

Tensor Flow Object Detection Walk-through

Walk-through video:

<https://www.youtube.com/watch?v=rWFg6R5ccOc>

Table of Contents:

- 1) Complete the previous walk-throughs.
- 2) Complete the previous walk-throughs.
- 3) Clone the repository containing this document
- 4) Follow TensorFlow Object Detection API readme installation instructions
- 5) Clone the TensorFlow “models” repository
- 6) Download and Compile Protobuf
- 7) Test the TensorFlow Object Detection API using the pre-trained model within a Jupyter Notebook
- 8) Run [0_verify_models_and_protoc_install.py](#) to test the TensorFlow Object Detection API using the pre-trained model outside of a Jupyter Notebook
- 9) Download Images for training / testing
- 10) Use the program “labelImg” to create a .xml file to go with each scene image
- 11) Make “training_images” and “test_images” directories, then copy each image / .xml pair into these
- 12) Run [1_xml_to_csv.py](#) to convert the .xml file for each image to 2 .csv files, one for training and one for evaluation
- 13) Run [2_generate_tfrecords.py](#) to Create training and testing .tfrecord files
- 14) Choose, download, and extract a model (“ssd_inception_v2_coco” is recommended)
- 15) Check / edit “label_map.pbtxt”
- 16) Check / edit “ssd_inception_v2_coco.config”
- 17) Run [3_train.py](#) to perform the training
- 18) Run [4_export_inference_graph.py](#) to export the Inference Graph
- 19) Run [5_test.py](#) to test on your own images

1) Complete the previous walk-throughs.

Complete these previous walk-throughs if you have not already:

TensorFlow Tutorial 1:

https://www.youtube.com/watch?v=oXWVuK_NjbY

https://github.com/MicrocontrollersAndMore/TensorFlow_Tut_1_Installation_and_First_Progs

TensorFlow Tutorial 2:

<https://www.youtube.com/watch?v=oXpsAiSajE0>

https://github.com/MicrocontrollersAndMore/TensorFlow_Tut_2_Classification_Walk-through

2) Complete the previous walk-throughs.

Really, seriously, complete the above walk-throughs before continuing with this one:

TensorFlow Tutorial 1:

https://www.youtube.com/watch?v=oXWVuK_NjbY

https://github.com/MicrocontrollersAndMore/TensorFlow_Tut_1_Installation_and_First_Progs

TensorFlow Tutorial 2:

<https://www.youtube.com/watch?v=oXpsAiSajE0>

https://github.com/MicrocontrollersAndMore/TensorFlow_Tut_2_Classification_Walk-through

This walk-through won't work if you haven't performed the steps in the previous walk-throughs. Go through these previous walk-throughs before continuing if you haven't already.

3) Backdate to TensorFlow 1.8

With the current version of TensorFlow (1.10 as I'm typing this) there are some incompatibilities between TensorFlow 1.10 and models (more on models later) 1.10. To Remedy these incompatibilities it is necessary to backdate TensorFlow to 1.8.

Check your TensorFlow version:

```
pip3 list
```

If not 1.8.0, open an **administrative** command prompt and enter:

```
pip3 uninstall tensorflow  
(wait until the uninstall is complete)
```

(if using TensorFlow CPU version)

```
pip3 install --upgrade tensorflow==1.8.0
```

(if using TensorFlow GPU version)

```
pip3 install --upgrade tensorflow-gpu==1.8.0
```

4) Clone the repository containing this document

Clone the repository containing this document:

https://github.com/MicrocontrollersAndMore/TensorFlow_Tut_3_Object_Detection_Walk-through

to a location you'd like to work in, for example I'll use:

C:\Users\cdahms\Documents\TensorFlow_Tut_3_Object_Detection_Walk-through

You can choose any directory you'd like. Going forward in this document we'll refer to this location as:
(repository_location)

5) Follow TensorFlow Object Detection API readme installation instructions

Google on "TensorFlow Object Detection API", this should take you to:

https://github.com/tensorflow/models/tree/master/research/object_detection

Scroll down to the readme.md and, under "Setup", choose the "Installation" link, this should take you to:

https://github.com/tensorflow/models/blob/master/research/object_detection/g3doc/installation.md

In subsequent steps we will more or less follow these Object Detection API instructions, with some modifications due to these instructions being intended for Mac / Linux use and this document being a Windows walk-through.

Open an **administrative** command prompt, then copy/paste in the following commands one by one (modified for Windows use):

```
pip3 install pillow  
pip3 install lxml  
pip3 install jupyter  
pip3 install matplotlib  
pip3 install pandas
```

6) Clone the TensorFlow "models" repository and backdate to commit dea7ecf

Create a directory "C:\TensorFlow" (or use a different drive letter if you prefer), then clone the TensorFlow "models" repository:

<https://github.com/tensorflow/models>

to this location.

Next, to avoid compatibility concerns that seem to be present in the newest version of models, backdate to commit dea7ecf, which is for models 1.8.1 but is a non-release commit so it will retain the research directory:

```
cd C:\TensorFlow\models  
git commit dea7ecf
```

7) Download and Compile Protobuf

Continuing with the TensorFlow Object Detection API readme.md installation instructions, Google on “Google Protobuf GitHub”, this should take you to <https://github.com/google/protobuf>. Choose “releases” (top-right center-ish on the page) and download the Windows version of either the latest release, or v3.4.0 if the latest release results in errors in the subsequent steps. At the time of this writing I’ve found v3.5.1 cannot successfully parse the *.proto command below so for the moment version v3.4.0 is recommended. If when you’re reading these instructions a substantially newer version is available you may want to try the newer version.

In any case, download the applicable win32.zip, ex. “protoc-3.4.0-win32.zip” or “protoc-X.X.X-win32.zip” if you’re trying a more recent version. Bear in mind that you will need to adjust the rest of the commands in this document per your chosen protoc version.

Extract your download and copy the extracted directory to C:\, so as to end up with Protobuf at the location “C:\protoc-3.4.0-win32”. Note that this directory should include “bin\”, “include\”, and “readme.txt”

Navigate to “C:\TensorFlow\models\research\object_detection\protos”, you will find many files ending in .proto, but none ending in .py. The next step will create .py files in this directory.

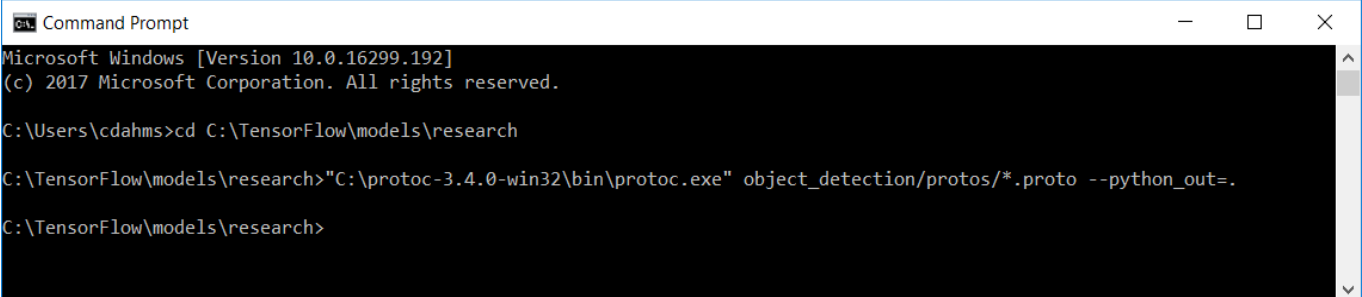
Bring up a command prompt and cd into the models\research directory with the following command:

```
cd C:\TensorFlow\models\research
```

then enter the following command to compile protoc:

```
“C:\protoc-3.4.0-win32\bin\protoc.exe” object_detection/protos/*.proto --python_out=.
```

If this command works, there will be no message, like so:



```
Command Prompt
Microsoft Windows [Version 10.0.16299.192]
(c) 2017 Microsoft Corporation. All rights reserved.

C:\Users\cdahms>cd C:\TensorFlow\models\research

C:\TensorFlow\models\research>"C:\protoc-3.4.0-win32\bin\protoc.exe" object_detection/protos/*.proto --python_out=.

C:\TensorFlow\models\research>
```

If this command does not work, there will most likely be an error message.

Note that you have to either enter the protoc-3.4.0-win32 directory in your PATH, or specify the full path at the command prompt as show here.

Next navigate back to “C:\TensorFlow\models\research\object_detection\protos”, if the compile was successful, there will now be a .py file for each .proto file.

8) Test the TensorFlow Object Detection API using the pre-trained model within a Jupyter Notebook

Open a command prompt and cd to the \models\research\object_detection direction, ex:

```
cd C:\TensorFlow\models\research\object_detection
```

Note that this directory contains a “object_detection_tutorial.ipynb” Jupyter Notebook file. Enter this command at the command prompt to start this notebook

```
jupyter notebook
```

This should start a Jupyter Notebook in your default browser.

In the Jupyter Notebook in your browser, choose “object_detection_tutorial.ipynb”, then at the top choose “Cell”, then “Run All”.

The notebook script will take perhaps a few minutes to run, unfortunately Jupyter Notebooks do not seem to provide any kind of progress bar or indication the script is running. After a few minutes (perhaps slightly longer depending on your computer and internet connection speed) you will see two example output images at the bottom of the page, one of two dogs being identified, and the other of various people and kites being identified at a beach.

The actual detection is pretty quick, most of the time in this example is downloading the pre-trained COCO model (more details on this later).

9) Run [0_verify_models_and_protoc_install.py](#) to test the TensorFlow Object Detection API using the pre-trained model outside of a Jupyter Notebook

In [\(repository_location\)](#) open the file “0_verify_models_and_protoc_install.py” in your chosen Python editor, ex. PyCharm. You may notice red underlines beneath the following two lines at the top:

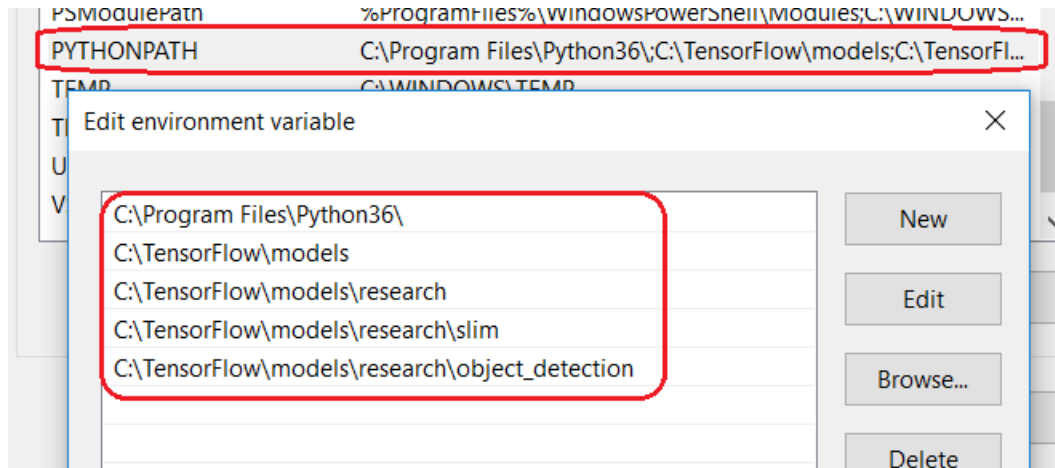
```
from utils import label_map_util
from utils import visualization_utils as vis_util
```

If you attempt to run the script you will likely get an error to the effect of “ModuleNotFoundError: No module named 'utils'”, this is because we haven’t yet informed Windows of the location of the TensorFlow models repository so the script can’t find the necessary libraries when ran. To remedy this, proceed as follows:

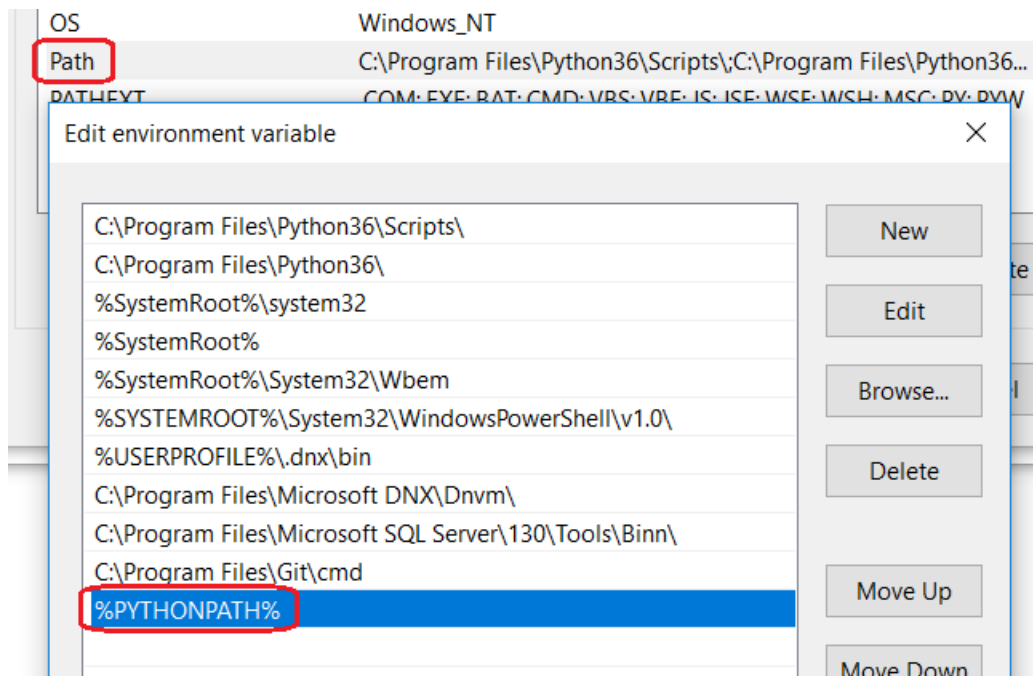
Go to System -> Advanced system settings -> Environment Variables -> System Variables -> New, and add a variable with the name PYTHONPATH and these values:

C:\Program Files\Python36\
C:\TensorFlow\models
C:\TensorFlow\models\research
C:\TensorFlow\models\research\slim
C:\TensorFlow\models\research\object_detection

When you're done PYTHONPATH should look like this:

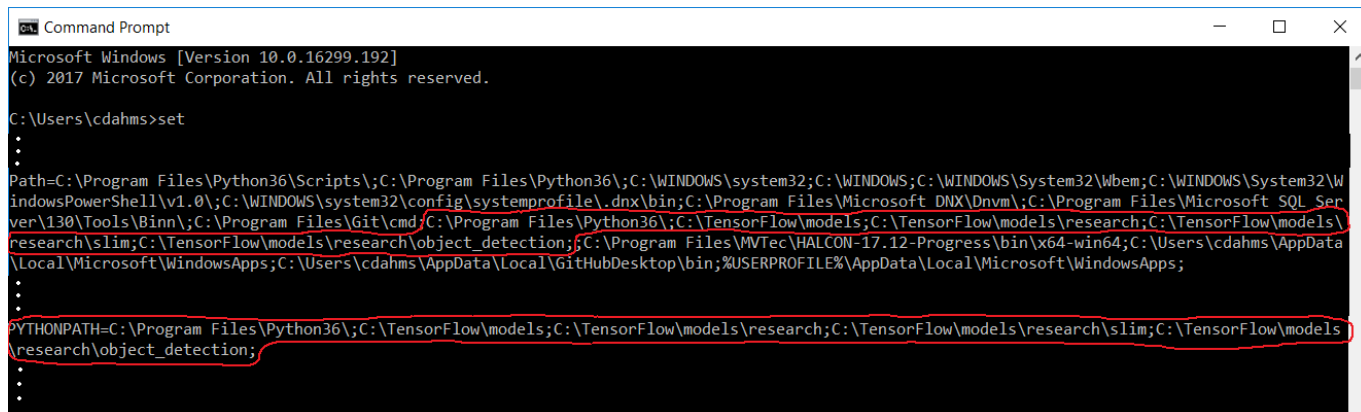


Next, while still in Environment Variables, edit PATH and add %PYTHONPATH% like so:



Reboot so the path changes take effect (do NOT skip this step)

After the reboot is complete, pull up a command prompt and type "set" with no parameters, this will show the contents of all your environment variables. Verify PATH and PYTHONPATH have the values you entered above:



```
Microsoft Windows [Version 10.0.16299.192]
(c) 2017 Microsoft Corporation. All rights reserved.

C:\Users\cdahms>set

Path=C:\Program Files\Python36\Scripts\;C:\Program Files\Python36\;C:\WINDOWS\system32;C:\WINDOWS;C:\WINDOWS\System32\Wbem;C:\WINDOWS\System32\WindowsPowerShell\v1.0\;C:\WINDOWS\system32\config\systemprofile\.dnx\bin;C:\Program Files\Microsoft DNX\Dnvm\;C:\Program Files\Microsoft SQL Server\130\Tools\Binn\;C:\Program Files\Git\cmd\;C:\Program Files\Python36\;C:\TensorFlow\models;C:\TensorFlow\models\research;C:\TensorFlow\models\research\slim;C:\TensorFlow\models\research\object_detection;C:\Program Files\MVTec\HALCON-17.12-Progress\bin\x64-win64;C:\Users\cdahms\AppData\Local\Microsoft\WindowsApps;C:\Users\cdahms\AppData\Local\GitHubDesktop\bin;%USERPROFILE%\AppData\Local\Microsoft\WindowsApps;

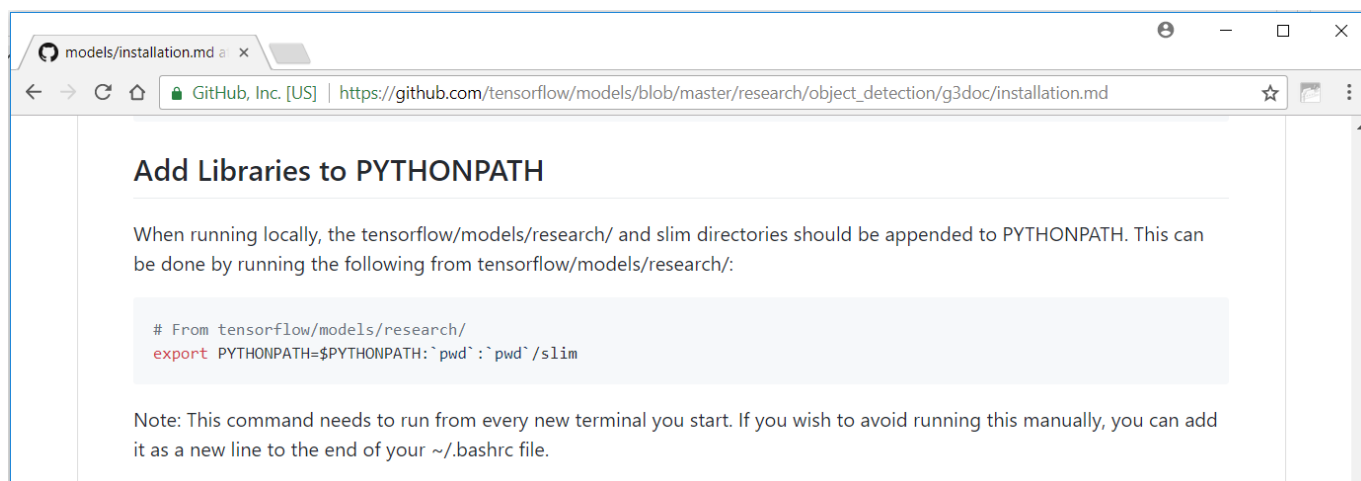
PYTHONPATH=C:\Program Files\Python36\;C:\TensorFlow\models;C:\TensorFlow\models\research;C:\TensorFlow\models\research\slim;C:\TensorFlow\models\research\object_detection;
```

In ([repository_location](#)) open the file “0_verify_models_and_protoc_install.py” again, the red underlines under the from utils import lines should now be gone. Verify the paths in the “module level variables” section at the top are correct, then go ahead and run the script. It should run successfully, producing substantially the same result as the object_detection_tutorial.ipynb file did in the notebook, the only difference being the two images will be shown one at a time in OpenCV windows. Click on the image window and press any key to go to the next image or end the program if on the 2nd image.

Once this script runs from a directory other than C:\TensorFlow\models\research\object_detection you’ve proven out the path entries above and should now be able to run this script, or any script that uses `from utils import` from any directory.

Take a moment to skim the “0_verify_models_and_protoc_install.py” code, you don’t have to understand the details of every line fully but try to familiarize yourself with the gist of the steps involved. You should be able to verify the content of this file is similar to the “object_detection_tutorial.ipynb” contents, with relatively minor modifications to adjust from being ran as a regular Python file rather than within a Jupyter Notebook.

Note that the TensorFlow Object Detection API Installation instructions mentioned above state the following:



Add Libraries to PYTHONPATH

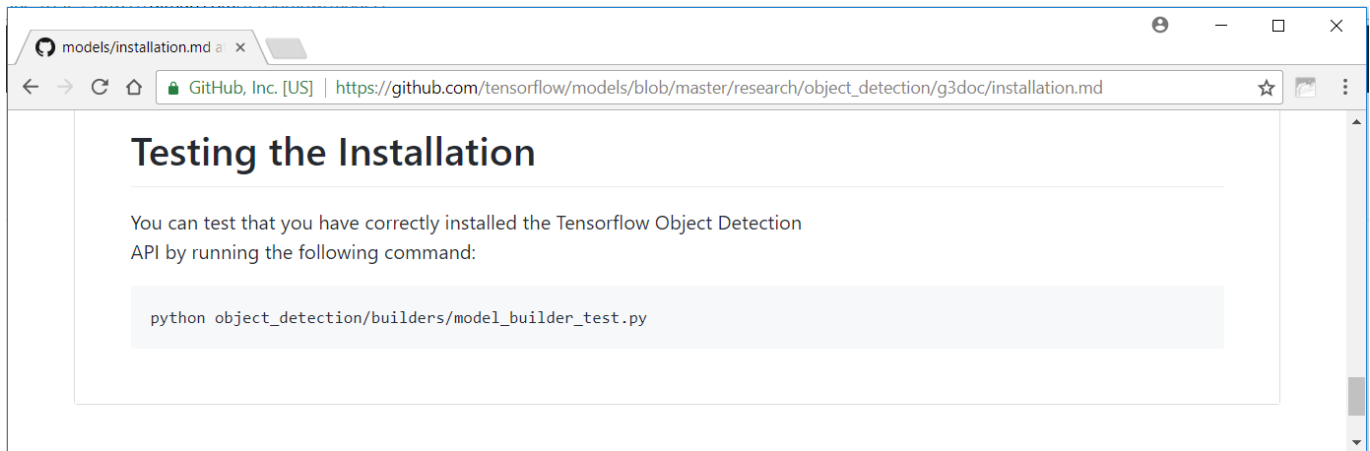
When running locally, the tensorflow/models/research/ and slim directories should be appended to PYTHONPATH. This can be done by running the following from tensorflow/models/research/:

```
# From tensorflow/models/research/
export PYTHONPATH=$PYTHONPATH:`pwd`:`pwd`/slim
```

Note: This command needs to run from every new terminal you start. If you wish to avoid running this manually, you can add it as a new line to the end of your ~/.bashrc file.

The PYTHONPATH and PATH editing steps we just performed are the Windows equivalent of this.

Once we've gotten "0_verify_models_and_protoc_install.py" to run the TensorFlow Object Detection API install is complete. If you'd like to complete the TensorFlow Object Detection API installation instructions, the final step as stated is:



Since we've verified "0_verify_models_and_protoc_install.py" runs this isn't really necessary at this point, however if you'd like you can copy the file

C:\TensorFlow\models\research\object_detection\builders\model_builder_test.py

to any directory and verify it runs as well, the output of running this script should be similar to:

.....

Ran 11 tests in 0.089s

OK

Now that we've gotten 0_verify_models_and_protoc_install.py to run using the pretrained model, we'll make our own model

10) Download Images for training / testing

Download at least 110 images (preferably more) of an object you'd like to identify in a scene. You can use my downloaded images of scenes with traffic lights if you'd like to save time on this step:

Google Drive:

<https://drive.google.com/drive/folders/1pWnmPuMv9LJ5Cw0UybVaHJGXTJ9QECRF?usp=sharing>

OneDrive:

https://1drv.ms/f/s!AoYpNs_C1pusgxm5ziwTZtL6B7Io

I'm providing links to both my Google Drive and my OneDrive with these images so if one or the other ever goes missing the other will still be available. The images are the same on both.

Downloading at least 110 images is recommended so when we separate out 10 images for testing, we will still have at least 100 different images for training.

11) Use the program “labellmg” to create a .xml file to go with each scene image

If you’d like to save time for the moment on this step, you can download my images with the already created labels:

Google Drive:

<https://drive.google.com/drive/folders/1OFx1QpVFx7A0JZA4GTgB4Rm1lIFDemlm?usp=sharing>

OneDrive:

https://1drv.ms/f/s!AoYpNs_C1pusgxo-0saTbmrEUw1N

However, I suggest going through the labeling process. It’s not difficult and you will need to know how to do this when you use your own images later on.

Google on “labellmg GitHub”, that should take you to <https://github.com/tzutalin/labellmg>

In the readme.md, scroll down to the “Download prebuild binaries” section, then choose the “Windows & Linux” link. Scroll to the bottom of the next screen and click on the most recent Windows version download, ex. “Windows_v1.6.0” as of this writing.

Make a directory in Program Files named labellmg_vX.X.X where X.X.X is your version number, ex:

C:\Program Files\labellmg_v1.6.0

Then extract the labellmg pre-build binary zip to this location. If the zip contains an extra layer of folder with the same name as the zip you can remove the unnecessary layer, the idea is the contents of the zip, currently an executable “labellmg.exe” and a directory “data” should end up in “C:\Program Files\labellmg_v1.5.2”.

Double-click on labellmg.exe to start the program, it should start and run without any further steps. You may want to add a desktop shortcut and/or pin to the start menu or taskbar for convenience.

To use labellmg, choose “Open Dir” on the left, then choose the directory with your saved images in it. “File List” at the bottom right will list all the images in the directory, and you can use the “Next Image” and “Previous Image” buttons to navigate back and forth. Note that files are navigated through within labellmg in ASCII order not numeric order, i.e. the order of 1.jpg, 2.jpg, 10.jpg, and 100.jpg would be 1.jpg, 10.jpg, 100.jpg, and 2.jpg.

Use Ctrl + mouse wheel to zoom out or in. Note that when zooming in the window will zoom in towards where the mouse cursor is, so for example if you’d like to zoom in toward the top left of the image, put the mouse cursor towards the top left, then use Ctrl + mouse wheel to zoom in. Once zoomed in there is not currently a pan feature, however you can use the horizontal and vertical scroll bars to move around.

When you're ready to draw a box around an object you'd like to train on, simply choose "Create RectBox" on the left and left-click and drag a box with the mouse. For the first box drawn, you will be prompted to enter a text description of the classification, for example, "traffic_light". Make sure to not include a space in the name, use underscores if necessary. If you enter the classification description in the "Use default label" text box and check the adjacent check box then you won't be prompted for this each time.

When you've drawn a box around each instance of an object you'd like to train on in an image, choose "Save" on the left and labellmg will prompt to save an .xml file in the same directory as the image with the same name, but ending in .xml instead of an image file extension.

Once you get the hand of the labellmg UI you'll find that it only takes perhaps 5-10 seconds to label each image, so you can label quite a few images in a relatively short amount of time.

Take a look at you're xml files as you go, they should look something like this:

```
<annotation>
  <folder>traffic_lights_with_info</folder>
  <filename>1.jpg</filename>
  <path>/home/cdahms/Dropbox/OpenCV pics and stuff/traffic_lights_with_info/1.jpg</path>
  <source>
    <database>Unknown</database>
  </source>
  <size>
    <width>1259</width>
    <height>942</height>
    <depth>3</depth>
  </size>
  <segmented>0</segmented>
  <object>
    <name>traffic_light</name>
    <pose>Unspecified</pose>
    <truncated>0</truncated>
    <difficult>0</difficult>
    <bndbox>
      <xmin>441</xmin>
      <ymin>321</ymin>
      <xmax>472</xmax>
      <ymax>383</ymax>
    </bndbox>
  </object>
  <object>
    <name>traffic_light</name>
    <pose>Unspecified</pose>
    <truncated>0</truncated>
    <difficult>0</difficult>
    <bndbox>
      <xmin>990</xmin>
      <ymin>267</ymin>
      <xmax>1028</xmax>
      <ymax>348</ymax>
    </bndbox>
  </object>
</annotation>
```

In the event labellmg ever disappears, I've forked it to my GitHub:

<https://github.com/MicrocontrollersAndMore/labellmg>

Hopefully labellmg will be around for a long time as it's fantastic for this purpose, but just in case something unusual should happen to the original I'll keep the fork on my GitHub as a back-up.

Before we move on to the next step, some anti-virus programs seem to flag labellmg as a virus:

<https://www.virustotal.com/#/file/7111532720254e72f53441b0e9854eb851b2d9a6871e11568fb3cfce28fba7f8/detection>

There is an issue filed on the labellmg GitHub pertaining to this:

<https://github.com/tzutalin/labellmg/issues/178>

As of version 1.6.0, Windows Defender does not report labellmg to be a virus. I've built labellmg from source and used it under Ubuntu 16.04 and had no problems. Somebody who is very skeptical may point out that, when using a pre-built binary, it is possible the author could have put malware in the pre-built binary that is not in the repository source on GitHub, however I feel this is extraordinarily unlikely. labellmg has a substantial user community, if the pre-built binary contained malware surely this would have been mentioned in the repo issues or on an online forum somewhere (I was not able to find any comments this effect anywhere).

If you are obsessed over security, you could read every line in the labellmg GitHub repository to assure there is not any malicious content, then follow the readme.md instructions to build from source. However, I've used the pre-build binary for a while with no ill effects, I'm pretty confident it's more than safe and reviewing every line of source then compiling from source is almost for certain not necessary. However, I cannot personally guarantee this so if you demand the utmost in security then reviewing every line of code and compiling from source is the only option.

12) Make "training_images" and "test_images" directories, then copy each image / .xml pair into these

In [\(repository_location\)](#), make a directory "training_images" and a directory "test_images". From wherever you saved your images and associated .xml files from the previous step, copy (make sure to copy rather than move to preserve the originals) them all into the "test_images" directory you just made, for example in my case I would copy the images and the associated .xml files to:

C:\Users\cdahms\Documents\TensorFlow_Tut_3_Object_Detection_Walk-through\test_images

Note that although the file location is included in the .xml files, this will be removed when we convert to .csv in the next step, so it is not necessary to update this file location when moving the .xml files.

Next, choose 10 images and the associated .xml files to test on and move (don't copy) those from [\(repository_location\)](#)\training_images into [\(repository_location\)](#)\test_images. Note that we are separating out the images we will use before training (the next step) so the images we test on will not have been used for training.

13) Run [1_xml_to_csv.py](#) to convert the .xml file for each image to 2 .csv files, one for training and one for evaluation

Next, in [\(repository_location\)](#), make a directory "training_data", the script we are about to run will write two .csv files which summarize the .xml content to this location.

With your chosen Python editor, in [\(repository_location\)](#) open the file "1_xml_to_csv.py". Verify the paths in the module level variables section at the top are correct, then run the script, then check the data directory in [\(repository_location\)](#) and you should find "train_labels.csv" and "eval_labels.csv", for example in my case in location of these files would be:

C:\Users\cdahms\Documents\TensorFlow_Tut_3_Object_Detection_Walk-through\data\train_labels.csv

C:\Users\cdahms\Documents\TensorFlow_Tut_3_Object_Detection_Walk-through\data\eval_labels.csv

Open these files in Notepad or any other editor that will show .csv file content without suggesting to convert to a different format. Opening these .csv files with Excel is not recommended since Excel will try to get you to convert to .xlsx file format which we don't want to do. Verify the files are not empty and contain roughly the correct number of lines for the images you used. Note that there will be a line in each .csv file for each box drawn, not a line for each image. i.e. if in your training set you had 100 images and drew a total of 250 boxes, there should be 250 lines in your train_labels.csv file (not 100 lines).

14) Run [2_generate_tfrecords.py](#) to Create training and testing .tfrecord files

Using your chosen Python editor, in [\(repository_location\)](#) open the script "2_generate_tfrecords.py". In the module-level variables section at the top, verify the paths are correct.

Next, scroll down to the "class_text_to_int" function and update the if-else statement per the classification names you used when generating the .xml files to go with each image above. For example, if you're using only one classification called "traffic_light" in my example, your if statement should be:

```
if row_label == 'traffic_light':
    return 1
else:
    print("error in class_text_to_int(), row_label could not be identified")
    return -1
# end if
```

If you're using 3 classifications, "traffic_light", "stop_sign", and "yield_sign", your if statement would be:

```

if row_label == 'traffic_light':
    return 1
elif row_label == 'stop_sign':
    return 2
elif row_label == 'yield_sign':
    return 3
else:
    print("error in class_text_to_int(), row_label could not be identified")
    return -1
# end if

```

Next, run the script and verify no errors occur, then check your [\(repository_location\)](#) data directory, you should now find 2 more files, “train.tfrecord” and “test.tfrecord”.

15) Choose, download, and extract a model (“ssd_inception_v2_coco” is recommended)

Google on “TensorFlow GitHub”, that should take you to <https://github.com/tensorflow>. Next, go to the “models” repository, then research -> object_detection -> g3doc -> detection_model_zoo.md, this should take you to https://github.com/tensorflow/models/blob/master/research/object_detection/g3doc/detection_model_zoo.md

This page lists the available models. You can also train your own model, but that is very time consuming and in most cases not necessary as there are quite a few stock models to choose from.

You can do some Googling to read up further on the models available. When choosing a model there is inherently a speed / accuracy tradeoff to some degree, also some models are better at detecting certain types of objects than others.

To make a long story short, probably the best all-around choice for detecting most objects in most images is “ssd_inception_v2_coco”, which is the model we will choose in our example here.

For other potential choices, if you need the fastest detection possible (i.e. if you’re working with images being streamed from a webcam) you should probably choose “ssd_mobilenet_v1_coco”, which is intended to be fast and therefore able to run on mobile devices that do not have the full computing power of a desktop, hence the word “mobile” being in the name.

Inception provides very good accuracy, but if you need the highest accuracy possible at the expense of speed you can experiment with some of the other slower models that may provide moderately better accuracy in some cases.

Click on your chosen model and download it to your [\(repository_location\)](#) directory. This will be a .tar.gz file, ex. ssd_inception_v2_coco_2017_11_17.tar.gz.

Note that the model name includes a date which will change as Google updates the model over time. Take care to adjust the subsequent steps per the date in the model name in comparison to the date used in the video and this document if by the time you are following along the date has changed slightly.

Right click on the .tar.gz file and choose 7-Zip -> Extract Here, this will extract the .tar.gz file in to a .tar file, i.e. in [\(repository_location\)](#) you will now have “ssd_mobilenet_v1_coco_2017_11_17.tar.gz” and “ssd_mobilenet_v1_coco_2017_11_17.tar”

Right click on the .tar file (not the tar.gz file) and choose 7-Zip -> Extract Here, this will create a directory of the same name, except without the .tar at the end, i.e. you will now have a directory [\(repository_location\)](#)\ssd_mobilenet_v1_coco_2017_11_17. Navigate into this directory and verify it's not empty.

16) Check / edit “label_map.pbtxt”

Open [\(repository_location\)](#)\label_map.pbtxt in Notepad or a similar text editor and verify the contents are:

```
item {  
  id: 1  
  name: 'traffic_light'  
}
```

If you're detecting something other than traffic lights, change the name to match the name you used when generating the .xml files with labelImg. If you're using multiple labels, add a { } section for each label type, with an incrementing id matching the other uses throughout this document.

For more examples of label map files for TensorFlow object detection you can view Google's examples here: https://github.com/tensorflow/models/tree/master/research/object_detection/data

When complete, save your changes to label_map.pbtxt and close it.

17) Check / edit “ssd_inception_v2_coco.config”

Open [\(repository_location\)](#)\label_map.pbtxt in Notepad or a similar text editor and skim the contents. “ssd_inception_v2_coco.config” is a large configuration file that will be used by “3_train.py” in the next step.

This file is from https://github.com/tensorflow/models/blob/master/research/object_detection/samples/configs/ssd_inception_v2_coco.config with some modifications.

If you are using a model other than Inception v2 then of course you will need to use a different config file from https://github.com/tensorflow/models/tree/master/research/object_detection/samples/configs and make the applicable modifications. Comparing [\(repository_location\)](#)\label_map.pbtxt to https://github.com/tensorflow/models/blob/master/research/object_detection/samples/configs/ssd_inception_v2_coco.config would probably be the best way to determine what modifications to make to any of the other

config files located at

https://github.com/tensorflow/models/tree/master/research/object_detection/samples/configs.

The following settings are especially noteworthy:

num_classes: Change this to your number of classes if applicable. For example, if you're detecting traffic lights only, leave this as "1". If you're detecting traffic lights, stop signs, and yield signs, change this to "3".

num_steps: Google's default for this setting is 200000, which I've changed to 500 for a relatively quick training time, perhaps five hours on a moderate computer. Once you get this process to work all the way through, it would be recommended to re-train with a much higher value, ex. 5000, for production-grade results.

fine_tune_checkpoint, train_input_reader input_path and label_map_path, and eval_input_reader input_path and label_map_path are all set to relative paths currently. Verify these paths exist on your computer. If you experience "file not found" errors when running "3_train.py" in the next step, try changing the paths to absolute paths. For example if you encounter an error similar to "fine_tune_checkpoint not found", try changing:

```
fine_tune_checkpoint: "ssd_inception_v2_coco_2017_11_17/model.ckpt"
```

to:

```
fine_tune_checkpoint:
```

```
"C:/path/to/cloned/repo/location/TensorFlow_Tut_3_Object_Detection_Walk-through/ssd_inception_v2_coco_2017_11_17/model.ckpt"
```

Note that it seems best to use forward slashes in this file to separate files/directories, even though on Windows usually backslashes are used.

fine_tune_checkpoint: This is set as follows:

```
fine_tune_checkpoint: "ssd_inception_v2_coco_2017_11_17/model.ckpt"
```

This is a relative path to the model directory (which was downloaded as a previous step).

Note that there is not actually a file "model.ckpt", this actually refers to 3 files, "model.ckpt.data-00000-of-00001", "model.ckpt.index", and "model.ckpt.meta".

Of course if you are using an Inception model of a different version or a different date you will need to change the version and/or date to match the model you are using. If you are using a model other than Inception entirely, you will need to change this line completely, or better yet start with a different config file entirely from

https://github.com/tensorflow/models/tree/master/research/object_detection/samples/configs

train_input_reader: Currently these are set as follows, verify these (relative) paths/files exist:

```
input_path: "training_data/train.tfrecord"
```

```
label_map_path: "label_map.pbtxt"
```

eval_input_reader: Currently these are set as follows, verify these (relative) paths/files exist:

```
input_path: "training_data/eval.tfrecord"
```

```
label_map_path: "label_map.pbtxt"
```

When entering these paths, if you copy/paste this out of Windows File Explorer, take care to change the back slashes to forward slashes.

Additional things you may want to change include:

fixed_shape_resizer: the default width and height to resize your images to before training is 300 x 300, this is a good general value, but other values may work better for your images so you may want to try other values eventually

batch_size: Depending on your computer's memory you may want to lower this to something substantially lower than the default value of 24, especially if you experience memory errors in the subsequent steps. 10 may be a good all-around choice to use less memory but still produce a good result.

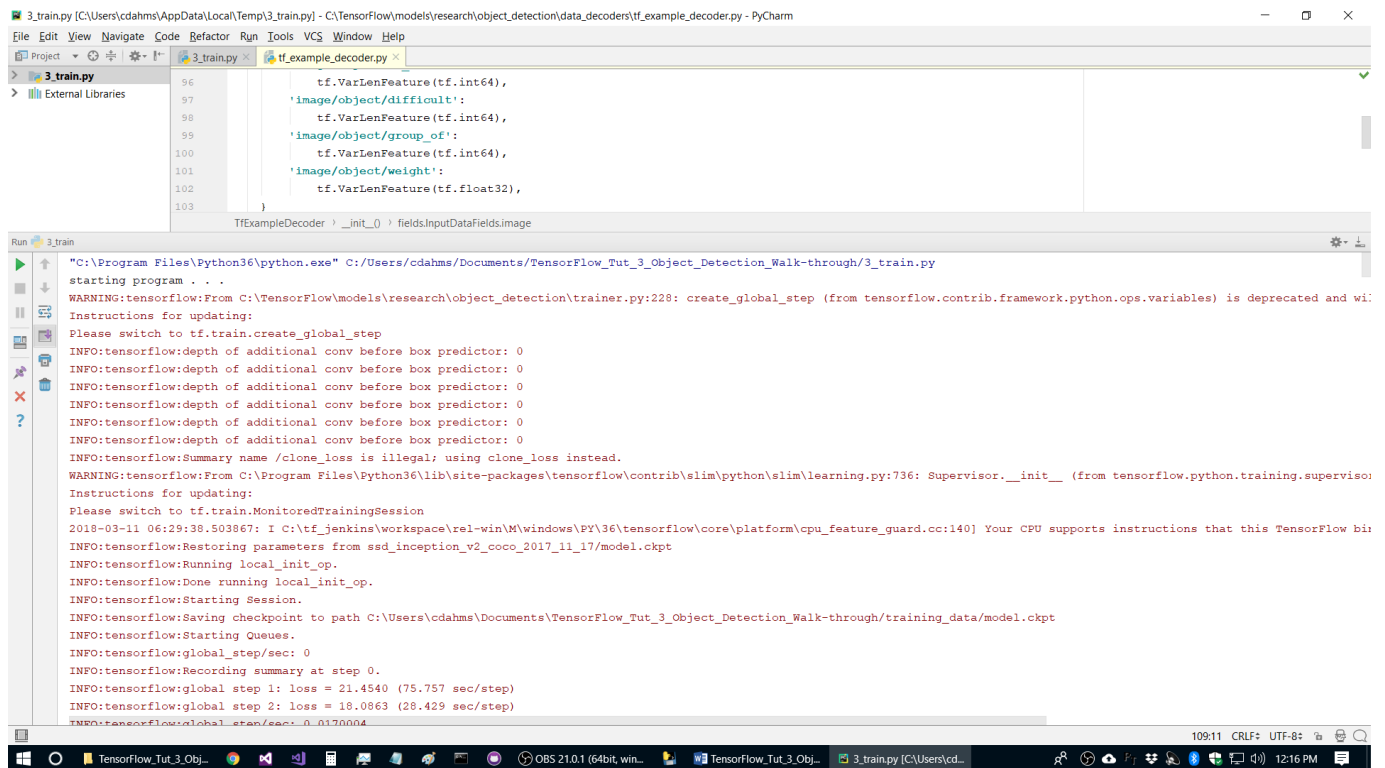
There are many other parameters that can be fine-tuned as well for better results in certain situations. Once you've completed this process successfully a few times through, skim through "ssd_inception_v2_coco.config" again and consider further experimenting with some of the other parameters for best results for a given training situation.

18) Run [3_train.py](#) to perform the training

Run "3_train.py" either from the command line or from within your chosen Python editor. The necessary files and paths should already have been produced from the previous steps, if not, follow any error messages to resolve concerns as needed.

With the .config setting of num_steps set to 500 as described above this will take perhaps 3-4 hours on a moderate computer, or substantially less if you have a high-end computer or have TensorFlow configured to use a GPU.

The training should start out looking something like this:

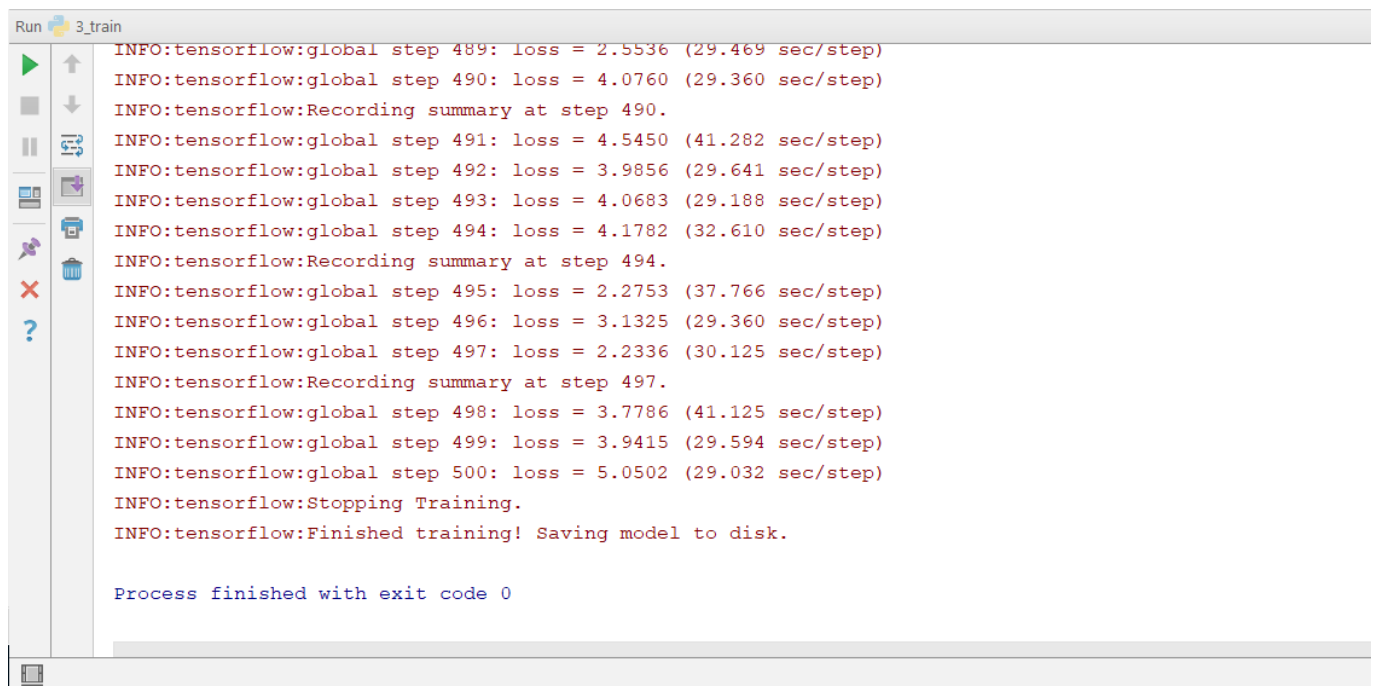


The screenshot shows the PyCharm IDE with the file `3_train.py` open. The code defines a `TfExampleDecoder` class with an `__init__` method that sets up input data fields for an image. The Run console shows the execution of `3_train.py`, displaying various TensorFlow warnings and information messages. The output indicates that the training process is starting, and the first few steps of training are being recorded, showing a loss of approximately 21.4540 at step 1.

```
INFO:tensorflow:depth of additional conv before box predictor: 0
INFO:tensorflow:depth of additional conv before box predictor: 0
INFO:tensorflow:depth of additional conv before box predictor: 0
INFO:tensorflow:depth of additional conv before box predictor: 0
INFO:tensorflow:depth of additional conv before box predictor: 0
INFO:tensorflow:depth of additional conv before box predictor: 0
INFO:tensorflow:Summary name /clone_loss is illegal; using clone_loss instead.
WARNING:tensorflow:From C:\Program Files\Python36\lib\site-packages\tensorflow\contrib\slim\python\slim\learning.py:736: Supervisor.__init__ (from tensorflow.python.training.supervisor) is deprecated and will be removed in a future version.
Instructions for updating:
Please switch to tf.train.MonitoredTrainingSession
2018-03-11 06:29:38.503867: I C:\tf_jenkins\workspace\rel-win\M\windows\PR\36\tensorflow\core\platform\cpu_feature_guard.cc:140] Your CPU supports instructions that this TensorFlow binary is not built to use: SSE4.1, SSE4.2, SSE4.4, FMA3, AVX2, FMA4
INFO:tensorflow:Restoring parameters from ssd_inception_v2_coco_2017_11_17/model.ckpt
INFO:tensorflow:Running local_init_op.
INFO:tensorflow:Done running local_init_op.
INFO:tensorflow:Starting Session.
INFO:tensorflow:Saving checkpoint to path C:\Users\cdahms\Documents\TensorFlow_Tut_3_Object_Detection_Walk-through\training_data\model.ckpt
INFO:tensorflow:Starting Queues.
INFO:tensorflow:global_step/sec: 0
INFO:tensorflow:Recording summary at step 0.
INFO:tensorflow:global step 1: loss = 21.4540 (75.757 sec/step)
INFO:tensorflow:global step 2: loss = 18.0863 (28.429 sec/step)
INFO:tensorflow:global step/sec: 0.0170004
```

As the training is proceeding, you will notice that files are written to in [\(repository_location\)\training_data](#).

If training completes successfully, you should see something similar to the following:



The screenshot shows the PyCharm IDE with the file `3_train.py` open. The Run console displays the final stages of the training process, showing global steps 489 through 500. The loss decreases significantly, reaching a minimum of 2.2336 at step 497. The training process concludes with the message "Finished training! Saving model to disk." and "Process finished with exit code 0".

```
INFO:tensorflow:global step 489: loss = 2.5536 (29.469 sec/step)
INFO:tensorflow:global step 490: loss = 4.0760 (29.360 sec/step)
INFO:tensorflow:Recording summary at step 490.
INFO:tensorflow:global step 491: loss = 4.5450 (41.282 sec/step)
INFO:tensorflow:global step 492: loss = 3.9856 (29.641 sec/step)
INFO:tensorflow:global step 493: loss = 4.0683 (29.188 sec/step)
INFO:tensorflow:global step 494: loss = 4.1782 (32.610 sec/step)
INFO:tensorflow:Recording summary at step 494.
INFO:tensorflow:global step 495: loss = 2.2753 (37.766 sec/step)
INFO:tensorflow:global step 496: loss = 3.1325 (29.360 sec/step)
INFO:tensorflow:global step 497: loss = 2.2336 (30.125 sec/step)
INFO:tensorflow:Recording summary at step 497.
INFO:tensorflow:global step 498: loss = 3.7786 (41.125 sec/step)
INFO:tensorflow:global step 499: loss = 3.9415 (29.594 sec/step)
INFO:tensorflow:global step 500: loss = 5.0502 (29.032 sec/step)
INFO:tensorflow:Stopping Training.
INFO:tensorflow:Finished training! Saving model to disk.

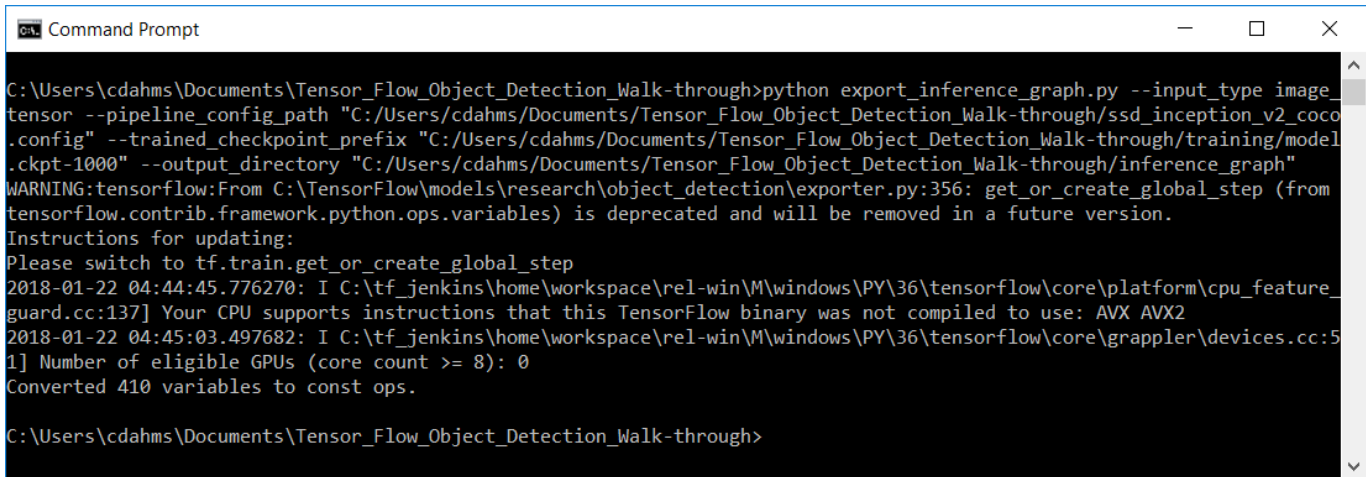
Process finished with exit code 0
```

19) Run `4_export_inference_graph.py` to export the Inference Graph

In your chosen Python editor open “4_export_inference_graph.py” and give it a quick skim. Note that if you used a different number of steps than 500, you will have to change the “500” in TRAINED_CHECKPOINT_PREFIX_LOC to the number of steps you used.

Run “4_export_inference_graph.py” to export the Inference Graph. This will take roughly a minute to run and will create a directory “([repository_location](#))/inference_graph”

If this process completes successfully you should see something similar to the following:

A screenshot of a Windows Command Prompt window titled "Command Prompt". The window shows the execution of a Python script: `python export_inference_graph.py --input_type image_tensor --pipeline_config_path "C:/Users/cdahms/Documents/Tensor_Flow_Object_Detection_Walk-through/ssd_inception_v2_coco.config" --trained_checkpoint_prefix "C:/Users/cdahms/Documents/Tensor_Flow_Object_Detection_Walk-through/training/model.ckpt-1000" --output_directory "C:/Users/cdahms/Documents/Tensor_Flow_Object_Detection_Walk-through/inference_graph"`. The output includes a TensorFlow warning about a deprecated function, instructions to update the code, and system information messages from TensorFlow, including CPU feature detection and GPU count reporting. The command prompt ends with the directory path `C:\Users\cdahms\Documents\Tensor_Flow_Object_Detection_Walk-through>`.

```
Command Prompt
C:\Users\cdahms\Documents\Tensor_Flow_Object_Detection_Walk-through>python export_inference_graph.py --input_type image_
tensor --pipeline_config_path "C:/Users/cdahms/Documents/Tensor_Flow_Object_Detection_Walk-through/ssd_inception_v2_coco
.config" --trained_checkpoint_prefix "C:/Users/cdahms/Documents/Tensor_Flow_Object_Detection_Walk-through/training/model
.ckpt-1000" --output_directory "C:/Users/cdahms/Documents/Tensor_Flow_Object_Detection_Walk-through/inference_graph"
WARNING:tensorflow:From C:\TensorFlow\models\research\object_detection\exporter.py:356: get_or_create_global_step (from
tensorflow.contrib.framework.python.ops.variables) is deprecated and will be removed in a future version.
Instructions for updating:
Please switch to tf.train.get_or_create_global_step
2018-01-22 04:44:45.776270: I C:\tf_jenkins\home\workspace\rel-win\M\windows\PY\36\tensorflow\core\platform\cpu_feature_
guard.cc:137] Your CPU supports instructions that this TensorFlow binary was not compiled to use: AVX AVX2
2018-01-22 04:45:03.497682: I C:\tf_jenkins\home\workspace\rel-win\M\windows\PY\36\tensorflow\core\grappler\devices.cc:5
1] Number of eligible GPUs (core count >= 8): 0
Converted 410 variables to const ops.

C:\Users\cdahms\Documents\Tensor_Flow_Object_Detection_Walk-through>
```

Once this is complete, check the ([repository_location](#))/inference_graph directory and verify that checkpoint, frozen_inference_graph.pb, and model.ckpt.* files are there.

20) Run [5_test.py](#) to test on your own images

From ([repository_location](#)), open the file “5_test.py” in your chosen Python editor. In the module level variables section at the top, verify the TEST_IMAGE_DIR properly points to your test images directory, then run the script. This script will show each of the images in your test images directory one by one, simply click on the image and press any key to go to the next image. Your results will hopefully look something like this:



Note that one of the 3 traffic lights is missing. Following the steps above, you will likely find you'll get a traffic light detection rate of 50%, or moderately higher.

The main reason this detection rate is not all that great is the relatively low training set size of about 100 images. For something production grade, 10,000+ images would be recommended. Also, upping the `num_steps` configuration parameter to 10000+ would likely improve accuracy.

Done!!

If you used my images your first time through, the next step is to perform the process again on your own images. For my next two tutorials, I'm planning on re-doing the content from tutorials 2 & 3 in C++ and .NET, I'm not sure in which order.