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Github Repository: <https://github.com/thewitking/billing-system> (<https://github.com/thewitking/billing-system>)

Billing system based on Image segmentation using Retinanet

This Jupyter notebook implements a transfer learning approach using an already pretrained deep neural network. Consider that a business 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.

Extension: This experiment can be extended with facenet so to make a real time application for pricing the product for an individual customer using camera network approach.

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 Steps for getting the retinanet

Initial setup contains getting keras-retinanet implementation. Once we have got the retinanet we need to build it from using the source.

Get the keras-retinanet using git clone command from <https://github.com/fizyr/keras-retinanet> (<https://github.com/fizyr/keras-retinanet>) once we have got it build it.

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/msl1313/exp3/objdet_fizyr_colab/keras-retinanet
Collecting keras (from keras-retinanet===0.5.0)
Using cached <https://files.pythonhosted.org/packages/5e/10/aa32dad071ce52b5502266b5c659451cfd6ffcbf14e6c8c4f16c0ff5aaab/Keras-2.2.4-py2.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/00a976f728d0dlfecfe898238ce23f502a721c0ac0ecfedb80e0d88c64e9/six-1.12.0-py2.py3-none-any.whl>
Collecting scipy (from keras-retinanet===0.5.0)
Using cached https://files.pythonhosted.org/packages/14/49/8f13fa215e10a7ab0731cc95b0e9bb66cf83c6a98260b154cfbd0b55fb19/scipy-1.3.0-cp35-cp35m-manylinux1_x86_64.whl
Collecting cython (from keras-retinanet===0.5.0)
Using cached https://files.pythonhosted.org/packages/e7/bd/59054534d09830394470c14e4dd4a2e8fa64ac14559095a044208bf34c18/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/62/6358ccd27b9e340affaa29e3e678b5d93a4b17f6bd7533fd6e6e87930b12/Pillow-6.0.0-cp35-cp35m-manylinux1_x86_64.whl
Collecting opencv-python (from keras-retinanet===0.5.0)
Using cached https://files.pythonhosted.org/packages/fe/c8/421eeac942ebc89552a5c90c2141b936be9cfde24dc3c6eeb472c62d1f8e/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/d90f9ff03285d8eb56994e8ceclb73a4d0dc9bb529c1f8e8e10b1b663843/progressbar2-3.39.3-py2.py3-none-any.whl>
Collecting keras-preprocessing>=1.0.5 (from keras->keras-retinanet==0.5.0)
Using cached https://files.pythonhosted.org/packages/c0/bf/0315ef6a9fd3fc2346e85b0ff1f5f83ca17073f2c31ac719ab2e4da0d4a3/Keras_Preprocessing-1.0.9-py2.py3-none-any.whl
Collecting keras-applications>=1.0.6 (from keras->keras-retinanet==0.5.0)
Using cached https://files.pythonhosted.org/packages/90/85/64c82949765cfb246bbdaf5aca2d55f400f792655927a017710a78445def/Keras_Applications-1.0.7-py2.py3-none-any.whl
Collecting h5py (from keras->keras-retinanet===0.5.0)
Using cached https://files.pythonhosted.org/packages/4c/77/c4933e12dca0f61bcdafc207c7532e1250b8d12719459fd85132f3daa9fd/h5py-2.9.0-cp35-cp35m-manylinux1_x86_64.whl
Collecting numpy>=1.9.1 (from keras->keras-retinanet===0.5.0)
Using cached https://files.pythonhosted.org/packages/f6/f3/cc6c6745347c1e997cc3e58390584a250b8e22b6dfc45414a7d69a3df016/numpy-1.16.3-cp35-cp35m-manylinux1_x86_64.whl
Collecting pyyaml (from keras->keras-retinanet===0.5.0)
Collecting python-utils>=2.3.0 (from progressbar2->keras-retinanet==0.5.0)
Using cached https://files.pythonhosted.org/packages/eb/a0/19119d8b7c05be49baf6c593f11c432d571b70d805f2fe94c0585e55e4c8/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/85/24316705879941b5d2744e4b3282b78026bd9fd21618e2dc4c

Successfully built keras-retinanet

Installing collected packages: numpy, six, keras-preprocessing, scipy, h5py, keras-applications, pyyaml, keras, keras-resnet, cython, Pillow, 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 progressbar2-3.39.3 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' command.

use setup.py utility to install keras-retinanet

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_overlap.cpython-35m-x86_64-linux-gnu.so -> keras_retinanet/utils

In [4]:

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

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

Using TensorFlow backend.

Product Image Dataset

we need all the annotations related to images in Fizr 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
  ...
...
```

Get the Product image dataset and convert it from Pascal voc format to Fizyr Annotation format.

Pascal voc format looks like this:

```
1 <annotation>
2   <folder>pringle</folder>
3   <filename>205.jpg</filename>
4   <path>/Users/thewitking/Documents/dataset/pringle/205.jpg</path>
5   <source>
6     <database>Unknown</database>
7   </source>
8   <size>
9     <width>143</width>
10    <height>350</height>
11    <depth>3</depth>
12  </size>
13  <segmented>2</segmented>
14  <object>
15    <name>pringle</name>
16    <pose>Unspecified</pose>
17    <truncated>0</truncated>
18    <difficult>0</difficult>
19    <bndbox>
20      <xmin>9</xmin>
21      <ymin>7</ymin>
22      <xmax>134</xmax>
23      <ymax>348</ymax>
24    </bndbox>
25  </object>
26 </annotation>
```

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 Unzipped')
```

File Unzipped

In [8]:

```
import os
annotations = []
classes = set([])
abkdir='dataset'
tarSET_DIR=IMG_DATASET_DIR+'/'+abkdir
#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))
```

Available Products in image dataset

Show a sample of different product image.

In [10]:

```
import matplotlib.pyplot as plt

CLASSES_FILE = 'classes.csv'

labels_to_names = pandas.read_csv(CLASSES_FILE,header=None).T.loc[0].to_dict()
num_products= len(labels_to_names)
plt.figure(figsize=(20,20))
for i in range(num_products):
    product_name=labels_to_names[i]
    img_path = os.path.join('dataset/dataset',product_name,sorted(os.listdir('dataset/dataset/'+product_name), reverse=False)[2])
    print(img_path)
    image = plt.imread(img_path)
    plt.subplot(1,num_products,i+1)
    plt.imshow(image)
    plt.title(product_name)
    plt.xticks([])
    plt.yticks([])
```

dataset/dataset/pringle/201.jpg
dataset/dataset/hershey/401.jpeg
dataset/dataset/kitkat/301.jpeg
dataset/dataset/reese/101.jpg
dataset/dataset/cheetos/001.jpg
dataset/dataset/maggie/501.jpg



Get a Pretrained model

First step is to get a pretrained model.

Lets download Fizyr Resnet50 pretrained model

In [11]:

```
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)
```

pretrained model available at: ./snapshots/_pretrained_model.h5

Training Model on Product Image dataset

Lets use commandline arguements to train the model using pretrained model for weights.

command line instruction:

```
!python3 kerasretinanet/bin/train.py --freeze-backbone --random-transform --weights { Pretrained Model
Path } --batch-size ImageCount --steps STEPCOUNT --epochs nEpoch csv { annotations csv file } { classes
csv file _}
```

In [12]:

```
!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.

```
2019-05-22 04:17:17.087014: 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
2019-05-22 04:17:17.218986: 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
2019-05-22 04:17:17.219937: 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
2019-05-22 04:17:17.219973: I tensorflow/core/common_runtime/gpu/gpu
_device.cc:1435] Adding visible gpu devices: 0
2019-05-22 04:17:17.672232: I tensorflow/core/common_runtime/gpu/gpu
_device.cc:923] Device interconnect StreamExecutor with strength 1 e
dge matrix:
2019-05-22 04:17:17.672323: I tensorflow/core/common_runtime/gpu/gpu
_device.cc:929] 0
2019-05-22 04:17:17.672335: I tensorflow/core/common_runtime/gpu/gpu
_device.cc:942] 0: N
2019-05-22 04:17:17.673133: 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) connected to	Output Shape	Param #	Con
input_1 (InputLayer)	(None, None, None, 3 0		
conv1 (Conv2D) ut_1[0][0]	(None, None, None, 6 9408		inp
bn_conv1 (BatchNormalization) v1[0][0]	(None, None, None, 6 256		con
conv1_relu (Activation) conv1[0][0]	(None, None, None, 6 0		bn_
pool1 (MaxPooling2D) v1_relu[0][0]	(None, None, None, 6 0		con
res2a_branch2a (Conv2D) l1[0][0]	(None, None, None, 6 4096		poo
bn2a_branch2a (BatchNormalizati 2a_branch2a[0][0]	(None, None, None, 6 256		res
res2a_branch2a_relu (Activation a_branch2a[0][0]	(None, None, None, 6 0		bn2
padding2a_branch2b (ZeroPadding 2a_branch2a_relu[0][0]	(None, None, None, 6 0		res

res2a_branch2b (Conv2D)	(None, None, None, 6 36864	padding2a_branch2b[0][0]
bn2a_branch2b (BatchNormalizati	(None, None, None, 6 256	res2a_branch2b[0][0]
res2a_branch2b_relu (Activation	(None, None, None, 6 0	bn2a_branch2b[0][0]
res2a_branch2c (Conv2D)	(None, None, None, 2 16384	res2a_branch2b_relu[0][0]
res2a_branch1 (Conv2D)	(None, None, None, 2 16384	pool1[0][0]
bn2a_branch2c (BatchNormalizati	(None, None, None, 2 1024	res2a_branch2c[0][0]
bn2a_branch1 (BatchNormalizatio	(None, None, None, 2 1024	res2a_branch1[0][0]
res2a (Add)	(None, None, None, 2 0	bn2a_branch2c[0][0]
bn2a_branch1[0][0]		
res2a_relu (Activation)	(None, None, None, 2 0	res2a[0][0]
res2b_branch2a (Conv2D)	(None, None, None, 6 16384	res2a_relu[0][0]
bn2b_branch2a (BatchNormalizati	(None, None, None, 6 256	res2b_branch2a[0][0]
res2b_branch2a_relu (Activation	(None, None, None, 6 0	bn2b_branch2a[0][0]
padding2b_branch2b (ZeroPadding	(None, None, None, 6 0	res2b_branch2a_relu[0][0]

2b_branch2a_relu[0][0]		
res2b_branch2b (Conv2D) padding2b_branch2b[0][0]	(None, None, None, 6 36864	padding
bn2b_branch2b (BatchNormalizati 2b_branch2b[0][0]	(None, None, None, 6 256	res
res2b_branch2b_relu (Activation b_branch2b[0][0]	(None, None, None, 6 0	bn2
res2b_branch2c (Conv2D) 2b_branch2b_relu[0][0]	(None, None, None, 2 16384	res
bn2b_branch2c (BatchNormalizati 2b_branch2c[0][0]	(None, None, None, 2 1024	res
res2b (Add) b_branch2c[0][0]	(None, None, None, 2 0	bn2
res2a_relu[0][0]		
res2b_relu (Activation) 2b[0][0]	(None, None, None, 2 0	res
res2c_branch2a (Conv2D) 2b_relu[0][0]	(None, None, None, 6 16384	res
bn2c_branch2a (BatchNormalizati 2c_branch2a[0][0]	(None, None, None, 6 256	res
res2c_branch2a_relu (Activation c_branch2a[0][0]	(None, None, None, 6 0	bn2
padding2c_branch2b (ZeroPadding 2c_branch2a_relu[0][0]	(None, None, None, 6 0	res
res2c_branch2b (Conv2D) ding2c_branch2b[0][0]	(None, None, None, 6 36864	padding

bn2c_branch2b (BatchNormalizati	(None, None, None, 6 256	res
2c_branch2b[0][0]		
<hr/>		
res2c_branch2b_relu (Activation	(None, None, None, 6 0	bn2
c_branch2b[0][0]		
<hr/>		
res2c_branch2c (Conv2D)	(None, None, None, 2 16384	res
2c_branch2b_relu[0][0]		
<hr/>		
bn2c_branch2c (BatchNormalizati	(None, None, None, 2 1024	res
2c_branch2c[0][0]		
<hr/>		
res2c (Add)	(None, None, None, 2 0	bn2
c_branch2c[0][0]		
<hr/>		
res2b_relu[0][0]		
<hr/>		
res2c_relu (Activation)	(None, None, None, 2 0	res
2c[0][0]		
<hr/>		
res3a_branch2a (Conv2D)	(None, None, None, 1 32768	res
2c_relu[0][0]		
<hr/>		
bn3a_branch2a (BatchNormalizati	(None, None, None, 1 512	res
3a_branch2a[0][0]		
<hr/>		
res3a_branch2a_relu (Activation	(None, None, None, 1 0	bn3
a_branch2a[0][0]		
<hr/>		
padding3a_branch2b (ZeroPadding	(None, None, None, 1 0	res
3a_branch2a_relu[0][0]		
<hr/>		
res3a_branch2b (Conv2D)	(None, None, None, 1 147456	pad
ding3a_branch2b[0][0]		
<hr/>		
bn3a_branch2b (BatchNormalizati	(None, None, None, 1 512	res
3a_branch2b[0][0]		
<hr/>		
res3a_branch2b_relu (Activation	(None, None, None, 1 0	bn3
a_branch2b[0][0]		
<hr/>		

res3a_branch2c (Conv2D) 3a_branch2b_relu[0][0]	(None, None, None, 5 65536	res
res3a_branch1 (Conv2D) 2c_relu[0][0]	(None, None, None, 5 131072	res
bn3a_branch2c (BatchNormalizati 3a_branch2c[0][0]	(None, None, None, 5 2048	res
bn3a_branch1 (BatchNormalizatio 3a_branch1[0][0]	(None, None, None, 5 2048	res
res3a (Add) a_branch2c[0][0] bn3a_branch1[0][0]	(None, None, None, 5 0	bn3
res3a_relu (Activation) 3a[0][0]	(None, None, None, 5 0	res
res3b_branch2a (Conv2D) 3a_relu[0][0]	(None, None, None, 1 65536	res
bn3b_branch2a (BatchNormalizati 3b_branch2a[0][0]	(None, None, None, 1 512	res
res3b_branch2a_relu (Activation b_branch2a[0][0]	(None, None, None, 1 0	bn3
padding3b_branch2b (ZeroPadding 3b_branch2a_relu[0][0]	(None, None, None, 1 0	res
res3b_branch2b (Conv2D) ding3b_branch2b[0][0]	(None, None, None, 1 147456	pad
bn3b_branch2b (BatchNormalizati 3b_branch2b[0][0]	(None, None, None, 1 512	res
res3b_branch2b_relu (Activation b_branch2b[0][0]	(None, None, None, 1 0	bn3

res3b_branch2c (Conv2D) 3b_branch2b_relu[0][0]	(None, None, None, 5 65536	res
bn3b_branch2c (BatchNormalizati 3b_branch2c[0][0]	(None, None, None, 5 2048	res
res3b (Add) b_branch2c[0][0]	(None, None, None, 5 0	bn3
res3a_relu[0][0]		
res3b_relu (Activation) 3b[0][0]	(None, None, None, 5 0	res
res3c_branch2a (Conv2D) 3b_relu[0][0]	(None, None, None, 1 65536	res
bn3c_branch2a (BatchNormalizati 3c_branch2a[0][0]	(None, None, None, 1 512	res
res3c_branch2a_relu (Activation c_branch2a[0][0]	(None, None, None, 1 0	bn3
padding3c_branch2b (ZeroPadding 3c_branch2a_relu[0][0]	(None, None, None, 1 0	res
res3c_branch2b (Conv2D) ding3c_branch2b[0][0]	(None, None, None, 1 147456	pad
bn3c_branch2b (BatchNormalizati 3c_branch2b[0][0]	(None, None, None, 1 512	res
res3c_branch2b_relu (Activation c_branch2b[0][0]	(None, None, None, 1 0	bn3
res3c_branch2c (Conv2D) 3c_branch2b_relu[0][0]	(None, None, None, 5 65536	res
bn3c_branch2c (BatchNormalizati	(None, None, None, 5 2048	res

3c_branch2c[0][0]		
res3c (Add) c_branch2c[0][0]	(None, None, None, 5 0	bn3
res3b_relu[0][0]		
res3c_relu (Activation) 3c[0][0]	(None, None, None, 5 0	res
res3d_branch2a (Conv2D) 3c_relu[0][0]	(None, None, None, 1 65536	res
bn3d_branch2a (BatchNormalizati 3d_branch2a[0][0]	(None, None, None, 1 512	res
res3d_branch2a_relu (Activation d_branch2a[0][0]	(None, None, None, 1 0	bn3
padding3d_branch2b (ZeroPadding 3d_branch2a_relu[0][0]	(None, None, None, 1 0	res
res3d_branch2b (Conv2D) ding3d_branch2b[0][0]	(None, None, None, 1 147456	pad
bn3d_branch2b (BatchNormalizati 3d_branch2b[0][0]	(None, None, None, 1 512	res
res3d_branch2b_relu (Activation d_branch2b[0][0]	(None, None, None, 1 0	bn3
res3d_branch2c (Conv2D) 3d_branch2b_relu[0][0]	(None, None, None, 5 65536	res
bn3d_branch2c (BatchNormalizati 3d_branch2c[0][0]	(None, None, None, 5 2048	res
res3d (Add) d_branch2c[0][0]	(None, None, None, 5 0	bn3
res3c_relu[0][0]		

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

bn4a_branch1[0][0]		
res4a_relu (Activation) 4a[0][0]	(None, None, None, 1 0	res
res4b_branch2a (Conv2D) 4a_relu[0][0]	(None, None, None, 2 262144	res
bn4b_branch2a (BatchNormalizati 4b_branch2a[0][0]	(None, None, None, 2 1024	res
res4b_branch2a_relu (Activation b_branch2a[0][0]	(None, None, None, 2 0	bn4
padding4b_branch2b (ZeroPadding 4b_branch2a_relu[0][0]	(None, None, None, 2 0	res
res4b_branch2b (Conv2D) ding4b_branch2b[0][0]	(None, None, None, 2 589824	pad
bn4b_branch2b (BatchNormalizati 4b_branch2b[0][0]	(None, None, None, 2 1024	res
res4b_branch2b_relu (Activation b_branch2b[0][0]	(None, None, None, 2 0	bn4
res4b_branch2c (Conv2D) 4b_branch2b_relu[0][0]	(None, None, None, 1 262144	res
bn4b_branch2c (BatchNormalizati 4b_branch2c[0][0]	(None, None, None, 1 4096	res
res4b (Add) b_branch2c[0][0]	(None, None, None, 1 0	bn4
res4a_relu[0][0]		
res4b_relu (Activation) 4b[0][0]	(None, None, None, 1 0	res

res4c_branch2a (Conv2D) 4b_relu[0][0]	(None, None, None, 2 262144	res
bn4c_branch2a (BatchNormalizati 4c_branch2a[0][0]	(None, None, None, 2 1024	res
res4c_branch2a_relu (Activation c_branch2a[0][0]	(None, None, None, 2 0	bn4
padding4c_branch2b (ZeroPadding 4c_branch2a_relu[0][0]	(None, None, None, 2 0	res
res4c_branch2b (Conv2D) ding4c_branch2b[0][0]	(None, None, None, 2 589824	pad
bn4c_branch2b (BatchNormalizati 4c_branch2b[0][0]	(None, None, None, 2 1024	res
res4c_branch2b_relu (Activation c_branch2b[0][0]	(None, None, None, 2 0	bn4
res4c_branch2c (Conv2D) 4c_branch2b_relu[0][0]	(None, None, None, 1 262144	res
bn4c_branch2c (BatchNormalizati 4c_branch2c[0][0]	(None, None, None, 1 4096	res
res4c (Add) c_branch2c[0][0]	(None, None, None, 1 0	bn4
res4b_relu[0][0]		
res4c_relu (Activation) 4c[0][0]	(None, None, None, 1 0	res
res4d_branch2a (Conv2D) 4c_relu[0][0]	(None, None, None, 2 262144	res
bn4d_branch2a (BatchNormalizati 4d_branch2a[0][0]	(None, None, None, 2 1024	res

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)	padding4d_branch2b[0][0]
bn4d_branch2b (BatchNormalization)	(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 (BatchNormalization)	(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 (BatchNormalization)	(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	padding4e_branch2b[0][0]
bn4e_branch2b (BatchNormalizati	(None, None, None, 2 1024	res4e_branch2b[0][0]
res4e_branch2b_relu (Activation	(None, None, None, 2 0	bn4e_branch2b[0][0]
res4e_branch2c (Conv2D)	(None, None, None, 1 262144	res4e_branch2b_relu[0][0]
bn4e_branch2c (BatchNormalizati	(None, None, None, 1 4096	res4e_branch2c[0][0]
res4e (Add)	(None, None, None, 1 0	bn4e_branch2c[0][0]
res4d_relu[0][0]		
res4e_relu (Activation)	(None, None, None, 1 0	res4e[0][0]
res4f_branch2a (Conv2D)	(None, None, None, 2 262144	res4e_relu[0][0]
bn4f_branch2a (BatchNormalizati	(None, None, None, 2 1024	res4f_branch2a[0][0]
res4f_branch2a_relu (Activation	(None, None, None, 2 0	bn4f_branch2a[0][0]
padding4f_branch2b (ZeroPadding	(None, None, None, 2 0	res4f_branch2a_relu[0][0]
res4f_branch2b (Conv2D)	(None, None, None, 2 589824	padding4f_branch2b[0][0]
bn4f_branch2b (BatchNormalizati	(None, None, None, 2 1024	res4f_branch2b[0][0]

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]		
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) 5b_branch2b_relu[0][0]	(None, None, None, 2 1048576	res
bn5b_branch2c (BatchNormalizati 5b_branch2c[0][0]	(None, None, None, 2 8192	res
res5b (Add) b_branch2c[0][0]	(None, None, None, 2 0	bn5
res5a_relu[0][0]		
res5b_relu (Activation) 5b[0][0]	(None, None, None, 2 0	res
res5c_branch2a (Conv2D) 5b_relu[0][0]	(None, None, None, 5 1048576	res
bn5c_branch2a (BatchNormalizati 5c_branch2a[0][0]	(None, None, None, 5 2048	res
res5c_branch2a_relu (Activation c_branch2a[0][0]	(None, None, None, 5 0	bn5
padding5c_branch2b (ZeroPadding 5c_branch2a_relu[0][0]	(None, None, None, 5 0	res
res5c_branch2b (Conv2D) ding5c_branch2b[0][0]	(None, None, None, 5 2359296	pad
bn5c_branch2b (BatchNormalizati 5c_branch2b[0][0]	(None, None, None, 5 2048	res
res5c_branch2b_relu (Activation c_branch2b[0][0]	(None, None, None, 5 0	bn5
res5c_branch2c (Conv2D) 5c_branch2b_relu[0][0]	(None, None, None, 2 1048576	res
bn5c_branch2c (BatchNormalizati 5c_branch2c[0][0]	(None, None, None, 2 8192	res

res5c (Add) c_branch2c[0][0]	(None, None, None, 2 0	bn5
res5b_relu[0][0]		
res5c_relu (Activation) 5c[0][0]	(None, None, None, 2 0	res
C5_reduced (Conv2D) 5c_relu[0][0]	(None, None, None, 2 524544	res
P5_upsampled (UpsampleLike) reduced[0][0]	(None, None, None, 2 0	C5_
res4f_relu[0][0]		
C4_reduced (Conv2D) 4f_relu[0][0]	(None, None, None, 2 262400	res
P4_merged (Add) upsampled[0][0]	(None, None, None, 2 0	P5_
C4_reduced[0][0]		
P4_upsampled (UpsampleLike) merged[0][0]	(None, None, None, 2 0	P4_
res3d_relu[0][0]		
C3_reduced (Conv2D) 3d_relu[0][0]	(None, None, None, 2 131328	res
P6 (Conv2D) 5c_relu[0][0]	(None, None, None, 2 4718848	res
P3_merged (Add) upsampled[0][0]	(None, None, None, 2 0	P4_
C3_reduced[0][0]		
C6_relu (Activation)	(None, None, None, 2 0	P6[

0][0]			
P3 (Conv2D) merged[0][0]	(None, None, None, 2 590080		P3_
P4 (Conv2D) merged[0][0]	(None, None, None, 2 590080		P4_
P5 (Conv2D) reduced[0][0]	(None, None, None, 2 590080		C5_
P7 (Conv2D) relu[0][0]	(None, None, None, 2 590080		C6_
regression_submodel (Model) 0][0]	(None, None, 4)	2443300	P3[
P4[0][0]			
P5[0][0]			
P6[0][0]			
P7[0][0]			
classification_submodel (Model) 0][0]	(None, None, 6)	2484790	P3[
P4[0][0]			
P5[0][0]			
P6[0][0]			
P7[0][0]			
regression (Concatenate) ression_submodel[1][0]	(None, None, 4)	0	reg
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 [=====] - 911s 2s/step - loss: 1.33
87 - regression_loss: 0.7204 - classification_loss: 0.6182

Epoch 00001: saving model to ./snapshots/resnet50_csv_01.h5
Epoch 2/10
500/500 [=====] - 891s 2s/step - loss: 0.75
21 - regression_loss: 0.5247 - classification_loss: 0.2273

Epoch 00002: saving model to ./snapshots/resnet50_csv_02.h5
Epoch 3/10
500/500 [=====] - 900s 2s/step - loss: 0.57
71 - regression_loss: 0.4407 - classification_loss: 0.1365

Epoch 00003: saving model to ./snapshots/resnet50_csv_03.h5
Epoch 4/10
500/500 [=====] - 904s 2s/step - loss: 0.48
41 - regression_loss: 0.3887 - classification_loss: 0.0954

Epoch 00004: saving model to ./snapshots/resnet50_csv_04.h5
Epoch 5/10
500/500 [=====] - 903s 2s/step - loss: 0.43
00 - regression_loss: 0.3584 - classification_loss: 0.0717

Epoch 00005: saving model to ./snapshots/resnet50_csv_05.h5
Epoch 6/10
500/500 [=====] - 905s 2s/step - loss: 0.39
44 - regression_loss: 0.3358 - classification_loss: 0.0586

Epoch 00006: saving model to ./snapshots/resnet50_csv_06.h5
Epoch 7/10
500/500 [=====] - 910s 2s/step - loss: 0.36
18 - regression_loss: 0.3124 - classification_loss: 0.0493

```
Epoch 00007: saving model to ./snapshots/resnet50_csv_07.h5
Epoch 8/10
500/500 [=====] - 911s 2s/step - loss: 0.34
03 - regression_loss: 0.2977 - classification_loss: 0.0426

Epoch 00008: saving model to ./snapshots/resnet50_csv_08.h5
Epoch 9/10
500/500 [=====] - 912s 2s/step - loss: 0.32
06 - regression_loss: 0.2827 - classification_loss: 0.0379

Epoch 00009: saving model to ./snapshots/resnet50_csv_09.h5
Epoch 10/10
500/500 [=====] - 907s 2s/step - loss: 0.30
66 - regression_loss: 0.2722 - classification_loss: 0.0344

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

Inference Model

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

In [13]:

```
# 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())
```

Get the snapshot directory's recently trained model's path (on product image dataset)

In [14]:

```
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)

model.summary()
```

snapshots/resnet50_csv_10.h5

Layer (type) connected to	Output Shape	Param #	Con
=====			
input_1 (InputLayer)	(None, None, None, 3 0		
conv1 (Conv2D) ut_1[0][0]	(None, None, None, 6 9408		inp
bn_conv1 (BatchNormalization) v1[0][0]	(None, None, None, 6 256		con
conv1_relu (Activation) conv1[0][0]	(None, None, None, 6 0		bn_
pool1 (MaxPooling2D) v1_relu[0][0]	(None, None, None, 6 0		con
res2a_branch2a (Conv2D) l1[0][0]	(None, None, None, 6 4096		poo
bn2a_branch2a (BatchNormalizati 2a_branch2a[0][0]	(None, None, None, 6 256		res
res2a_branch2a_relu (Activation a_branch2a[0][0]	(None, None, None, 6 0		bn2
padding2a_branch2b (ZeroPadding	(None, None, None, 6 0		res

2a_branch2a_relu[0][0]		
res2a_branch2b (Conv2D) padding2a_branch2b[0][0]	(None, None, None, 6 36864	padding
bn2a_branch2b (BatchNormalizati 2a_branch2b[0][0]	(None, None, None, 6 256	res
res2a_branch2b_relu (Activation a_branch2b[0][0]	(None, None, None, 6 0	bn2
res2a_branch2c (Conv2D) 2a_branch2b_relu[0][0]	(None, None, None, 2 16384	res
res2a_branch1 (Conv2D) l1[0][0]	(None, None, None, 2 16384	pool
bn2a_branch2c (BatchNormalizati 2a_branch2c[0][0]	(None, None, None, 2 1024	res
bn2a_branch1 (BatchNormalizatio 2a_branch1[0][0]	(None, None, None, 2 1024	res
res2a (Add) a_branch2c[0][0]	(None, None, None, 2 0	bn2
bn2a_branch1[0][0]		
res2a_relu (Activation) 2a[0][0]	(None, None, None, 2 0	res
res2b_branch2a (Conv2D) 2a_relu[0][0]	(None, None, None, 6 16384	res
bn2b_branch2a (BatchNormalizati 2b_branch2a[0][0]	(None, None, None, 6 256	res
res2b_branch2a_relu (Activation b_branch2a[0][0]	(None, None, None, 6 0	bn2

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]		
bn2b_branch2b (BatchNormalizati	(None, None, None, 6 256	res
2b_branch2b[0][0]		
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]		

bn2c_branch2b (BatchNormalizati 2c_branch2b[0][0])	(None, None, None, 6 256	res
res2c_branch2b_relu (Activation c_branch2b[0][0])	(None, None, None, 6 0	bn2
res2c_branch2c (Conv2D) 2c_branch2b_relu[0][0])	(None, None, None, 2 16384	res
bn2c_branch2c (BatchNormalizati 2c_branch2c[0][0])	(None, None, None, 2 1024	res
res2c (Add) c_branch2c[0][0])	(None, None, None, 2 0	bn2
res2b_relu[0][0])		
res2c_relu (Activation) 2c[0][0])	(None, None, None, 2 0	res
res3a_branch2a (Conv2D) 2c_relu[0][0])	(None, None, None, 1 32768	res
bn3a_branch2a (BatchNormalizati 3a_branch2a[0][0])	(None, None, None, 1 512	res
res3a_branch2a_relu (Activation a_branch2a[0][0])	(None, None, None, 1 0	bn3
padding3a_branch2b (ZeroPadding 3a_branch2a_relu[0][0])	(None, None, None, 1 0	res
res3a_branch2b (Conv2D) ding3a_branch2b[0][0])	(None, None, None, 1 147456	pad
bn3a_branch2b (BatchNormalizati 3a_branch2b[0][0])	(None, None, None, 1 512	res
res3a_branch2b_relu (Activation a_branch2b[0][0])	(None, None, None, 1 0	bn3

res3a_branch2c (Conv2D) 3a_branch2b_relu[0][0]	(None, None, None, 5 65536	res
res3a_branch1 (Conv2D) 2c_relu[0][0]	(None, None, None, 5 131072	res
bn3a_branch2c (BatchNormalizati 3a_branch2c[0][0]	(None, None, None, 5 2048	res
bn3a_branch1 (BatchNormalizatio 3a_branch1[0][0]	(None, None, None, 5 2048	res
res3a (Add) a_branch2c[0][0]	(None, None, None, 5 0	bn3
bn3a_branch1[0][0]		
res3a_relu (Activation) 3a[0][0]	(None, None, None, 5 0	res
res3b_branch2a (Conv2D) 3a_relu[0][0]	(None, None, None, 1 65536	res
bn3b_branch2a (BatchNormalizati 3b_branch2a[0][0]	(None, None, None, 1 512	res
res3b_branch2a_relu (Activation b_branch2a[0][0]	(None, None, None, 1 0	bn3
padding3b_branch2b (ZeroPadding 3b_branch2a_relu[0][0]	(None, None, None, 1 0	res
res3b_branch2b (Conv2D) ding3b_branch2b[0][0]	(None, None, None, 1 147456	pad
bn3b_branch2b (BatchNormalizati 3b_branch2b[0][0]	(None, None, None, 1 512	res
res3b_branch2b_relu (Activation	(None, None, None, 1 0	bn3

b_branch2b[0][0]		
res3b_branch2c (Conv2D) 3b_branch2b_relu[0][0]	(None, None, None, 5 65536	res
bn3b_branch2c (BatchNormalizati 3b_branch2c[0][0]	(None, None, None, 5 2048	res
res3b (Add) b_branch2c[0][0]	(None, None, None, 5 0	bn3
res3a_relu[0][0]		
res3b_relu (Activation) 3b[0][0]	(None, None, None, 5 0	res
res3c_branch2a (Conv2D) 3b_relu[0][0]	(None, None, None, 1 65536	res
bn3c_branch2a (BatchNormalizati 3c_branch2a[0][0]	(None, None, None, 1 512	res
res3c_branch2a_relu (Activation c_branch2a[0][0]	(None, None, None, 1 0	bn3
padding3c_branch2b (ZeroPadding 3c_branch2a_relu[0][0]	(None, None, None, 1 0	res
res3c_branch2b (Conv2D) ding3c_branch2b[0][0]	(None, None, None, 1 147456	pad
bn3c_branch2b (BatchNormalizati 3c_branch2b[0][0]	(None, None, None, 1 512	res
res3c_branch2b_relu (Activation c_branch2b[0][0]	(None, None, None, 1 0	bn3
res3c_branch2c (Conv2D) 3c_branch2b_relu[0][0]	(None, None, None, 5 65536	res

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]		
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]		
bn3d_branch2b (BatchNormalizati	(None, None, None, 1 512	res
3d_branch2b[0][0]		
res3d_branch2b_relu (Activation	(None, None, None, 1 0	bn3
d_branch2b[0][0]		
res3d_branch2c (Conv2D)	(None, None, None, 5 65536	res
3d_branch2b_relu[0][0]		
bn3d_branch2c (BatchNormalizati	(None, None, None, 5 2048	res
3d_branch2c[0][0]		
res3d (Add)	(None, None, None, 5 0	bn3
d_branch2c[0][0]		

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

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) 4b_relu[0][0]	(None, None, None, 2 262144	res
bn4c_branch2a (BatchNormalizati 4c_branch2a[0][0]	(None, None, None, 2 1024	res
res4c_branch2a_relu (Activation c_branch2a[0][0]	(None, None, None, 2 0	bn4
padding4c_branch2b (ZeroPadding 4c_branch2a_relu[0][0]	(None, None, None, 2 0	res
res4c_branch2b (Conv2D) ding4c_branch2b[0][0]	(None, None, None, 2 589824	pad
bn4c_branch2b (BatchNormalizati 4c_branch2b[0][0]	(None, None, None, 2 1024	res
res4c_branch2b_relu (Activation c_branch2b[0][0]	(None, None, None, 2 0	bn4
res4c_branch2c (Conv2D) 4c_branch2b_relu[0][0]	(None, None, None, 1 262144	res
bn4c_branch2c (BatchNormalizati 4c_branch2c[0][0]	(None, None, None, 1 4096	res
res4c (Add) c_branch2c[0][0]	(None, None, None, 1 0	bn4
res4b_relu[0][0]		
res4c_relu (Activation) 4c[0][0]	(None, None, None, 1 0	res
res4d_branch2a (Conv2D) 4c_relu[0][0]	(None, None, None, 2 262144	res
bn4d_branch2a (BatchNormalizati 4d_branch2a[0][0]	(None, None, None, 2 1024	res

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) padding4e_branch2b[0][0]	(None, None, None, 2 589824	padding
bn4e_branch2b (BatchNormalizati 4e_branch2b[0][0]	(None, None, None, 2 1024	res
res4e_branch2b_relu (Activation e_branch2b[0][0]	(None, None, None, 2 0	bn4
res4e_branch2c (Conv2D) 4e_branch2b_relu[0][0]	(None, None, None, 1 262144	res
bn4e_branch2c (BatchNormalizati 4e_branch2c[0][0]	(None, None, None, 1 4096	res
res4e (Add) e_branch2c[0][0]	(None, None, None, 1 0	bn4
res4d_relu[0][0]		
res4e_relu (Activation) 4e[0][0]	(None, None, None, 1 0	res
res4f_branch2a (Conv2D) 4e_relu[0][0]	(None, None, None, 2 262144	res
bn4f_branch2a (BatchNormalizati 4f_branch2a[0][0]	(None, None, None, 2 1024	res
res4f_branch2a_relu (Activation f_branch2a[0][0]	(None, None, None, 2 0	bn4
padding4f_branch2b (ZeroPadding 4f_branch2a_relu[0][0]	(None, None, None, 2 0	res
res4f_branch2b (Conv2D) ding4f_branch2b[0][0]	(None, None, None, 2 589824	padding

bn4f_branch2b (BatchNormalizati	(None, None, None, 2 1024	res
4f_branch2b[0][0]		
<hr/>		
res4f_branch2b_relu (Activation	(None, None, None, 2 0	bn4
f_branch2b[0][0]		
<hr/>		
res4f_branch2c (Conv2D)	(None, None, None, 1 262144	res
4f_branch2b_relu[0][0]		
<hr/>		
bn4f_branch2c (BatchNormalizati	(None, None, None, 1 4096	res
4f_branch2c[0][0]		
<hr/>		
res4f (Add)	(None, None, None, 1 0	bn4
f_branch2c[0][0]		
<hr/>		
res4e_relu[0][0]		
<hr/>		
res4f_relu (Activation)	(None, None, None, 1 0	res
4f[0][0]		
<hr/>		
res5a_branch2a (Conv2D)	(None, None, None, 5 524288	res
4f_relu[0][0]		
<hr/>		
bn5a_branch2a (BatchNormalizati	(None, None, None, 5 2048	res
5a_branch2a[0][0]		
<hr/>		
res5a_branch2a_relu (Activation	(None, None, None, 5 0	bn5
a_branch2a[0][0]		
<hr/>		
padding5a_branch2b (ZeroPadding	(None, None, None, 5 0	res
5a_branch2a_relu[0][0]		
<hr/>		
res5a_branch2b (Conv2D)	(None, None, None, 5 2359296	pad
ding5a_branch2b[0][0]		
<hr/>		
bn5a_branch2b (BatchNormalizati	(None, None, None, 5 2048	res
5a_branch2b[0][0]		
<hr/>		
res5a_branch2b_relu (Activation	(None, None, None, 5 0	bn5
a_branch2b[0][0]		
<hr/>		

res5a_branch2c (Conv2D) 5a_branch2b_relu[0][0]	(None, None, None, 2 1048576	res
res5a_branch1 (Conv2D) 4f_relu[0][0]	(None, None, None, 2 2097152	res
bn5a_branch2c (BatchNormalizati 5a_branch2c[0][0]	(None, None, None, 2 8192	res
bn5a_branch1 (BatchNormalizatio 5a_branch1[0][0]	(None, None, None, 2 8192	res
res5a (Add) a_branch2c[0][0] bn5a_branch1[0][0]	(None, None, None, 2 0	bn5
res5a_relu (Activation) 5a[0][0]	(None, None, None, 2 0	res
res5b_branch2a (Conv2D) 5a_relu[0][0]	(None, None, None, 5 1048576	res
bn5b_branch2a (BatchNormalizati 5b_branch2a[0][0]	(None, None, None, 5 2048	res
res5b_branch2a_relu (Activation b_branch2a[0][0]	(None, None, None, 5 0	bn5
padding5b_branch2b (ZeroPadding 5b_branch2a_relu[0][0]	(None, None, None, 5 0	res
res5b_branch2b (Conv2D) ding5b_branch2b[0][0]	(None, None, None, 5 2359296	pad
bn5b_branch2b (BatchNormalizati 5b_branch2b[0][0]	(None, None, None, 5 2048	res
res5b_branch2b_relu (Activation b_branch2b[0][0]	(None, None, None, 5 0	bn5

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) c_branch2c[0][0]	(None, None, None, 2 0	bn5
res5b_relu[0][0]		
res5c_relu (Activation) 5c[0][0]	(None, None, None, 2 0	res
C5_reduced (Conv2D) 5c_relu[0][0]	(None, None, None, 2 524544	res
P5_upsampled (UpsampleLike) reduced[0][0]	(None, None, None, 2 0	C5_
res4f_relu[0][0]		
C4_reduced (Conv2D) 4f_relu[0][0]	(None, None, None, 2 262400	res
P4_merged (Add) upsampled[0][0]	(None, None, None, 2 0	P5_
C4_reduced[0][0]		
P4_upsampled (UpsampleLike) merged[0][0]	(None, None, None, 2 0	P4_
res3d_relu[0][0]		
C3_reduced (Conv2D) 3d_relu[0][0]	(None, None, None, 2 131328	res
P6 (Conv2D) 5c_relu[0][0]	(None, None, None, 2 4718848	res
P3_merged (Add) upsampled[0][0]	(None, None, None, 2 0	P4_
C3_reduced[0][0]		

C6_relu (Activation) 0][0]	(None, None, None, 2 0		P6[
P3 (Conv2D) merged[0][0]	(None, None, None, 2 590080		P3_
P4 (Conv2D) merged[0][0]	(None, None, None, 2 590080		P4_
P5 (Conv2D) reduced[0][0]	(None, None, None, 2 590080		C5_
P7 (Conv2D) relu[0][0]	(None, None, None, 2 590080		C6_
anchors_0 (Anchors) 0][0]	(None, None, 4)	0	P3[
anchors_1 (Anchors) 0][0]	(None, None, 4)	0	P4[
anchors_2 (Anchors) 0][0]	(None, None, 4)	0	P5[
anchors_3 (Anchors) 0][0]	(None, None, 4)	0	P6[
anchors_4 (Anchors) 0][0]	(None, None, 4)	0	P7[
regression_submodel (Model) 0][0]	(None, None, 4)	2443300	P3[
P4[0][0]			
P5[0][0]			
P6[0][0]			
P7[0][0]			
anchors (Concatenate)	(None, None, 4)	0	anc

hors_0[0][0]			
anchors_1[0][0]			
anchors_2[0][0]			
anchors_3[0][0]			
anchors_4[0][0]			
<hr/>			
regression (Concatenate) ression_submodel[1][0]	(None, None, 4)	0	reg
regression_submodel[2][0]			
regression_submodel[3][0]			
regression_submodel[4][0]			
regression_submodel[5][0]			
<hr/>			
boxes (RegressBoxes) hors[0][0]	(None, None, 4)	0	anc
regression[0][0]			
<hr/>			
classification_submodel (Model) 0][0]	(None, None, 6)	2484790	P3[
P4[0][0]			
P5[0][0]			
P6[0][0]			
P7[0][0]			
<hr/>			
clipped_boxes (ClipBoxes) ut_1[0][0]	(None, None, 4)	0	inp
boxes[0][0]			
<hr/>			
classification (Concatenate) ssification_submodel[1][0]	(None, None, 6)	0	cla
classification_submodel[2][0]			
classification_submodel[3][0]			

classification_submodel[4][0]

classification_submodel[5][0]

filtered_detections (FilterDete [(None, 300, 4), (No 0 clipped_boxes[0][0]

classification[0][0]

=====

=====

Total params: 36,486,682

Trainable params: 12,925,530

Non-trainable params: 23,561,152

In [23]:

```
THRES_SCORE = 0.5
# get the label to names mapping for displaying
labels_to_names = pandas.read_csv(CLASSES_FILE,header=None).T.loc[0].to_dict()

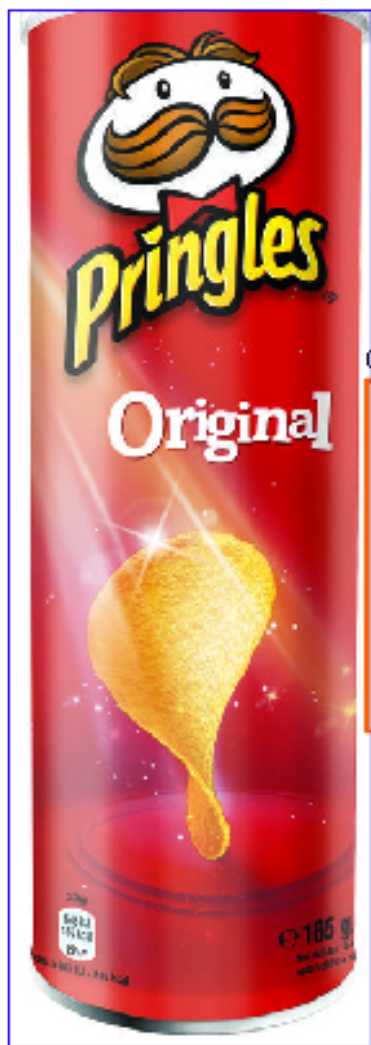
def img_inference(img_path):
    image = read_image_bgr(img_infer)
    # copy to draw on
    draw = image.copy()
    draw = cv2.cvtColor(draw, cv2.COLOR_BGR2RGB)
    # preprocess image for network
    image = preprocess_image(image)
    image, scale = resize_image(image)
    # process image
    start = 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_labels=[]
    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_labels.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_labels,inference_scores
```

In [29]:

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

for i in range(product_count):
    product_name=labels_to_names[i]
    product_inf_score=scores[i]
    print("Product Label",products[i])
    print("Product Name:",product_name)
    print("Inference score:",product_inf_score)
    print("=====")
```

Running inference on: test9.jpg
processing time: 0.07398509979248047



Product Name



Product Name



products labels are: [2, 2, 1, 0]

products score are: [0.9851149, 0.9413011, 0.9386572, 0.6491825]

Product Label 2

Product Name: pringle

Inference score: 0.9851149

=====

Product Label 2

Product Name: hershey

Inference score: 0.9413011

=====

Product Label 1

Product Name: kitkat

Inference score: 0.9386572

=====

Product Label 0

Product Name: reese

Inference score: 0.6491825

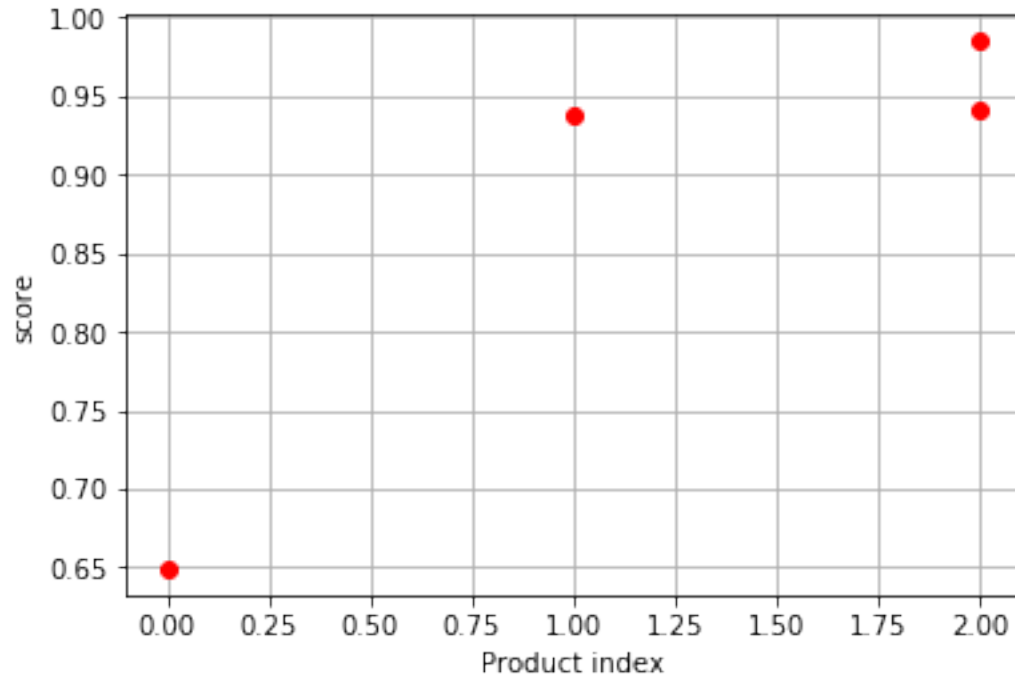
=====

In [30]:

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

Out[30]:

Text(0, 0.5, 'score')



In [31]:

```
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[31]:

	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 [34]:

```
total=0.0
print("products :",products)
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("-----")
    total=total+float(price)
print("=====")
print("Total Amount=",total)
```

```
products : [2, 2, 1, 0]
item: kitkat
item: 2
price: 2.99
-----
item: kitkat
item: 2
price: 2.99
-----
item: hershey
item: 1
price: 5.0
-----
item: pringle
item: 0
price: 1.67
-----
=====
Total Amount= 12.65
```

Conclusion

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

Shown above is an example where an image having four different products is used with already trained model on our product image dataset and it recognizes each object properly and calculates its price.