Objective: Identify cars and auto rickshaws in the traffic of Pune

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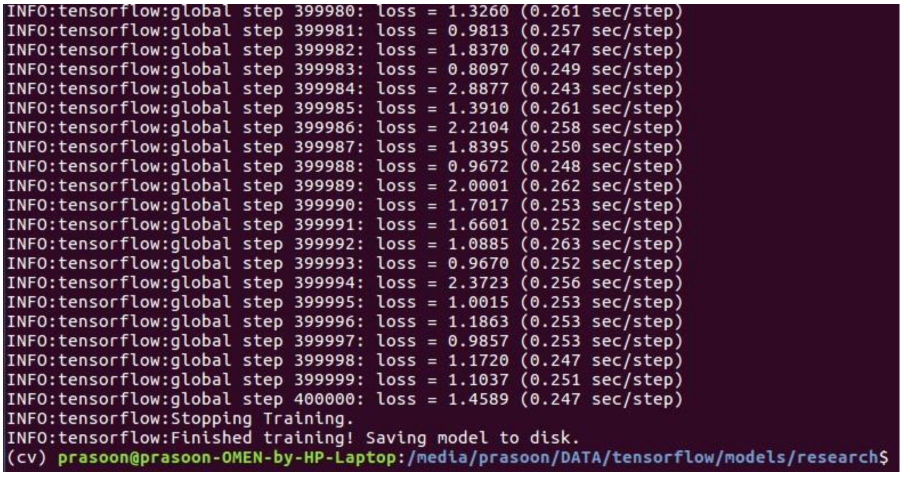
Challenges faced and arriving to conclusion

- Initial approach:
  - Used Darknet framework previously, to run the YOLO Network. Error convergence was very slow. And finally, the detection accuracy was not upto the mark(~70-80%).
- Used smaller network called SSD Moblienet V1, which is generally used in real time scenarios.
- TensorFlow gives a lot of freedom in terms of GPU utilisation, checkpoints when converging automatically.



```
INFO:tensorflow:global step 399980: loss = 1.3260 (0.261 sec/step)
INFO:tensorflow:global step 399981: loss = 0.9813 (0.257 sec/step)
INFO:tensorflow:global step 399982: loss = 1.8370 (0.247 sec/step)
INFO:tensorflow:global step 399983: loss = 0.8097 (0.249 sec/step)
INFO:tensorflow:global step 399984: loss = 2.8877 (0.243 sec/step)
INFO:tensorflow:global step 399985: loss = 1.3910 (0.261 sec/step)
INFO:tensorflow:global step 399986: loss = 2.2104 (0.258 sec/step)
INFO:tensorflow:global step 399987: loss = 1.8395 (0.250 sec/step)
INFO:tensorflow:global step 399988: loss = 0.9672 (0.248 sec/step)
INFO:tensorflow:global step 399989: loss = 2.0001 (0.262 sec/step)
INFO:tensorflow:global step 399990: loss = 1.7017 (0.253 sec/step)
INFO:tensorflow:global step 399991: loss = 1.6601 (0.252 sec/step)
INFO:tensorflow:global step 399992: loss = 1.0885 (0.263 sec/step)
INFO:tensorflow:global step 399993: loss = 0.9670 (0.252 sec/step)
INFO:tensorflow:global step 399994: loss = 2.3723 (0.256 sec/step)
INFO:tensorflow:global step 399995: loss = 1.0015 (0.253 sec/step)
INFO:tensorflow:global step 399996: loss = 1.1863 (0.253 sec/step)
INFO:tensorflow:global step 399997: loss = 0.9857 (0.253 sec/step)
INFO:tensorflow:global step 399998: loss = 1.1720 (0.247 sec/step)
INFO:tensorflow:global step 399999: loss = 1.1037 (0.251 sec/step)
INFO:tensorflow:global step 400000: loss = 1.4589 (0.247 sec/step)
INFO:tensorflow:Stopping Training.
INFO:tensorflow:Finished training! Saving model to disk.
(cv) prasoon@prasoon-OMEN-by-HP-Laptop:/media/prasoon/DATA/tensorflow/models/research$
```

Fig.1. Total 4,000,000 training steps in TensorFlow

CNN architecture, modifications, workflow

- SSD Moblienet V1 with 21 COCO Map for object detection.
- BBox-Label-Tool-multi-class for labelling.
- Convert the text annotation files to appropriate format needed by YOLO(for Darknet, initial approach).
- Stored image directories in train.txt and test.txt .
- Converted the annotations files and image details to tfrecord needed for training the pre-trained model.
- Edited SSD with Mobilenet v1 configuration for 2 classes, 4.000,000 steps, batch size of 8 with 344 images.
- Train the model.
- Freeze the graph after reaching avg loss rate closer to 1. Saving a Checkpoint Model (.ckpt) as a .pb File.
- Run the test script with the given video.
- Tune the threshold value to avoid false positives.

Resolution of the image for training and inference

- Most of the images were 960x720, and some downloaded from internet were 800x600.
- Converted the frames in the given video to images, for inference. Finally tested it in the given video.

GPU and CPU utilizations. How to reduce resource needs

- By reducing the batch size(total samples at any given time) while training, the GPU utilization can be lowered. Same methodology applies, when training on a CPU.
- Using smaller or relatively less complex networks like Moblienet which has a slight trade-off in accuracy, but very efficient for real time videos. The GPU will give more FPS in these scenarios.
- Lower resolution in video/image also reduces GPU utilization while testing the model. Same is true for lower FPS in a video.

```
prasoon@prasoon-OMEN-by-HP-Laptop:~$ vmstat 1 5
procs -----------memory---------- ---swap-- -----io---- -system-- ------cpu-----
 r  b   swpd   free   buff  cache   si   so    bi    bo   in   cs us sy id wa st
11  0      0 2732800 4666520 4324900    0    0    16    45  236    15 21  3 76  0  0
15  0      0 2711448 4666520 4324964    0    0     0     0 11395 39977 34  7 60  0  0
 2  0      0 2719912 4666520 4324948    0    0    16     0 11092 39379 35  5 58  2  0
 2  0      0 2738328 4666520 4324884    0    0     0     0 11271 41586 35  6 59  0  0
 1  0      0 2688384 4666520 4324852    0    0     0     0 11388 37277 34  6 60  0  0
```

Fig.2. CPU utilization

```
prasoon@prasoon-OMEN-by-HP-Laptop: ~
Every 0.1s: nvidia-smi                                   Thu Jul  5 23:06:59 2018

Thu Jul  5 23:06:59 2018
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 396.26                 Driver Version: 396.26                    |
|-------------------------------+----------------------+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|===============================+======================+======================|
|   0  GeForce GTX 105...  Off  | 00000000:01:00.0 Off |                  N/A |
| N/A   64C    P0    N/A /  N/A |   3525MiB /  4040MiB |     56%      Default |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
| Processes:                                                       GPU Memory |
|  GPU       PID   Type   Process name                             Usage      |
|=============================================================================|
|    0      1086      G   /usr/lib/xorg/Xorg                           184MiB |
|    0      2128      G   compiz                                       184MiB |
|    0     26960      C   python                                      3153MiB |
+-----------------------------------------------------------------------------+
```

Fig.3. GPU utilization

Image size impacting the results in accuracy and performance

- Resizing an image to lower value helps when the information required algorithm to learn from isn’t very complex for ex: dog vs cat. But, for complex objects like trees, reducing the image size reduces small scale detail on leaf shape in a way that's detrimental to the model. This affects the accuracy significantly. A typical rule of thumb is 800pixels by 600 pixels.
- When the objects to be classified differ very much, a smaller image will have sufficient feature vectors to recognize with a decent accuracy. Performance of the overall system in these situations increases.

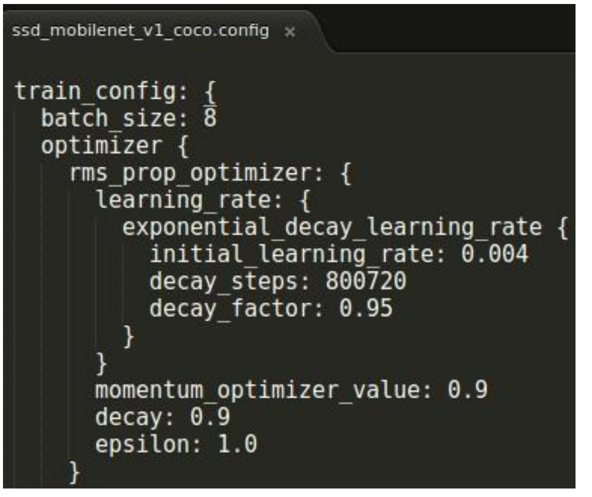


Fig.4. Configuring batch size

Metrics to measure accuracy

- The detection score written in the testing script, which is derived from the model. Refer line 72 and 76 in testing.py
- Uncomment line 77 in testing.py to measure fps. The speed of the video will be faster, since its running in GPU's multiple threads.
- Use Tensorboard from checkpoints in models/train/ to visually see the learning rate and convergence, no. of steps etc.
  - command: tensorboard --logdir path/to/logs

Usage, training and inference code

- Make sure you have tensorflow-gpu installed.
  - Follow these installation steps for dependencies and TensorFlow installation.
    - https://github.com/tensorflow/models/blob/master/research/object_detection/g3doc/installation.md
- Refer darknet_to_PascalVOC.py to convert Darknet labels to PASCAL VOC records.
- Create TFrecords
  - https://github.com/tensorflow/models/blob/master/research/object_detection/dataset_tools/create_pascal_tf_record.py
- Run the following command from tensorflow/models/research/ directory.
  - Refer train.py from link below in tensorflow/models/research/ directory
  - https://github.com/tensorflow/models/blob/master/research/object_detection/train.py
  - python object_detection/train.py \ --logtostderr \
    --pipeline_config_path=${PATH_TO_YOUR_PIPELINE_CONFIG} \
    --train_dir=${PATH_TO_TRAIN_DIR}
- Export the graph and save the checkpoint to .pb file:
  - python export_inference_graph.py --input_type image_tensor --pipeline_config_path ./rfcn_resnet101_coco.config --trained_checkpoint_prefix ./models/train/model.ckpt-5000 --output_directory ./fine_tuned_model
- Run the model:
  - Make sure you in OpenCV environment.
  - Run the following command from /tensorflow/models/research/object_detection/training_twoclass directory
    - python testing.py
    - Above script takes 'test.mp4' as a video stream and writes into 'output.mp4'