Object Detection in an Urban Environment

1. Project Overview

The goal of the project is to detect object in an urban environment. For this project, the waymo open dataset is used for sensor data. The waymo dataset is stored into .tfrecord files. A dataset of images of urban environments containing annotated cyclists, pedestrians and vehicles were provided. In the first task, we need to perform an Exploratory Data Analysis (EDA), like object occlusions, label distribution etc. Later we need to train a Single Shot detector, a pertained model of SSD Resnet 50 640x640 model is given. At first we need to train and evaluate the pre-trained model and then based on the results we need to improve the performance of object detection by modifying the hyper-parameters of the CNN in config files.

The modifications to the config file need to reduce the loss of model and better detection. At last step, after satisfactory results, the model will be exported and inference video is created.

2. Set Up

i) The jupyter notebook is launched using the script ./launch_jupyter.sh

ii) Download the pretrained model and move to the /home/workspace/experiments/pretrained_model/ folder and extract the tar.gz as described in the below steps

```
cd /home/workspace/experiments/pretrained_model/

wget http://download.tensorflow.org/models/object_detection/tf2/20200711/ssd_resnet50_v1_fpn_640x640_coco17_tpu-8.tar.gz

tar -xvzf ssd_resnet50_v1_fpn_640x640_coco17_tpu-8.tar.gz

rm -rf ssd_resnet50_v1_fpn_640x640_coco17_tpu-8.tar.gz
```

iii) Edit the config file so a new config file is created with name ***pipeline_new.config*** . Move this file to the ***/home/workspace/experiments/reference/ .***

cd /home/workspace/
python edit_config.py --train_dir /home/workspace/data/train/ --eval_dir/home/workspace/data/val/ --batch_size 2 --checkpoint/home/workspace/experiments/pretrained_model/ssd_resnet50_v1_fpn_640x640_coco17_tpu-8/checkpoint/ckpt-0 --label_map/home/workspace/experiments/label_map.pbtxt

iv) Training Process

python experiments/model_main_tf2.py --model_dir=experiments/reference/ --pipeline_config_path=experiments/reference/pipeline_new.config

Monitor the process by executing the below command.

```
python -m tensorboard.main --logdir experiments/reference/
```

```
Evaluation Process
```

```
python experiments/model_main_tf2.py --
model_dir=experiments/reference/ --
pipeline_config_path=experiments/reference/pipeline_new.config --
checkpoint_dir=experiments/reference/
```

v) Export the trained model

```
python experiments/exporter_main_v2.py --input_type image_tensor --
pipeline_config_path experiments/reference/pipeline_new.config --
trained_checkpoint_dir experiments/reference/ --output_directory
experiments/reference/exported/
```

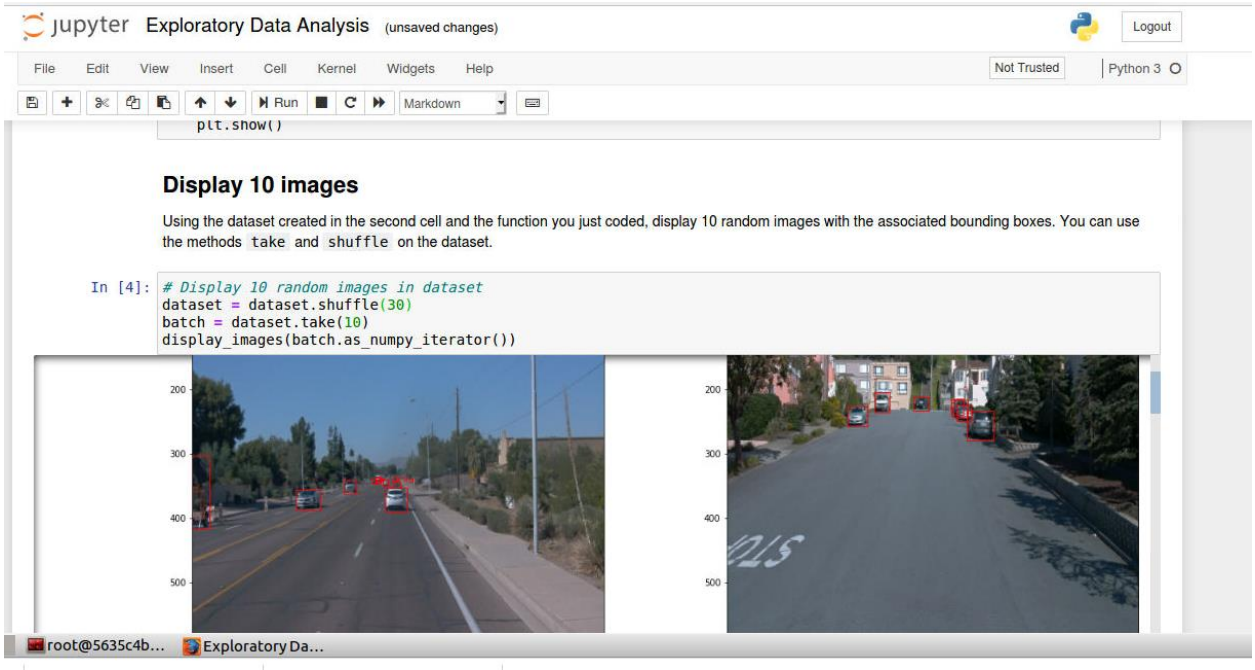
Modify the config file and train and export the trained model when you find the results are satisfactory.

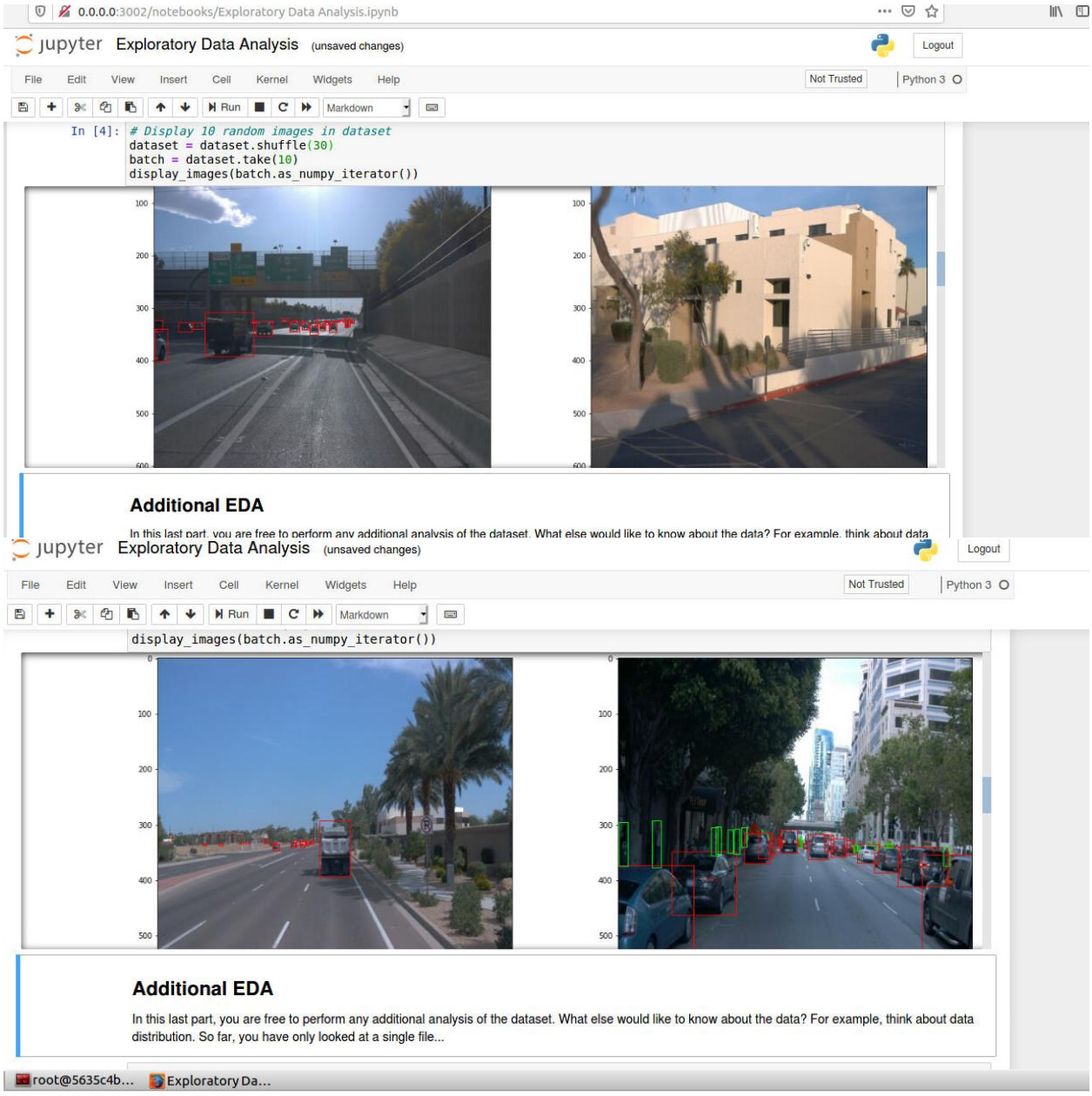
3. Dataset

- Dataset Analysis:

The dataset is divided into train, test, val and stored into respective folders. We use the train folder to do dataset analysis.

Below are some images of with its bounding boxes




0.0.0.0:3002/notebooks/Exploratory Data Analysis.ipynb
jupyter Exploratory Data Analysis (unsaved changes)
Logout
File Edit View Insert Cell Kernel Widgets Help
Not Trusted
Python 3
Run
Markdown
In [4]:
# Display 10 random images in dataset
dataset = dataset.shuffle(30)
batch = dataset.take(10)
display_images(batch.as_numpy_iterator())
Additional EDA
In this last part, you are free to perform any additional analysis of the dataset. What else would like to know about the data? For example, think about data distribution. So far, you have only looked at a single file...
root@5635c4b...
Exploratory Da...

jupyter Exploratory Data Analysis (unsaved changes)

Logout

File Edit View Insert Cell Kernel Widgets Help

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Run Markdown

```
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root@5635c4b... Exploratory Da...

jupyter Exploratory Data Analysis (autosaved)

Logout

File Edit View Insert Cell Kernel Widgets Help

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Run Markdown

```
display_images(batch.as_numpy_iterator())
```

Additional EDA

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jupyter Exploratory Data Analysis (unsaved changes)

Logout

File Edit View Insert Cell Kernel Widgets Help

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Run Markdown

the methods `take` and `shuffle` on the dataset.

In [6]:
```
# Display 10 random images in dataset
dataset = dataset.shuffle(30)
batch = dataset.take(10)
display_images(batch.as_numpy_iterator())
```

root@5635c4b... Exploratory Da...

jupyter Exploratory Data Analysis (unsaved changes)

Logout

File Edit View Insert Cell Kernel Widgets Help

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Run Markdown

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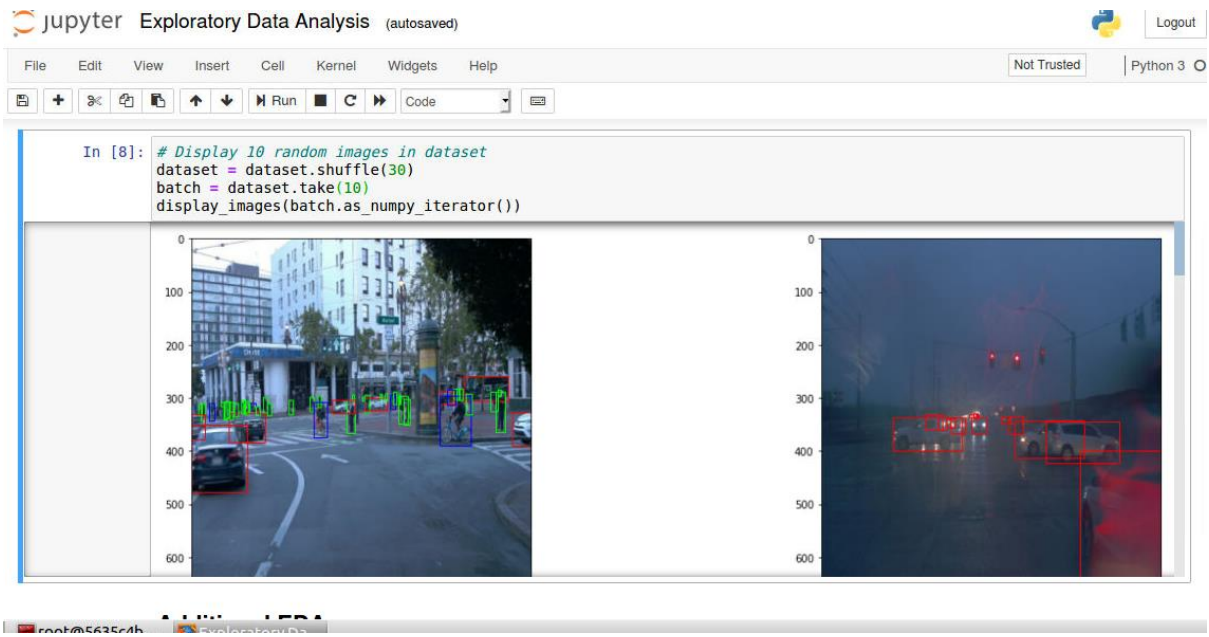
root@5635c4b... Exploratory Da...



The dataset consists of images with

Traffic: heavy traffic, no traffic, no detection of any vehicle

Types of roads: Highways, hill areas, Signal junctions, Residential area, Zebra crossing

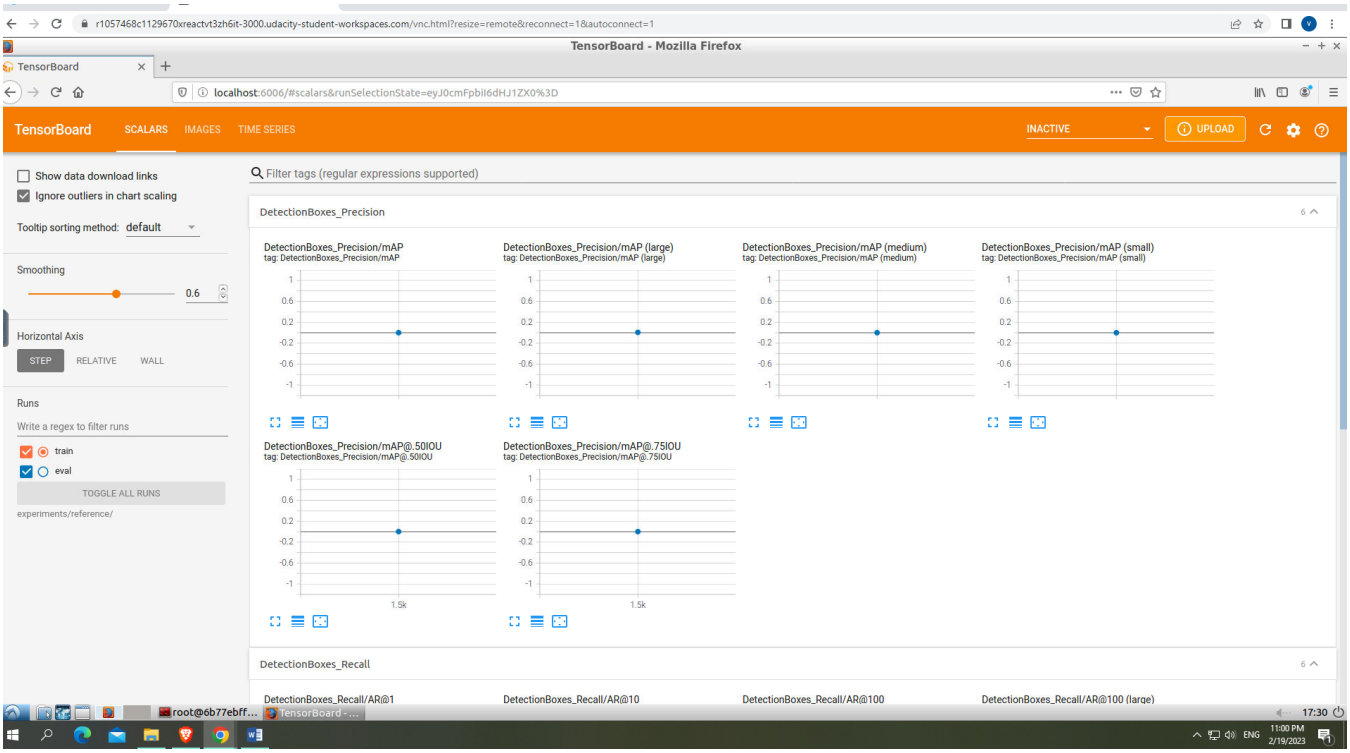
Environment: variation of sun light, Foggy, Night etc.

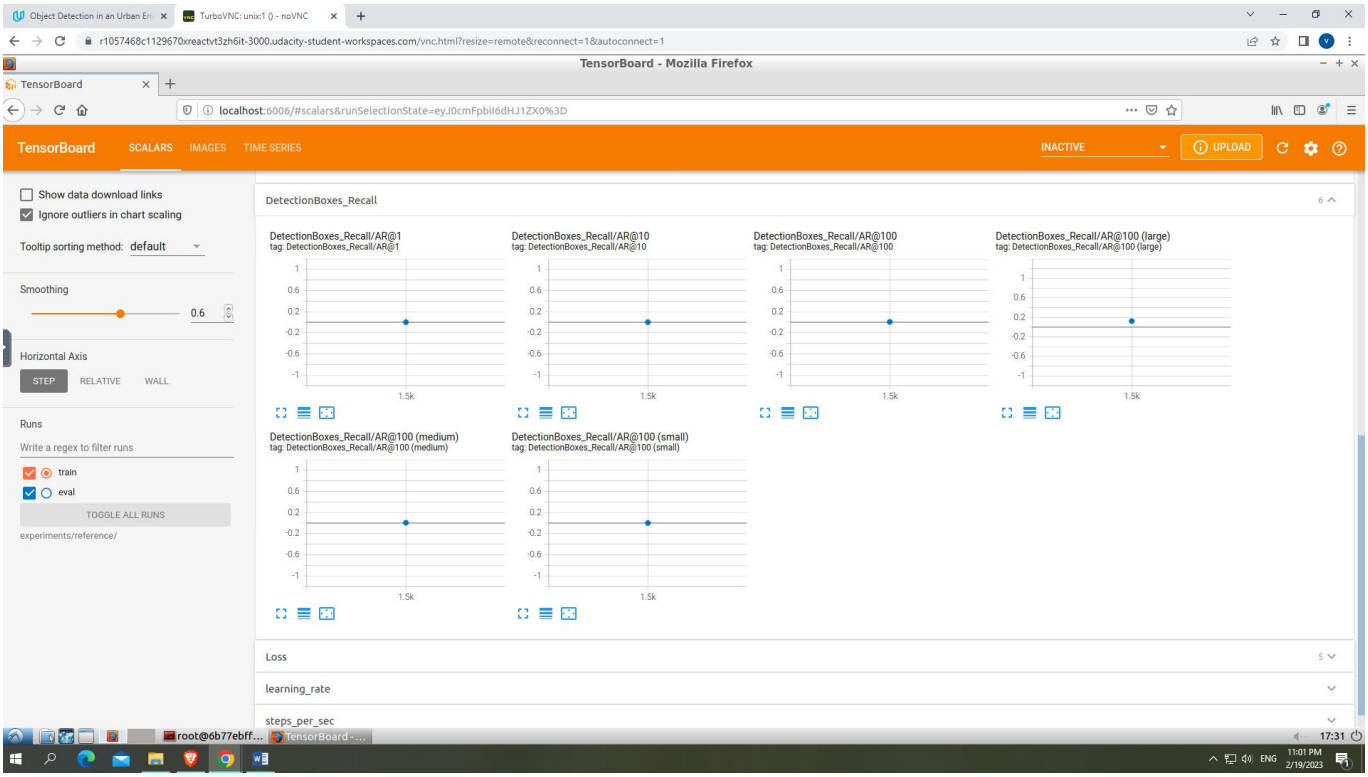
Heavy Vehicles, Light vehicles, bicycles etc.

4. Training

i) Reference Experiment: The loss and learning rate charts of the pre-trained model training and evaluation results shown below. Based on the observation, the more number of iterations, the more drop in the learning rate of the model and high increase in the loss.

The classification loss and localization loss decreased with more number of iterations. Where as the normalized total loss, regularization loss has steep increase after 800 steps and slowly decreasing afterwards. The learning rate has been decreasing after 200 steps. The evaluation process is shown in blue dot as it ran for on epoch only.


TensorBoard - Mozilla Firefox
TensorBoard
SCALARS
IMAGES
TIME SERIES
INACTIVE
UPLOAD
Show data download links
Ignore outliers in chart scaling
Tooltip sorting method: default
Smoothing
0.6
Horizontal Axis
STEP
RELATIVE
WALL
Runs
Write a regex to filter runs
train
eval
TOGGLE ALL RUNS
experiments/reference/
Filter tags (regular expressions supported)
DetectionBoxes_Precision
DetectionBoxes_Precision/mAP
DetectionBoxes_Precision/mAP (large)
DetectionBoxes_Precision/mAP (medium)
DetectionBoxes_Precision/mAP (small)
DetectionBoxes_Precision/mAP@.50IOU
DetectionBoxes_Precision/mAP@.75IOU
DetectionBoxes_Recall
DetectionBoxes_Recall/AR@1
DetectionBoxes_Recall/AR@10
DetectionBoxes_Recall/AR@100
DetectionBoxes_Recall/AR@100 (large)


TensorBoard - Mozilla Firefox
TensorBoard
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Write a regex to filter runs
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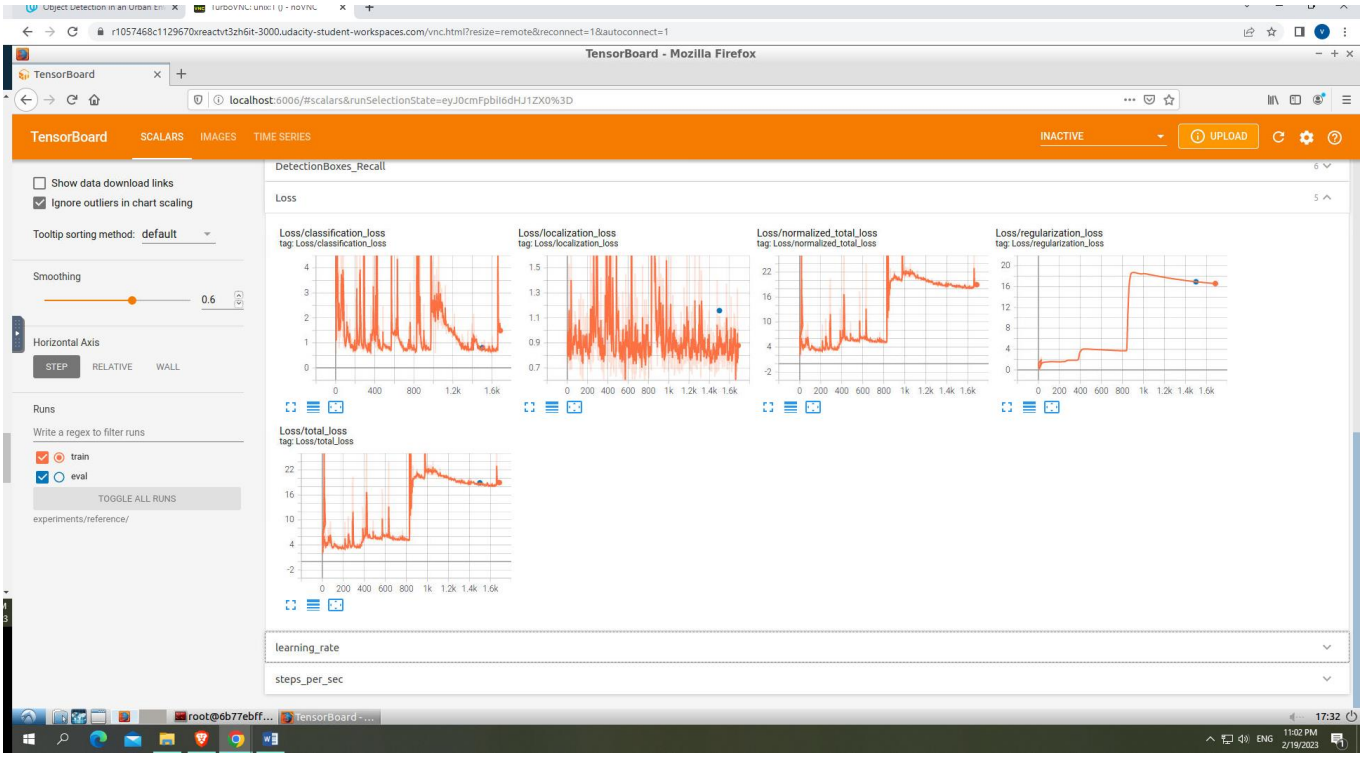
experiments/reference/
DetectionBoxes_Recall
DetectionBoxes_Recall/AR@1
DetectionBoxes_Recall/AR@10
DetectionBoxes_Recall/AR@100
DetectionBoxes_Recall/AR@100 (large)
DetectionBoxes_Recall/AR@100 (medium)
DetectionBoxes_Recall/AR@100 (small)
Loss
learning_rate
steps_per_sec


TensorBoard - Mozilla Firefox
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Write a regex to filter runs
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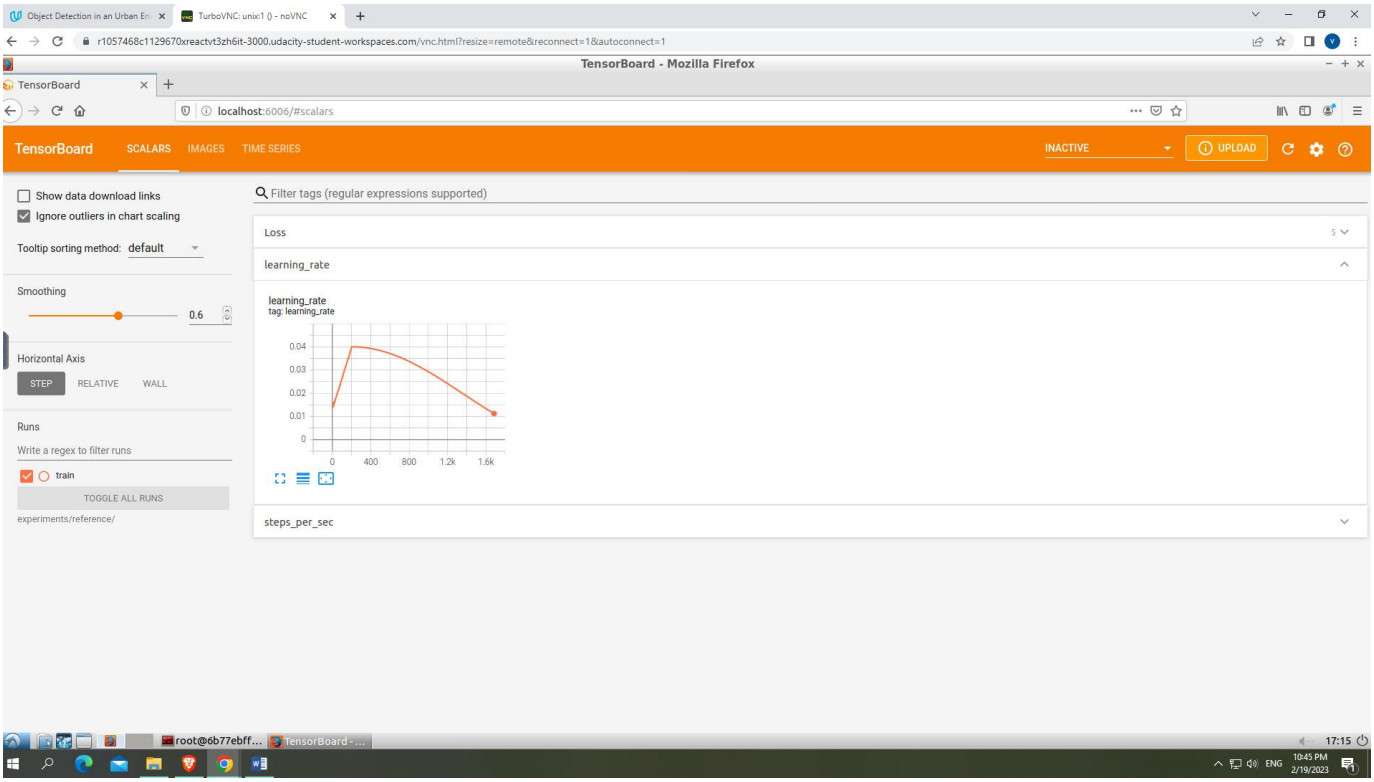
experiments/reference/
DetectionBoxes_Recall
Loss
Loss/classification_loss
tag: Loss/classification_loss
Loss/localization_loss
tag: Loss/localization_loss
Loss/normalized_total_loss
tag: Loss/normalized_total_loss
Loss/regularization_loss
tag: Loss/regularization_loss
Loss/total_loss
tag: Loss/total_loss
learning_rate
steps_per_sec


TensorBoard - Mozilla Firefox
TensorBoard
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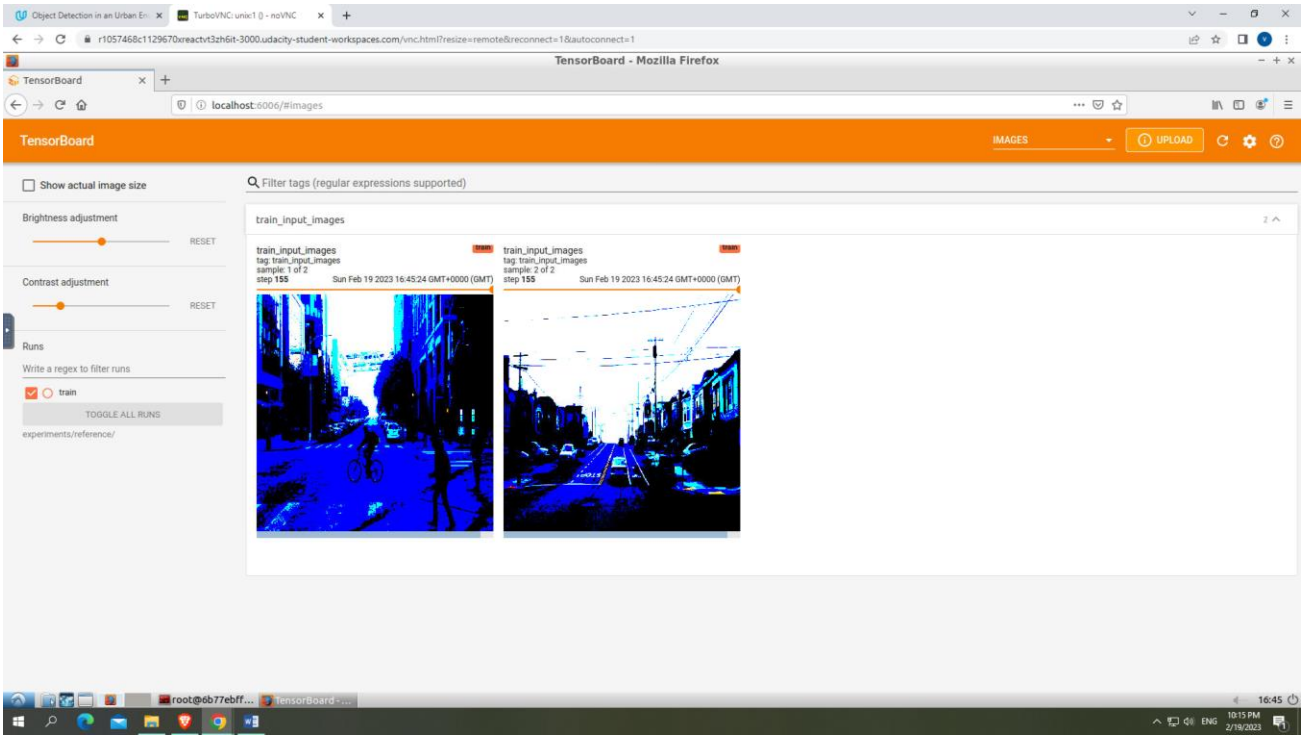
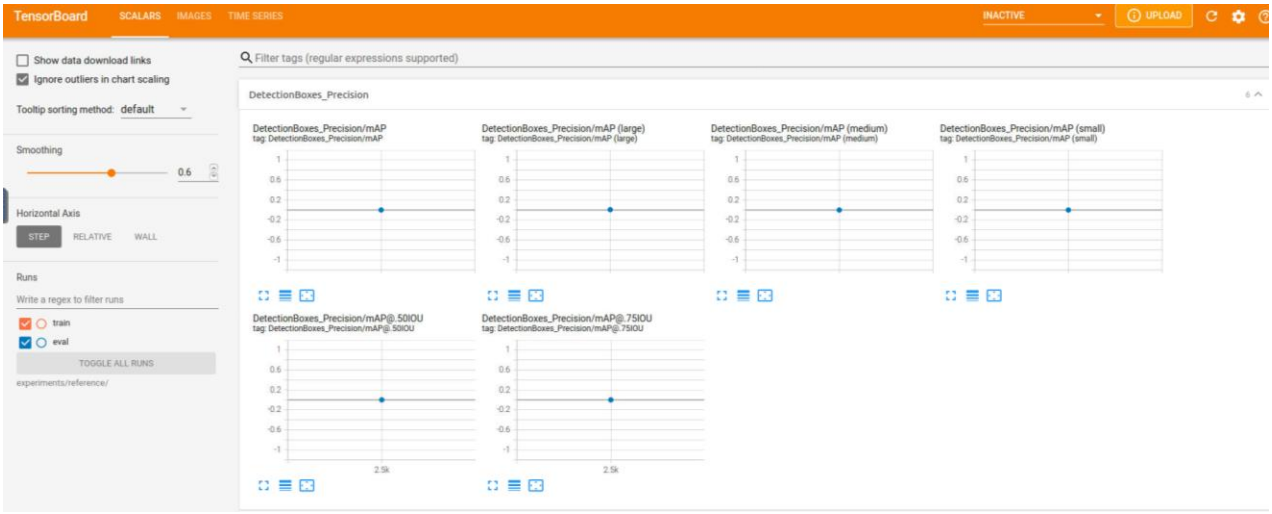
experiments/reference/
Filter tags (regular expressions supported)
Loss
learning_rate
learning_rate
tag: learning_rate
steps_per_sec


TensorBoard - Mozilla Firefox
TensorBoard
localhost:6006/#images
IMAGES
UPLOAD
Show actual image size
Brightness adjustment
RESET
Contrast adjustment
RESET
Runs
Write a regex to filter runs
train
TOGGLE ALL RUNS
experiments/reference/
Filter tags (regular expressions supported)
train_input_images
train_input_images
tag: train_input_images
sample: 1 of 2
step 155
Sun Feb 19 2023 16:45:24 GMT+0000 (GMT)
train_input_images
tag: train_input_images
sample: 2 of 2
step 155
Sun Feb 19 2023 16:45:24 GMT+0000 (GMT)


TensorBoard
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INACTIVE
UPLOAD
Show data download links
Ignore outliers in chart scaling
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DetectionBoxes_Precision/mAP (large)
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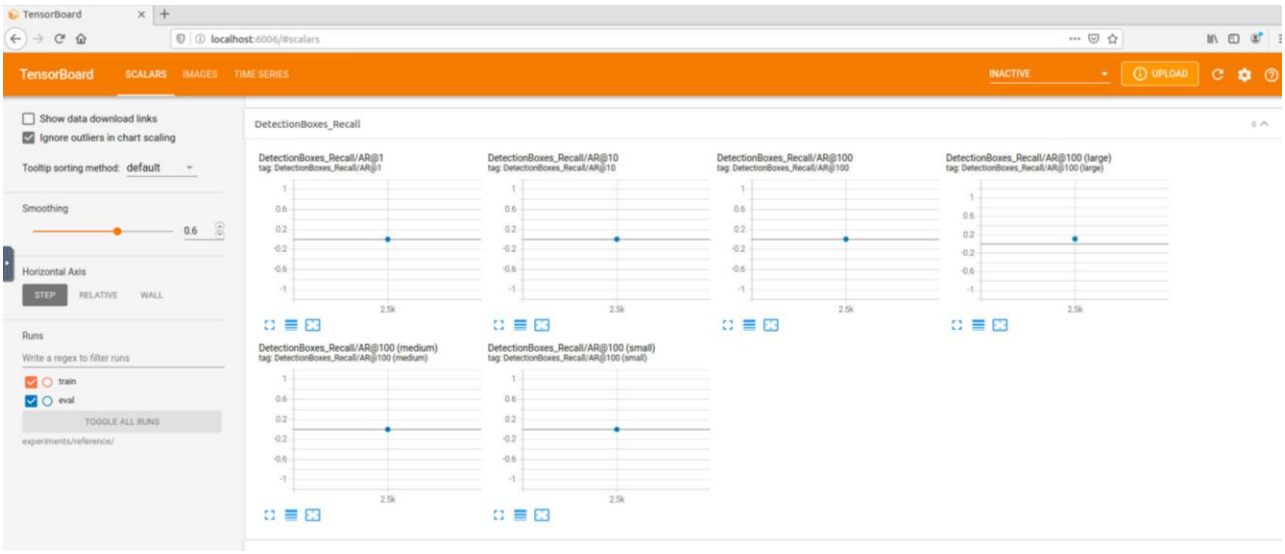
TensorBoard
localhost:6006/#scalars
TensorBoard
SCALARS
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DetectionBoxes_Recall/AR@1
tag: DetectionBoxes_Recall/AR@1
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DetectionBoxes_Recall/AR@100
tag: DetectionBoxes_Recall/AR@100
DetectionBoxes_Recall/AR@100 (large)
tag: DetectionBoxes_Recall/AR@100 (large)
DetectionBoxes_Recall/AR@100 (medium)
tag: DetectionBoxes_Recall/AR@100 (medium)
DetectionBoxes_Recall/AR@100 (small)
tag: DetectionBoxes_Recall/AR@100 (small)

TensorBoard
localhost:6006/#scalars
TensorBoard
SCALARS
IMAGES
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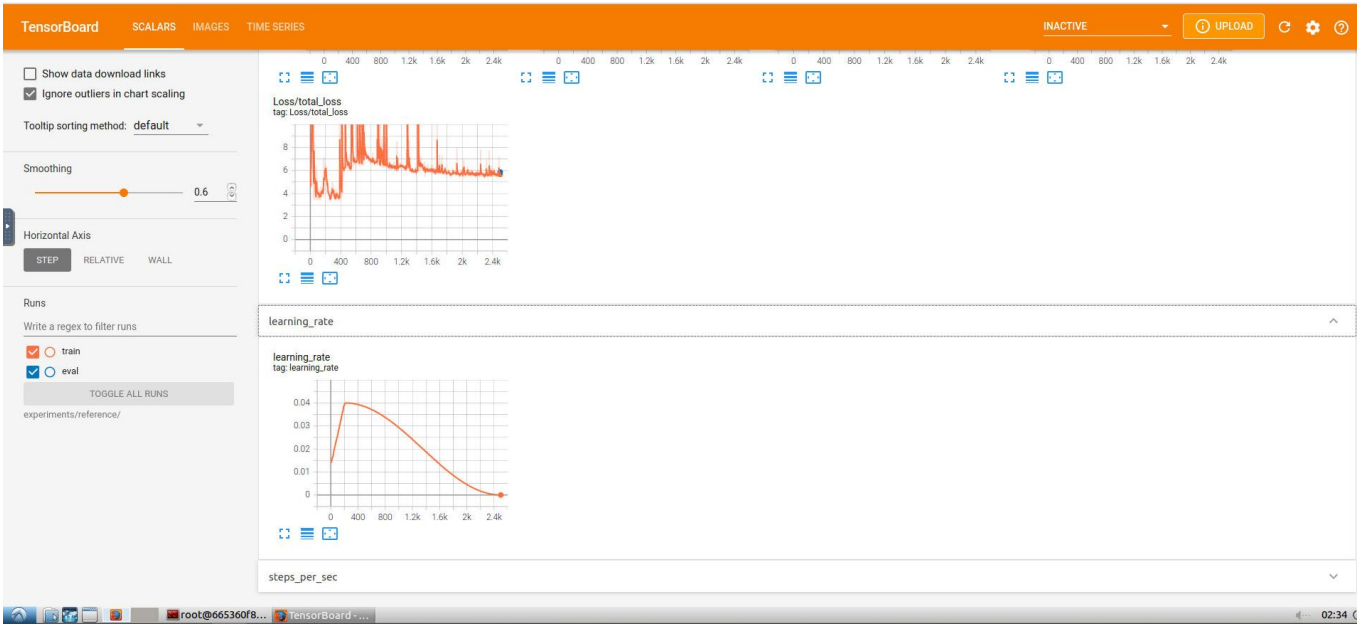
Loss/classification_loss
tag: Loss/classification_loss
Loss/localization_loss
tag: Loss/localization_loss
Loss/normalized_total_loss
tag: Loss/normalized_total_loss
Loss/regularization_loss
tag: Loss/regularization_loss
Loss/total_loss
tag: Loss/total_loss



ii) Improve on the Reference:

In the config file added the following data augmentations and decreased the learning rate. The loss is reduced ~3.

```
learning_rate {
  cosine_decay_learning_rate {
    learning_rate_base: 0.035
    total_steps: 2500
    warmup_learning_rate: 0.013333
    warmup_steps: 200
  }
}
```

```
data_augmentation_options {
  random_adjust_brightness {
    max_delta: 0.3
  }
}
data_augmentation_options {
  random_rgb_to_gray {
    probability: 0.2
  }
}
```

Data augmentation is a set of techniques to increase the amount of data artificially by generating new data points from existing data.

I have considered two data augmentations as shown above

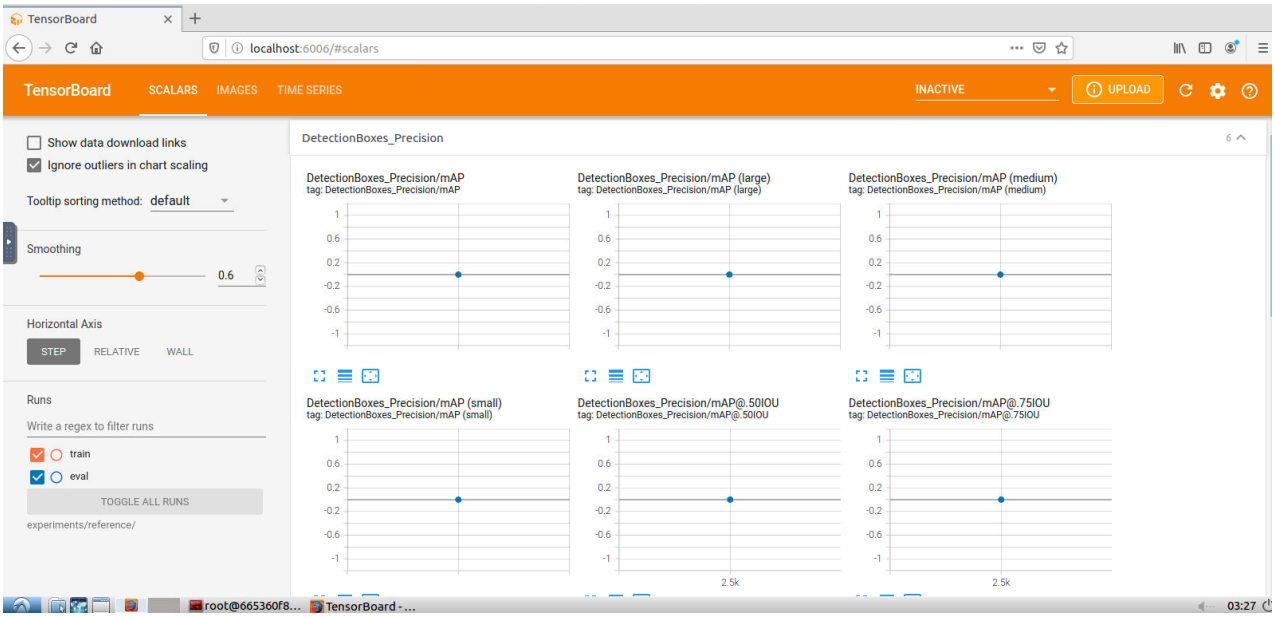
1. Random Adjust Brightness

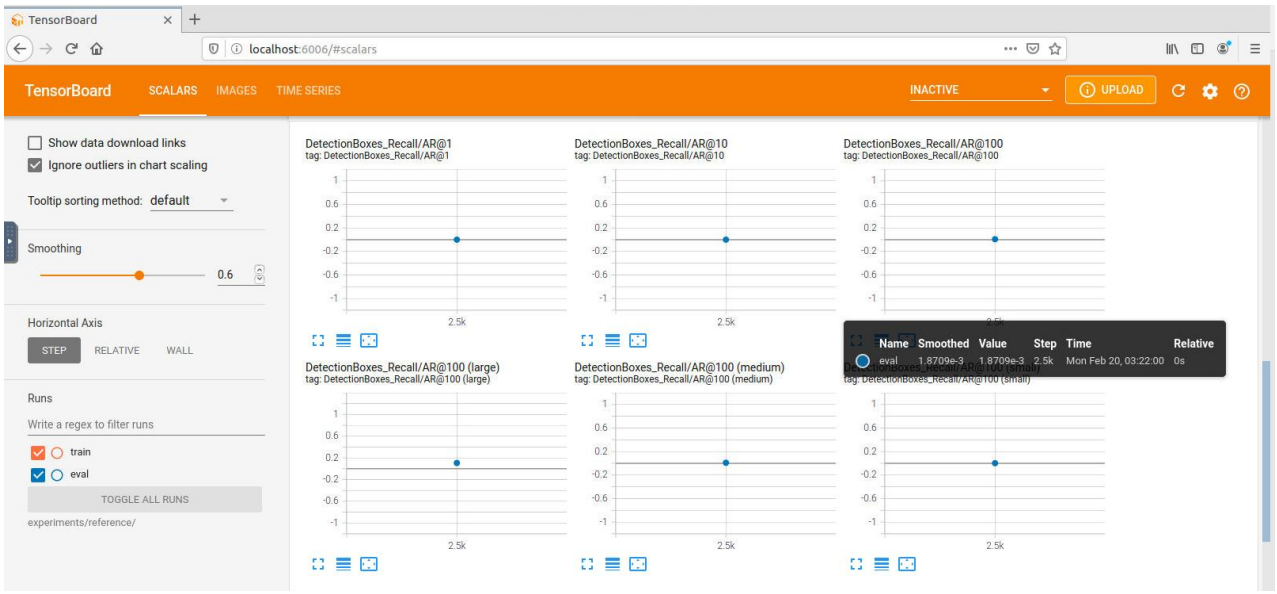
This data augmentation will increase the brightness of images randomly with maximum delta of 0.3, which seems effective in increasing the efficiency of the training model. This augmentation will help to overcome the difficulty of detecting objects against glare, varying brightness.

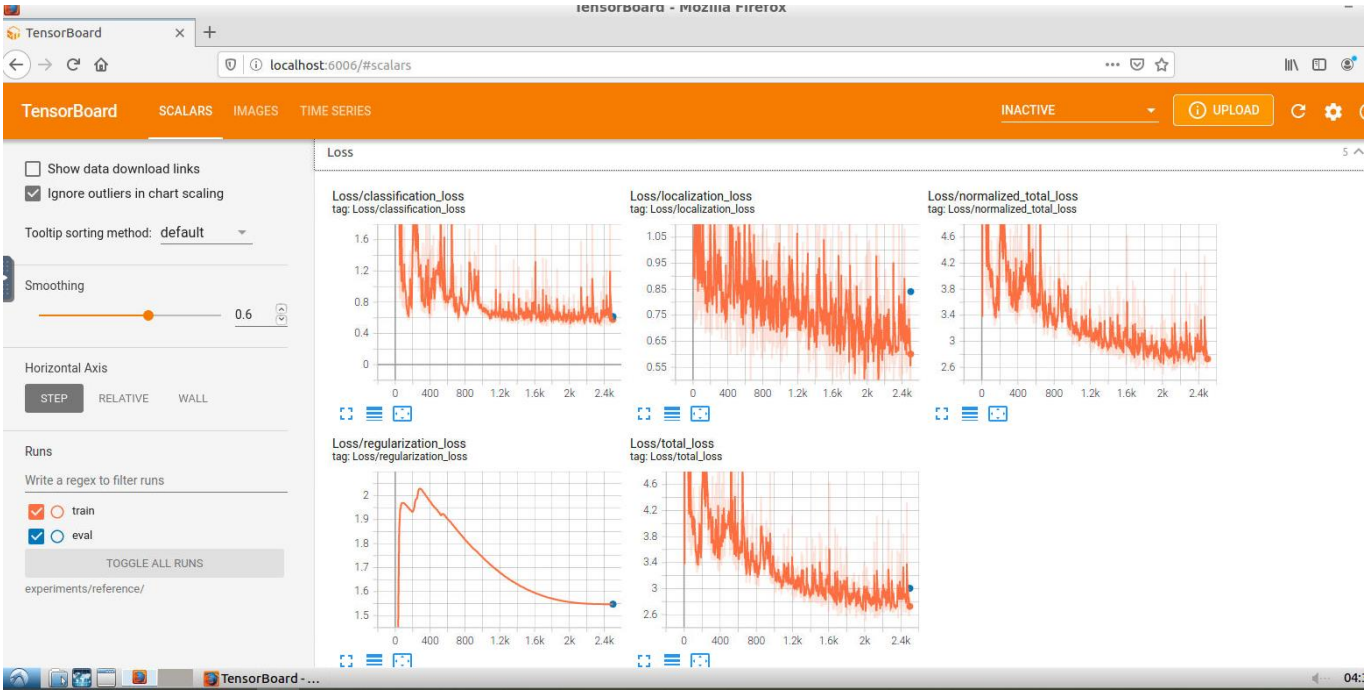
2. Random RGB to gray

This data augmentation converts the RGB image into gray scale, which reduces the color complexity and can negate the shadows resulting in better object detection.

Reduced the Learning Rate so that model gets trained to fit better with data, also its important to select a value so that it doesn't over fit.






TensorBoard - Mozilla Firefox
TensorBoard
localhost:6006/#scalars
TensorBoard
SCALARS
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TOGGLE ALL RUNS
experiments/reference/
Loss
Loss/classification_loss
tag: Loss/classification_loss
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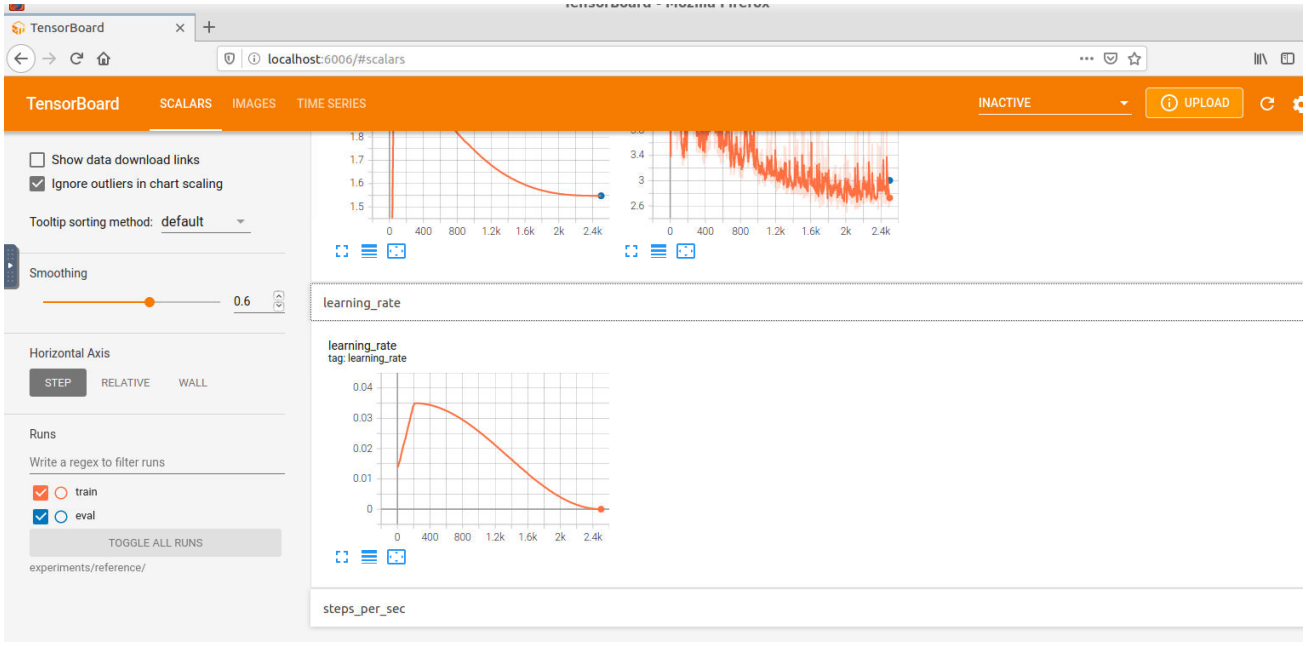
tag: Loss/localization_loss
Loss/normalized_total_loss
tag: Loss/normalized_total_loss
Loss/regularization_loss
tag: Loss/regularization_loss
Loss/total_loss
tag: Loss/total_loss
TensorBoard - ...


TensorBoard
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TensorBoard
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Tooltip sorting method: default
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Horizontal Axis
STEP
RELATIVE
WALL
Runs
Write a regex to filter runs
train
eval
TOGGLE ALL RUNS
experiments/reference/
learning_rate
learning_rate
tag: learning_rate
steps_per_sec