preproce
ssing-1.0.9-py2.py3-none-any.whl
Collecting numpy>=1.9.1 (from keras->keras-retinanet===0.5.0)
  Using cached https://files.pythonhosted.org/packages/f6/f3/cc6c674
5347c1e997cc3e58390584a250b8e22b6dfc45414a7d69a3df016/numpy-1.16.3-c
p35-cp35m-manylinux1_x86_64.whl
Collecting h5py (from keras->keras-retinanet===0.5.0)
  Using cached https://files.pythonhosted.org/packages/4c/77/c4933e1
2dca0f61bcdafc207c7532e1250b8d12719459fd85132f3daa9fd/h5py-2.9.0-cp3
5-cp35m-manylinux1_x86_64.whl
Collecting keras-applications>=1.0.6 (from keras->keras-retinanet===
0.5.0)
  Using cached https://files.pythonhosted.org/packages/90/85/64c8294
9765cfb246bbdaf5aca2d55f400f792655927a017710a78445def/Keras_Applicat
ions-1.0.7-py2.py3-none-any.whl
Collecting python-utils>=2.3.0 (from progressbar2->keras-retinanet==
=0.5.0)
  Using cached https://files.pythonhosted.org/packages/eb/a0/19119d8
b7c05be49baf6c593f11c432d571b70d805f2fe94c0585e55e4c8/python_utils-2
.3.0-py2.py3-none-any.whl
Building wheels for collected packages: keras-retinanet
  Running setup.py bdist_wheel for keras-retinanet ... done
  Stored in directory: /home/ms11313/.cache/pip/wheels/48/2c/85/2431
6705879941b5d2744e4b3282b78026bd9fd21618e2dc4c
Successfully built keras-retinanet
Installing collected packages: pyyaml, six, numpy, keras-preprocessi
ng, h5py, keras-applications, scipy, keras, keras-resnet, cython, Pi
llow, opencv-python, python-utils, progressbar2, keras-retinanet
Successfully installed Pillow-6.0.0 cython-0.29.7 h5py-2.9.0 keras-2
```

```
.2.4 keras-applications-1.0.2 keras-preprocessing-1.0.1 keras-resnet
-0.2.0 keras-retinanet-0.5.0 numpy-1.16.3 opencv-python-4.1.0.25 pro
gressbar2-3.39.3 python-utils-2.3.0 pyyaml-5.1 scipy-1.3.0 six-1.12.
0
You are using pip version 8.1.1, however version 19.1.1 is available
.
You should consider upgrading via the 'pip install --upgrade pip' co
mmand.
```

In [3]:

```
!python3 setup.py build_ext --inplace
```

```
running build_ext
skipping 'keras_retinanet/utils/compute_overlap.c' Cython extension
(up-to-date)
copying build/lib.linux-x86_64-3.5/keras_retinanet/utils/compute_ove
rlap.cpython-35m-x86_64-linux-gnu.so -> keras_retinanet/utils
```

In [4]:

```
! pwd
import os
import shutil
import zipfile
import urllib
import xml.etree.ElementTree as ET
import numpy as np
import csv
import pandas
import keras
```

```
/home/ms11313/exp3/objdet_fizyr_colab/keras-retinanet

Using TensorFlow backend.
```

Product Image Dataset

we need all the annotations related to images in Fizyr annotations format.

sample dataset is available in repository :

```
dataset.zip
|- cheetos
    |- 001.jpg
    |- 002.jpg
    ...
|- reese
    |- 101.jpg
    |- 102.jpg
    ...
|- pringle
    |- 201.jpg
    |- 202.jpg
    ...
...
```

In [5]:

```
!cp ./../dataset.zip ./
```

In [6]:

```
IMG_DATASET_DIR = 'dataset'
ANNOTATIONS_FILE = 'annotations.csv'
CLASSES_FILE = 'classes.csv'
```

In [7]:

```
file_name = IMG_DATASET_DIR + '.zip'

os.makedirs(IMG_DATASET_DIR, exist_ok=True)
with zipfile.ZipFile(file_name, 'r') as zip_src:
  zip_src.extractall(IMG_DATASET_DIR)
os.remove(file_name)
print('File Unziped')
```

```
File Unziped
```

In [8]:

```
import os
annotations = []
classes = set([])
abcdir='dataset'
tarSET_DIR=IMG_DATASET_DIR+'/'+abcdir
#for root, dirs, files in os.walk(dir):
for roott, dirst, filest in os.walk(tarSET_DIR):
    for xml_file in [f for f in filest if f.endswith(".xml")]:
        filepath=os.path.join(roott, xml_file)
        tree = ET.parse(filepath)
        root = tree.getroot()
        file_name = None
        for elem in root:
            if elem.tag == 'filename':
                file_name = os.path.join(roott, 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))
```

Get a Pretrained model

First step is to get a pretrained model.

Lets download Fizyr Resnet50 pretrained model

In [9]:

```
PRETRAINED_MODEL = './snapshots/_pretrained_model.h5'
URL_MODEL = 'https://github.com/fizyr/keras-retinanet/releases/download/0.5.0/re
snet50_coco_best_v2.1.0.h5'
urllib.request.urlretrieve(URL_MODEL, PRETRAINED_MODEL)

print('pretrained model available at: ' + PRETRAINED_MODEL)
```

```
Downloaded pretrained model to ./snapshots/_pretrained_model.h5
```

Training Model on Product Image dataset

Lets use commandline arguements to train the model.

In [10]:

```
!python3 keras_retinanet/bin/train.py --freeze-backbone --random-transform --wei
ghts {PRETRAINED_MODEL} --batch-size 8 --steps 500 --epochs 10 csv annotations.c
sv classes.csv
```

```
Using TensorFlow backend.
2019-05-20 01:56:37.100965: I tensorflow/core/platform/cpu_feature_g
uard.cc:140] Your CPU supports instructions that this TensorFlow bin
ary was not compiled to use: AVX2 FMA
2019-05-20 01:56:37.232245: I tensorflow/stream_executor/cuda/cuda_g
pu_executor.cc:898] successful NUMA node read from SysFS had negativ
e value (-1), but there must be at least one NUMA node, so returning
NUMA node zero
2019-05-20 01:56:37.233254: I tensorflow/core/common_runtime/gpu/gpu
_device.cc:1356] Found device 0 with properties:
name: Tesla P100-PCIE-16GB major: 6 minor: 0 memoryClockRate(GHz): 1
.3285
pciBusID: 0000:00:04.0
totalMemory: 15.90GiB freeMemory: 15.56GiB
2019-05-20 01:56:37.233312: I tensorflow/core/common_runtime/gpu/gpu
_device.cc:1435] Adding visible gpu devices: 0
2019-05-20 01:56:37.700142: I tensorflow/core/common_runtime/gpu/gpu
_device.cc:923] Device interconnect StreamExecutor with strength 1 e
dge matrix:
2019-05-20 01:56:37.700213: I tensorflow/core/common_runtime/gpu/gpu
_device.cc:929]      0
2019-05-20 01:56:37.700231: I tensorflow/core/common_runtime/gpu/gpu
```

```
_device.cc:942] 0:   N
2019-05-20 01:56:37.701126: I tensorflow/core/common_runtime/gpu/gpu
_device.cc:1053] Created TensorFlow device (/job:localhost/replica:0
/task:0/device:GPU:0 with 15085 MB memory) -> physical GPU (device:
0, name: Tesla P100-PCIE-16GB, pci bus id: 0000:00:04.0, compute cap
ability: 6.0)
Creating model, this may take a second...
/home/ms11313/.local/lib/python3.5/site-packages/keras/engine/saving
.py:1140: UserWarning: Skipping loading of weights for layer classif
ication_submodel due to mismatch in shape ((3, 3, 256, 54) vs (720,
256, 3, 3)).
  weight_values[i].shape))
/home/ms11313/.local/lib/python3.5/site-packages/keras/engine/saving
.py:1140: UserWarning: Skipping loading of weights for layer classif
ication_submodel due to mismatch in shape ((54,) vs (720,)).
  weight_values[i].shape))
____________________________________________________________________
______________________________
Layer (type)                    Output Shape         Param #     Con
nected to
====================================================================
==============================
input_1 (InputLayer)            (None, None, None, 3 0
____________________________________________________________________
______________________________
conv1 (Conv2D)                  (None, None, None, 6 9408        inp
ut_1[0][0]
____________________________________________________________________
______________________________
bn_conv1 (BatchNormalization)   (None, None, None, 6 256         con
v1[0][0]
____________________________________________________________________
______________________________
conv1_relu (Activation)         (None, None, None, 6 0           bn_
conv1[0][0]
____________________________________________________________________
______________________________
pool1 (MaxPooling2D)            (None, None, None, 6 0           con
v1_relu[0][0]
____________________________________________________________________
______________________________
res2a_branch2a (Conv2D)         (None, None, None, 6 4096        poo
l1[0][0]
____________________________________________________________________
______________________________
bn2a_branch2a (BatchNormalizati (None, None, None, 6 256         res
2a_branch2a[0][0]
____________________________________________________________________
______________________________
res2a_branch2a_relu (Activation (None, None, None, 6 0           bn2
a_branch2a[0][0]
____________________________________________________________________
______________________________
```

```
padding2a_branch2b (ZeroPadding (None, None, None, 6 0            res
2a_branch2a_relu[0][0]
______________________________________________________________________
_______________________________
res2a_branch2b (Conv2D)          (None, None, None, 6 36864        pad
ding2a_branch2b[0][0]
______________________________________________________________________
_______________________________
bn2a_branch2b (BatchNormalizati (None, None, None, 6 256          res
2a_branch2b[0][0]
______________________________________________________________________
_______________________________
res2a_branch2b_relu (Activation (None, None, None, 6 0            bn2
a_branch2b[0][0]
______________________________________________________________________
_______________________________
res2a_branch2c (Conv2D)          (None, None, None, 2 16384        res
2a_branch2b_relu[0][0]
______________________________________________________________________
_______________________________
res2a_branch1 (Conv2D)           (None, None, None, 2 16384        poo
l1[0][0]
______________________________________________________________________
_______________________________
bn2a_branch2c (BatchNormalizati (None, None, None, 2 1024         res
2a_branch2c[0][0]
______________________________________________________________________
_______________________________
bn2a_branch1 (BatchNormalizatio (None, None, None, 2 1024         res
2a_branch1[0][0]
______________________________________________________________________
_______________________________
res2a (Add)                      (None, None, None, 2 0            bn2
a_branch2c[0][0]

bn2a_branch1[0][0]
______________________________________________________________________
_______________________________
res2a_relu (Activation)          (None, None, None, 2 0            res
2a[0][0]
______________________________________________________________________
_______________________________
res2b_branch2a (Conv2D)          (None, None, None, 6 16384        res
2a_relu[0][0]
______________________________________________________________________
_______________________________
bn2b_branch2a (BatchNormalizati (None, None, None, 6 256          res
2b_branch2a[0][0]
______________________________________________________________________
_______________________________
res2b_branch2a_relu (Activation (None, None, None, 6 0            bn2
b_branch2a[0][0]
______________________________________________________________________
```

```
______________________________
padding2b_branch2b (ZeroPadding (None, None, None, 6 0           res
2b_branch2a_relu[0][0]
____________________________________________________________________
______________________________
res2b_branch2b (Conv2D)         (None, None, None, 6 36864       pad
ding2b_branch2b[0][0]
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______________________________
bn2b_branch2b (BatchNormalizati (None, None, None, 6 256         res
2b_branch2b[0][0]
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______________________________
res2b_branch2b_relu (Activation (None, None, None, 6 0           bn2
b_branch2b[0][0]
____________________________________________________________________
______________________________
res2b_branch2c (Conv2D)         (None, None, None, 2 16384       res
2b_branch2b_relu[0][0]
____________________________________________________________________
______________________________
bn2b_branch2c (BatchNormalizati (None, None, None, 2 1024        res
2b_branch2c[0][0]
____________________________________________________________________
______________________________
res2b (Add)                     (None, None, None, 2 0           bn2
b_branch2c[0][0]

res2a_relu[0][0]
____________________________________________________________________
______________________________
res2b_relu (Activation)         (None, None, None, 2 0           res
2b[0][0]
____________________________________________________________________
______________________________
res2c_branch2a (Conv2D)         (None, None, None, 6 16384       res
2b_relu[0][0]
____________________________________________________________________
______________________________
bn2c_branch2a (BatchNormalizati (None, None, None, 6 256         res
2c_branch2a[0][0]
____________________________________________________________________
______________________________
res2c_branch2a_relu (Activation (None, None, None, 6 0           bn2
c_branch2a[0][0]
____________________________________________________________________
______________________________
padding2c_branch2b (ZeroPadding (None, None, None, 6 0           res
2c_branch2a_relu[0][0]
____________________________________________________________________
______________________________
res2c_branch2b (Conv2D)         (None, None, None, 6 36864       pad
ding2c_branch2b[0][0]
```

```
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______________________________
bn2c_branch2b (BatchNormalizati (None, None, None, 6 256         res
2c_branch2b[0][0]
____________________________________________________________________
______________________________
res2c_branch2b_relu (Activation (None, None, None, 6 0           bn2
c_branch2b[0][0]
____________________________________________________________________
______________________________
res2c_branch2c (Conv2D)         (None, None, None, 2 16384       res
2c_branch2b_relu[0][0]
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______________________________
bn2c_branch2c (BatchNormalizati (None, None, None, 2 1024        res
2c_branch2c[0][0]
____________________________________________________________________
______________________________
res2c (Add)                     (None, None, None, 2 0           bn2
c_branch2c[0][0]

res2b_relu[0][0]
____________________________________________________________________
______________________________
res2c_relu (Activation)         (None, None, None, 2 0           res
2c[0][0]
____________________________________________________________________
______________________________
res3a_branch2a (Conv2D)         (None, None, None, 1 32768       res
2c_relu[0][0]
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______________________________
bn3a_branch2a (BatchNormalizati (None, None, None, 1 512         res
3a_branch2a[0][0]
____________________________________________________________________
______________________________
res3a_branch2a_relu (Activation (None, None, None, 1 0           bn3
a_branch2a[0][0]
____________________________________________________________________
______________________________
padding3a_branch2b (ZeroPadding (None, None, None, 1 0           res
3a_branch2a_relu[0][0]
____________________________________________________________________
______________________________
res3a_branch2b (Conv2D)         (None, None, None, 1 147456      pad
ding3a_branch2b[0][0]
____________________________________________________________________
______________________________
bn3a_branch2b (BatchNormalizati (None, None, None, 1 512         res
3a_branch2b[0][0]
____________________________________________________________________
______________________________
res3a_branch2b_relu (Activation (None, None, None, 1 0           bn3
a_branch2b[0][0]
____________________________________________________________________
______________________________
res3a_branch2c (Conv2D)         (None, None, None, 5 65536       res
3a_branch2b_relu[0][0]
____________________________________________________________________
______________________________
res3a_branch1 (Conv2D)          (None, None, None, 5 131072      res
2c_relu[0][0]
____________________________________________________________________
______________________________
bn3a_branch2c (BatchNormalizati (None, None, None, 5 2048        res
3a_branch2c[0][0]
____________________________________________________________________
______________________________
bn3a_branch1 (BatchNormalizatio (None, None, None, 5 2048        res
3a_branch1[0][0]
____________________________________________________________________
______________________________
res3a (Add)                     (None, None, None, 5 0           bn3
a_branch2c[0][0]

bn3a_branch1[0][0]
____________________________________________________________________
______________________________
res3a_relu (Activation)         (None, None, None, 5 0           res
3a[0][0]
____________________________________________________________________
______________________________
res3b_branch2a (Conv2D)         (None, None, None, 1 65536       res
3a_relu[0][0]
____________________________________________________________________
______________________________
bn3b_branch2a (BatchNormalizati (None, None, None, 1 512         res
3b_branch2a[0][0]
____________________________________________________________________
______________________________
res3b_branch2a_relu (Activation (None, None, None, 1 0           bn3
b_branch2a[0][0]
____________________________________________________________________
______________________________
padding3b_branch2b (ZeroPadding (None, None, None, 1 0           res
3b_branch2a_relu[0][0]
____________________________________________________________________
______________________________
res3b_branch2b (Conv2D)         (None, None, None, 1 147456      pad
ding3b_branch2b[0][0]
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______________________________
bn3b_branch2b (BatchNormalizati (None, None, None, 1 512         res
3b_branch2b[0][0]
____________________________________________________________________
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```
res3b_branch2b_relu (Activation (None, None, None, 1 0           bn3
b_branch2b[0][0]
____________________________________________________________________
______________________________
res3b_branch2c (Conv2D)         (None, None, None, 5 65536       res
3b_branch2b_relu[0][0]
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______________________________
bn3b_branch2c (BatchNormalizati (None, None, None, 5 2048        res
3b_branch2c[0][0]
____________________________________________________________________
______________________________
res3b (Add)                     (None, None, None, 5 0           bn3
b_branch2c[0][0]

res3a_relu[0][0]
____________________________________________________________________
______________________________
res3b_relu (Activation)         (None, None, None, 5 0           res
3b[0][0]
____________________________________________________________________
______________________________
res3c_branch2a (Conv2D)         (None, None, None, 1 65536       res
3b_relu[0][0]
____________________________________________________________________
______________________________
bn3c_branch2a (BatchNormalizati (None, None, None, 1 512         res
3c_branch2a[0][0]
____________________________________________________________________
______________________________
res3c_branch2a_relu (Activation (None, None, None, 1 0           bn3
c_branch2a[0][0]
____________________________________________________________________
______________________________
padding3c_branch2b (ZeroPadding (None, None, None, 1 0           res
3c_branch2a_relu[0][0]
____________________________________________________________________
______________________________
res3c_branch2b (Conv2D)         (None, None, None, 1 147456      pad
ding3c_branch2b[0][0]
____________________________________________________________________
______________________________
bn3c_branch2b (BatchNormalizati (None, None, None, 1 512         res
3c_branch2b[0][0]
____________________________________________________________________
______________________________
res3c_branch2b_relu (Activation (None, None, None, 1 0           bn3
c_branch2b[0][0]
____________________________________________________________________
______________________________
res3c_branch2c (Conv2D)         (None, None, None, 5 65536       res
3c_branch2b_relu[0][0]
____________________________________________________________________
```

```
______________________________
bn3c_branch2c (BatchNormalizati (None, None, None, 5 2048        res
3c_branch2c[0][0]

____________________________________________________________________

______________________________
res3c (Add)                     (None, None, None, 5 0           bn3
c_branch2c[0][0]

res3b_relu[0][0]

____________________________________________________________________

______________________________
res3c_relu (Activation)         (None, None, None, 5 0           res
3c[0][0]

____________________________________________________________________

______________________________
res3d_branch2a (Conv2D)         (None, None, None, 1 65536       res
3c_relu[0][0]

____________________________________________________________________

______________________________
bn3d_branch2a (BatchNormalizati (None, None, None, 1 512         res
3d_branch2a[0][0]

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______________________________
res3d_branch2a_relu (Activation (None, None, None, 1 0           bn3
d_branch2a[0][0]

____________________________________________________________________

______________________________
padding3d_branch2b (ZeroPadding (None, None, None, 1 0           res
3d_branch2a_relu[0][0]

____________________________________________________________________

______________________________
res3d_branch2b (Conv2D)         (None, None, None, 1 147456      pad
ding3d_branch2b[0][0]

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______________________________
bn3d_branch2b (BatchNormalizati (None, None, None, 1 512         res
3d_branch2b[0][0]

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______________________________
res3d_branch2b_relu (Activation (None, None, None, 1 0           bn3
d_branch2b[0][0]

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______________________________
res3d_branch2c (Conv2D)         (None, None, None, 5 65536       res
3d_branch2b_relu[0][0]

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______________________________
bn3d_branch2c (BatchNormalizati (None, None, None, 5 2048        res
3d_branch2c[0][0]

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______________________________
res3d (Add)                     (None, None, None, 5 0           bn3
d_branch2c[0][0]
```

```
res3c_relu[0][0]
____________________________________________________________________
______________________________
res3d_relu (Activation)         (None, None, None, 5 0           res
3d[0][0]
____________________________________________________________________
______________________________
res4a_branch2a (Conv2D)         (None, None, None, 2 131072      res
3d_relu[0][0]
____________________________________________________________________
______________________________
bn4a_branch2a (BatchNormalizati (None, None, None, 2 1024        res
4a_branch2a[0][0]
____________________________________________________________________
______________________________
res4a_branch2a_relu (Activation (None, None, None, 2 0           bn4
a_branch2a[0][0]
____________________________________________________________________
______________________________
padding4a_branch2b (ZeroPadding (None, None, None, 2 0           res
4a_branch2a_relu[0][0]
____________________________________________________________________
______________________________
res4a_branch2b (Conv2D)         (None, None, None, 2 589824      pad
ding4a_branch2b[0][0]
____________________________________________________________________
______________________________
bn4a_branch2b (BatchNormalizati (None, None, None, 2 1024        res
4a_branch2b[0][0]
____________________________________________________________________
______________________________
res4a_branch2b_relu (Activation (None, None, None, 2 0           bn4
a_branch2b[0][0]
____________________________________________________________________
______________________________
res4a_branch2c (Conv2D)         (None, None, None, 1 262144      res
4a_branch2b_relu[0][0]
____________________________________________________________________
______________________________
res4a_branch1 (Conv2D)          (None, None, None, 1 524288      res
3d_relu[0][0]
____________________________________________________________________
______________________________
bn4a_branch2c (BatchNormalizati (None, None, None, 1 4096        res
4a_branch2c[0][0]
____________________________________________________________________
______________________________
bn4a_branch1 (BatchNormalizatio (None, None, None, 1 4096        res
4a_branch1[0][0]
____________________________________________________________________
______________________________
res4a (Add)                     (None, None, None, 1 0           bn4
a_branch2c[0][0]

bn4a_branch1[0][0]
____________________________________________________________________
______________________________
res4a_relu (Activation)         (None, None, None, 1 0           res
4a[0][0]
____________________________________________________________________
______________________________
res4b_branch2a (Conv2D)         (None, None, None, 2 262144      res
4a_relu[0][0]
____________________________________________________________________
______________________________
bn4b_branch2a (BatchNormalizati (None, None, None, 2 1024        res
4b_branch2a[0][0]
____________________________________________________________________
______________________________
res4b_branch2a_relu (Activation (None, None, None, 2 0           bn4
b_branch2a[0][0]
____________________________________________________________________
______________________________
padding4b_branch2b (ZeroPadding (None, None, None, 2 0           res
4b_branch2a_relu[0][0]
____________________________________________________________________
______________________________
res4b_branch2b (Conv2D)         (None, None, None, 2 589824      pad
ding4b_branch2b[0][0]
____________________________________________________________________
______________________________
bn4b_branch2b (BatchNormalizati (None, None, None, 2 1024        res
4b_branch2b[0][0]
____________________________________________________________________
______________________________
res4b_branch2b_relu (Activation (None, None, None, 2 0           bn4
b_branch2b[0][0]
____________________________________________________________________
______________________________
res4b_branch2c (Conv2D)         (None, None, None, 1 262144      res
4b_branch2b_relu[0][0]
____________________________________________________________________
______________________________
bn4b_branch2c (BatchNormalizati (None, None, None, 1 4096        res
4b_branch2c[0][0]
____________________________________________________________________
______________________________
res4b (Add)                     (None, None, None, 1 0           bn4
b_branch2c[0][0]

res4a_relu[0][0]
____________________________________________________________________
______________________________
res4b_relu (Activation)         (None, None, None, 1 0           res
4b[0][0]
```

```
res4c_branch2a (Conv2D)         (None, None, None, 2 262144      res
4b_relu[0][0]

bn4c_branch2a (BatchNormalizati (None, None, None, 2 1024        res
4c_branch2a[0][0]

res4c_branch2a_relu (Activation (None, None, None, 2 0           bn4
c_branch2a[0][0]

padding4c_branch2b (ZeroPadding (None, None, None, 2 0           res
4c_branch2a_relu[0][0]

res4c_branch2b (Conv2D)         (None, None, None, 2 589824      pad
ding4c_branch2b[0][0]

bn4c_branch2b (BatchNormalizati (None, None, None, 2 1024        res
4c_branch2b[0][0]

res4c_branch2b_relu (Activation (None, None, None, 2 0           bn4
c_branch2b[0][0]

res4c_branch2c (Conv2D)         (None, None, None, 1 262144      res
4c_branch2b_relu[0][0]

bn4c_branch2c (BatchNormalizati (None, None, None, 1 4096        res
4c_branch2c[0][0]

res4c (Add)                     (None, None, None, 1 0           bn4
c_branch2c[0][0]

res4b_relu[0][0]

res4c_relu (Activation)         (None, None, None, 1 0           res
4c[0][0]

res4d_branch2a (Conv2D)         (None, None, None, 2 262144      res
4c_relu[0][0]

bn4d_branch2a (BatchNormalizati (None, None, None, 2 1024        res
4d_branch2a[0][0]
____________________________________________________________________
______________________________
res4d_branch2a_relu (Activation (None, None, None, 2 0           bn4
d_branch2a[0][0]
____________________________________________________________________
______________________________
padding4d_branch2b (ZeroPadding (None, None, None, 2 0           res
4d_branch2a_relu[0][0]
____________________________________________________________________
______________________________
res4d_branch2b (Conv2D)         (None, None, None, 2 589824      pad
ding4d_branch2b[0][0]
____________________________________________________________________
______________________________
bn4d_branch2b (BatchNormalizati (None, None, None, 2 1024        res
4d_branch2b[0][0]
____________________________________________________________________
______________________________
res4d_branch2b_relu (Activation (None, None, None, 2 0           bn4
d_branch2b[0][0]
____________________________________________________________________
______________________________
res4d_branch2c (Conv2D)         (None, None, None, 1 262144      res
4d_branch2b_relu[0][0]
____________________________________________________________________
______________________________
bn4d_branch2c (BatchNormalizati (None, None, None, 1 4096        res
4d_branch2c[0][0]
____________________________________________________________________
______________________________
res4d (Add)                     (None, None, None, 1 0           bn4
d_branch2c[0][0]

res4c_relu[0][0]
____________________________________________________________________
______________________________
res4d_relu (Activation)         (None, None, None, 1 0           res
4d[0][0]
____________________________________________________________________
______________________________
res4e_branch2a (Conv2D)         (None, None, None, 2 262144      res
4d_relu[0][0]
____________________________________________________________________
______________________________
bn4e_branch2a (BatchNormalizati (None, None, None, 2 1024        res
4e_branch2a[0][0]
____________________________________________________________________
______________________________
res4e_branch2a_relu (Activation (None, None, None, 2 0           bn4
e_branch2a[0][0]
____________________________________________________________________
______________________________
```

```
padding4e_branch2b (ZeroPadding (None, None, None, 2 0           res
4e_branch2a_relu[0][0]
____________________________________________________________________
______________________________
res4e_branch2b (Conv2D)         (None, None, None, 2 589824      pad
ding4e_branch2b[0][0]
____________________________________________________________________
______________________________
bn4e_branch2b (BatchNormalizati (None, None, None, 2 1024        res
4e_branch2b[0][0]
____________________________________________________________________
______________________________
res4e_branch2b_relu (Activation (None, None, None, 2 0           bn4
e_branch2b[0][0]
____________________________________________________________________
______________________________
res4e_branch2c (Conv2D)         (None, None, None, 1 262144      res
4e_branch2b_relu[0][0]
____________________________________________________________________
______________________________
bn4e_branch2c (BatchNormalizati (None, None, None, 1 4096        res
4e_branch2c[0][0]
____________________________________________________________________
______________________________
res4e (Add)                     (None, None, None, 1 0           bn4
e_branch2c[0][0]

res4d_relu[0][0]
____________________________________________________________________
______________________________
res4e_relu (Activation)         (None, None, None, 1 0           res
4e[0][0]
____________________________________________________________________
______________________________
res4f_branch2a (Conv2D)         (None, None, None, 2 262144      res
4e_relu[0][0]
____________________________________________________________________
______________________________
bn4f_branch2a (BatchNormalizati (None, None, None, 2 1024        res
4f_branch2a[0][0]
____________________________________________________________________
______________________________
res4f_branch2a_relu (Activation (None, None, None, 2 0           bn4
f_branch2a[0][0]
____________________________________________________________________
______________________________
padding4f_branch2b (ZeroPadding (None, None, None, 2 0           res
4f_branch2a_relu[0][0]
____________________________________________________________________
______________________________
res4f_branch2b (Conv2D)         (None, None, None, 2 589824      pad
ding4f_branch2b[0][0]
____________________________________________________________________
```

```
______________________________
bn4f_branch2b (BatchNormalizati (None, None, None, 2 1024        res
4f_branch2b[0][0]
____________________________________________________________________
______________________________
res4f_branch2b_relu (Activation (None, None, None, 2 0           bn4
f_branch2b[0][0]
____________________________________________________________________
______________________________
res4f_branch2c (Conv2D)         (None, None, None, 1 262144      res
4f_branch2b_relu[0][0]
____________________________________________________________________
______________________________
bn4f_branch2c (BatchNormalizati (None, None, None, 1 4096        res
4f_branch2c[0][0]
____________________________________________________________________
______________________________
res4f (Add)                     (None, None, None, 1 0           bn4
f_branch2c[0][0]

res4e_relu[0][0]
____________________________________________________________________
______________________________
res4f_relu (Activation)         (None, None, None, 1 0           res
4f[0][0]
____________________________________________________________________
______________________________
res5a_branch2a (Conv2D)         (None, None, None, 5 524288      res
4f_relu[0][0]
____________________________________________________________________
______________________________
bn5a_branch2a (BatchNormalizati (None, None, None, 5 2048        res
5a_branch2a[0][0]
____________________________________________________________________
______________________________
res5a_branch2a_relu (Activation (None, None, None, 5 0           bn5
a_branch2a[0][0]
____________________________________________________________________
______________________________
padding5a_branch2b (ZeroPadding (None, None, None, 5 0           res
5a_branch2a_relu[0][0]
____________________________________________________________________
______________________________
res5a_branch2b (Conv2D)         (None, None, None, 5 2359296     pad
ding5a_branch2b[0][0]
____________________________________________________________________
______________________________
bn5a_branch2b (BatchNormalizati (None, None, None, 5 2048        res
5a_branch2b[0][0]
____________________________________________________________________
______________________________
res5a_branch2b_relu (Activation (None, None, None, 5 0           bn5
a_branch2b[0][0]
```

```
____________________________________________________________________
______________________________
res5a_branch2c (Conv2D)         (None, None, None, 2 1048576     res
5a_branch2b_relu[0][0]

____________________________________________________________________
______________________________
res5a_branch1 (Conv2D)          (None, None, None, 2 2097152     res
4f_relu[0][0]

____________________________________________________________________
______________________________
bn5a_branch2c (BatchNormalizati (None, None, None, 2 8192        res
5a_branch2c[0][0]

____________________________________________________________________
______________________________
bn5a_branch1 (BatchNormalizatio (None, None, None, 2 8192        res
5a_branch1[0][0]

____________________________________________________________________
______________________________
res5a (Add)                     (None, None, None, 2 0           bn5
a_branch2c[0][0]

bn5a_branch1[0][0]

____________________________________________________________________
______________________________
res5a_relu (Activation)         (None, None, None, 2 0           res
5a[0][0]

____________________________________________________________________
______________________________
res5b_branch2a (Conv2D)         (None, None, None, 5 1048576     res
5a_relu[0][0]

____________________________________________________________________
______________________________
bn5b_branch2a (BatchNormalizati (None, None, None, 5 2048        res
5b_branch2a[0][0]

____________________________________________________________________
______________________________
res5b_branch2a_relu (Activation (None, None, None, 5 0           bn5
b_branch2a[0][0]

____________________________________________________________________
______________________________
padding5b_branch2b (ZeroPadding (None, None, None, 5 0           res
5b_branch2a_relu[0][0]

____________________________________________________________________
______________________________
res5b_branch2b (Conv2D)         (None, None, None, 5 2359296     pad
ding5b_branch2b[0][0]

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______________________________
bn5b_branch2b (BatchNormalizati (None, None, None, 5 2048        res
5b_branch2b[0][0]

____________________________________________________________________
______________________________
res5b_branch2b_relu (Activation (None, None, None, 5 0           bn5
b_branch2b[0][0]
____________________________________________________________________
______________________________
res5b_branch2c (Conv2D)         (None, None, None, 2 1048576     res
5b_branch2b_relu[0][0]
____________________________________________________________________
______________________________
bn5b_branch2c (BatchNormalizati (None, None, None, 2 8192        res
5b_branch2c[0][0]
____________________________________________________________________
______________________________
res5b (Add)                     (None, None, None, 2 0           bn5
b_branch2c[0][0]

res5a_relu[0][0]
____________________________________________________________________
______________________________
res5b_relu (Activation)         (None, None, None, 2 0           res
5b[0][0]
____________________________________________________________________
______________________________
res5c_branch2a (Conv2D)         (None, None, None, 5 1048576     res
5b_relu[0][0]
____________________________________________________________________
______________________________
bn5c_branch2a (BatchNormalizati (None, None, None, 5 2048        res
5c_branch2a[0][0]
____________________________________________________________________
______________________________
res5c_branch2a_relu (Activation (None, None, None, 5 0           bn5
c_branch2a[0][0]
____________________________________________________________________
______________________________
padding5c_branch2b (ZeroPadding (None, None, None, 5 0           res
5c_branch2a_relu[0][0]
____________________________________________________________________
______________________________
res5c_branch2b (Conv2D)         (None, None, None, 5 2359296     pad
ding5c_branch2b[0][0]
____________________________________________________________________
______________________________
bn5c_branch2b (BatchNormalizati (None, None, None, 5 2048        res
5c_branch2b[0][0]
____________________________________________________________________
______________________________
res5c_branch2b_relu (Activation (None, None, None, 5 0           bn5
c_branch2b[0][0]
____________________________________________________________________
______________________________
res5c_branch2c (Conv2D)         (None, None, None, 2 1048576     res
5c_branch2b_relu[0][0]
____________________________________________________________________
______________________________
```

```
bn5c_branch2c (BatchNormalizati (None, None, None, 2 8192        res
5c_branch2c[0][0]
____________________________________________________________________
______________________________
res5c (Add)                     (None, None, None, 2 0           bn5
c_branch2c[0][0]

res5b_relu[0][0]
____________________________________________________________________
______________________________
res5c_relu (Activation)         (None, None, None, 2 0           res
5c[0][0]
____________________________________________________________________
______________________________
C5_reduced (Conv2D)             (None, None, None, 2 524544      res
5c_relu[0][0]
____________________________________________________________________
______________________________
P5_upsampled (UpsampleLike)     (None, None, None, 2 0           C5_
reduced[0][0]

res4f_relu[0][0]
____________________________________________________________________
______________________________
C4_reduced (Conv2D)             (None, None, None, 2 262400      res
4f_relu[0][0]
____________________________________________________________________
______________________________
P4_merged (Add)                 (None, None, None, 2 0           P5_
upsampled[0][0]

C4_reduced[0][0]
____________________________________________________________________
______________________________
P4_upsampled (UpsampleLike)     (None, None, None, 2 0           P4_
merged[0][0]

res3d_relu[0][0]
____________________________________________________________________
______________________________
C3_reduced (Conv2D)             (None, None, None, 2 131328      res
3d_relu[0][0]
____________________________________________________________________
______________________________
P6 (Conv2D)                     (None, None, None, 2 4718848     res
5c_relu[0][0]
____________________________________________________________________
______________________________
P3_merged (Add)                 (None, None, None, 2 0           P4_
upsampled[0][0]

C3_reduced[0][0]
____________________________________________________________________
```

```
______________________________
C6_relu (Activation)            (None, None, None, 2 0           P6[
0][0]
____________________________________________________________________
______________________________
P3 (Conv2D)                     (None, None, None, 2 590080      P3_
merged[0][0]
____________________________________________________________________
______________________________
P4 (Conv2D)                     (None, None, None, 2 590080      P4_
merged[0][0]
____________________________________________________________________
______________________________
P5 (Conv2D)                     (None, None, None, 2 590080      C5_
reduced[0][0]
____________________________________________________________________
______________________________
P7 (Conv2D)                     (None, None, None, 2 590080      C6_
relu[0][0]
____________________________________________________________________
______________________________
regression_submodel (Model)     (None, None, 4)      2443300     P3[
0][0]

P4[0][0]

P5[0][0]

P6[0][0]

P7[0][0]
____________________________________________________________________
______________________________
classification_submodel (Model) (None, None, 6)      2484790     P3[
0][0]

P4[0][0]

P5[0][0]

P6[0][0]

P7[0][0]
____________________________________________________________________
______________________________
regression (Concatenate)        (None, None, 4)      0           reg
ression_submodel[1][0]

regression_submodel[2][0]

regression_submodel[3][0]

regression_submodel[4][0]
```

```
regression_submodel[5][0]
____________________________________________________________________
______________________________
classification (Concatenate)    (None, None, 6)      0           cla
ssification_submodel[1][0]

classification_submodel[2][0]

classification_submodel[3][0]

classification_submodel[4][0]

classification_submodel[5][0]
====================================================================
==============================
Total params: 36,486,682
Trainable params: 12,925,530
Non-trainable params: 23,561,152
____________________________________________________________________
______________________________
None
Epoch 1/10
500/500 [==============================] - 833s 2s/step - loss: 1.44
44 - regression_loss: 0.7845 - classification_loss: 0.6599

Epoch 00001: saving model to ./snapshots/resnet50_csv_01.h5
Epoch 2/10
500/500 [==============================] - 821s 2s/step - loss: 0.73
64 - regression_loss: 0.5279 - classification_loss: 0.2085

Epoch 00002: saving model to ./snapshots/resnet50_csv_02.h5
Epoch 3/10
500/500 [==============================] - 832s 2s/step - loss: 0.54
57 - regression_loss: 0.4273 - classification_loss: 0.1185

Epoch 00003: saving model to ./snapshots/resnet50_csv_03.h5
Epoch 4/10
500/500 [==============================] - 833s 2s/step - loss: 0.45
97 - regression_loss: 0.3778 - classification_loss: 0.0819

Epoch 00004: saving model to ./snapshots/resnet50_csv_04.h5
Epoch 5/10
500/500 [==============================] - 826s 2s/step - loss: 0.40
28 - regression_loss: 0.3411 - classification_loss: 0.0617

Epoch 00005: saving model to ./snapshots/resnet50_csv_05.h5
Epoch 6/10
500/500 [==============================] - 835s 2s/step - loss: 0.36
58 - regression_loss: 0.3152 - classification_loss: 0.0507

Epoch 00006: saving model to ./snapshots/resnet50_csv_06.h5
Epoch 7/10
```

```
500/500 [==============================] - 831s 2s/step - loss: 0.33
54 - regression_loss: 0.2931 - classification_loss: 0.0422

Epoch 00007: saving model to ./snapshots/resnet50_csv_07.h5
Epoch 8/10
500/500 [==============================] - 832s 2s/step - loss: 0.31
66 - regression_loss: 0.2810 - classification_loss: 0.0356

Epoch 00008: saving model to ./snapshots/resnet50_csv_08.h5
Epoch 9/10
500/500 [==============================] - 827s 2s/step - loss: 0.29
63 - regression_loss: 0.2644 - classification_loss: 0.0318

Epoch 00009: saving model to ./snapshots/resnet50_csv_09.h5
Epoch 10/10
500/500 [==============================] - 824s 2s/step - loss: 0.27
79 - regression_loss: 0.2507 - classification_loss: 0.0272

Epoch 00010: saving model to ./snapshots/resnet50_csv_10.h5
```

Inference

This step involves prediction or inference score generation for different products detected in test image.

In [10]:

```
# 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)

# 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())
```

In [11]:

```python
CLASSES_FILE = 'classes.csv'
model_path = os.path.join('snapshots', sorted(os.listdir('snapshots'), reverse=True)[0])
print(model_path)

# 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()
```

```
snapshots/resnet50_csv_10.h5
```

In [14]:

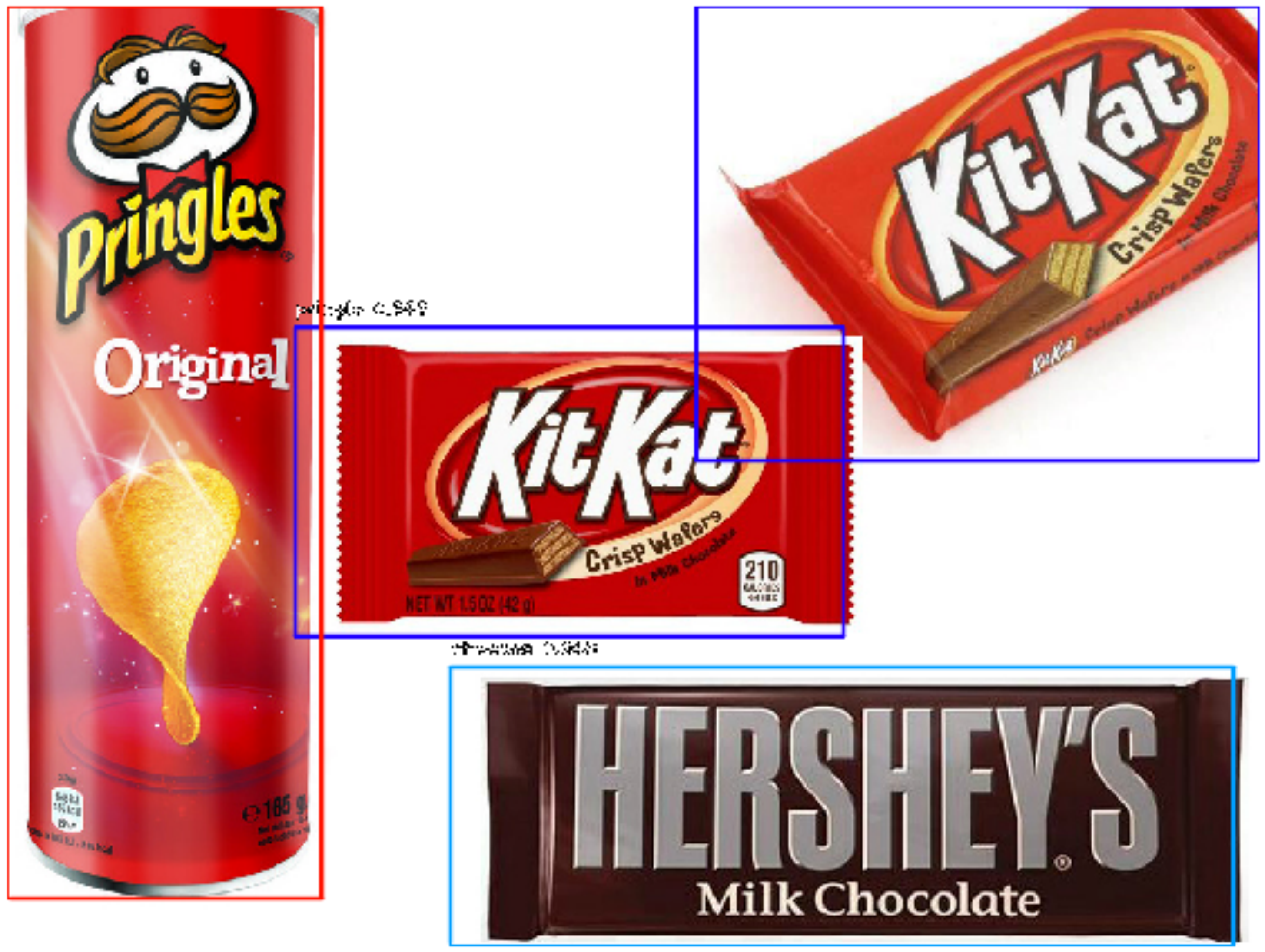
```
THRES_SCORE = 0.45
def img_inference(img_path):
    image = read_image_bgr(img_infer)
    # copy to draw on
    draw = image.copy()
    draw = cv2.cvtColor(draw, cv2.COLOR_BGR2RGB)
    # preprocess image for network
    image = preprocess_image(image)
    image, scale = resize_image(image)
    # process image
    start = time.time()
    boxes, scores, labels = model.predict_on_batch(np.expand_dims(image, axis=0)
)
    print("processing time: ", time.time() - start)
    # correct for image scale
    boxes /= scale
    product_lables=[]
    inference_scores=[]
    # 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:
            break
        color = label_color(label)
        product_lables.append(label)
        inference_scores.append(score)
        b = box.astype(int)
        draw_box(draw, b, color=color)
        caption = "{} {:.3f}".format(labels_to_names[label], score)
        draw_caption(draw, b, caption)
    plt.figure(figsize=(10, 10))
    plt.axis('off')
    plt.imshow(draw)
    plt.show()
    return product_lables,inference_scores
```

In [31]:

```python
img_infer='test9.jpg'
print('Running inference on: ' + img_infer)
products,scores=img_inference(img_infer)
print("products labels are:",products)

colors=[]
for lab in products:
    b=label_color(lab)
    colors.append(b)
colors
```

```
Running inference on: test9.jpg
processing time:  0.07264256477355957
```



```
products labels are: [1, 0, 0, 3]
```

Out[31]:

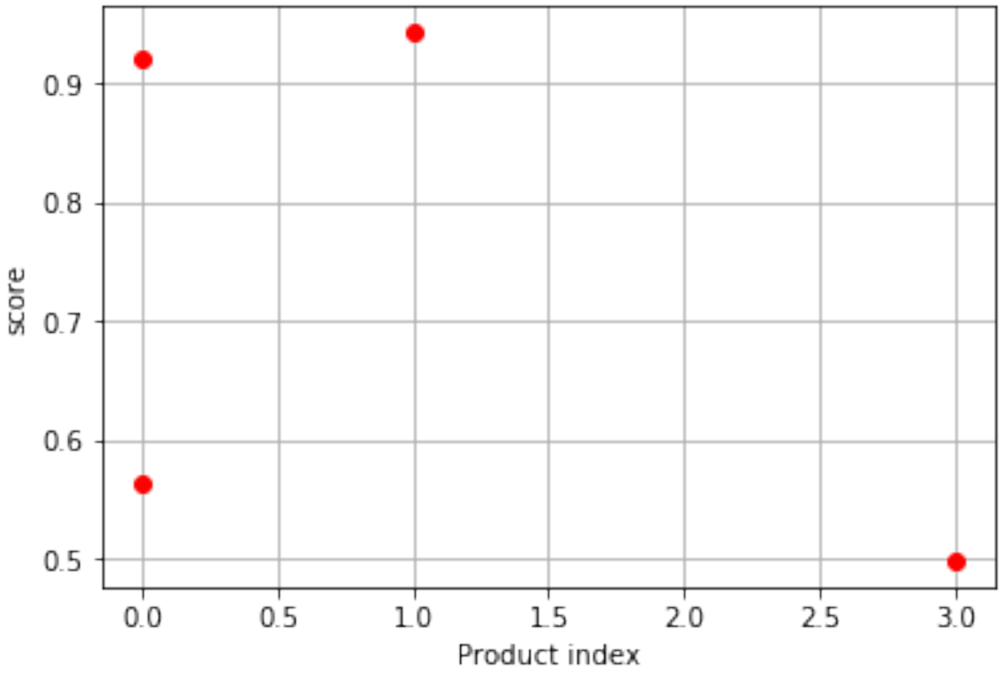
```
[[0, 159, 255], [31, 0, 255], [31, 0, 255], [255, 19, 0]]
```

In [36]:

```
plt.plot(products,scores,'ro',linewidth=2)
plt.grid()
plt.xlabel('Product index')
plt.ylabel('score')
```

Out[36]:

```
Text(0, 0.5, 'score')
```



In [15]:

```
PRICE_FILE='./../prices.csv'
df = pandas.read_csv(PRICE_FILE,header=None)
def calculate_price_for_label(label):
    col=df[df[0]==label].index.item()
    price=df[1][col]
    return price
print("Price table")
df
```

```
Price table
```

Out[15]:

	0	1
0	kitkat	2.99
1	hershey	5.00
2	reese	2.99
3	pringle	1.67
4	maggie	0.57
5	cheetos	1.59

In [16]:

```
total=0.0
for label in products:
    product=labels_to_names[label]
    print("item:",product)
    price=calculate_price_for_label(product)
    print("item:",label)
    print("price:",price)
    print("\n")
    total=total+float(price)
print("Total Amount=",total)
```

```
item: maggie
item: 1
price: 0.57


item: hershey
item: 0
price: 5.0


item: hershey
item: 0
price: 5.0


item: cheetos
item: 3
price: 1.59


Total Amount= 12.16
```

Conclusion

This jupyter notebook aims to use a pretrained model and to transer that learning for training on product image dataset to detect various products in image so to calculate the final bill amount.