Project : Object Detection in an Urban Environment

Project Overview

In this project,

On the Early stage of project, I tried to setup a local environment on my laptop. But , I been faced so many errors(version not match each other between the packages), finally I gave up to build a local environment. (it tooks 11 days!!). So, I asked you a environment.yml files for the project.)

Finally, Project is developed under the udacity workspace environment.

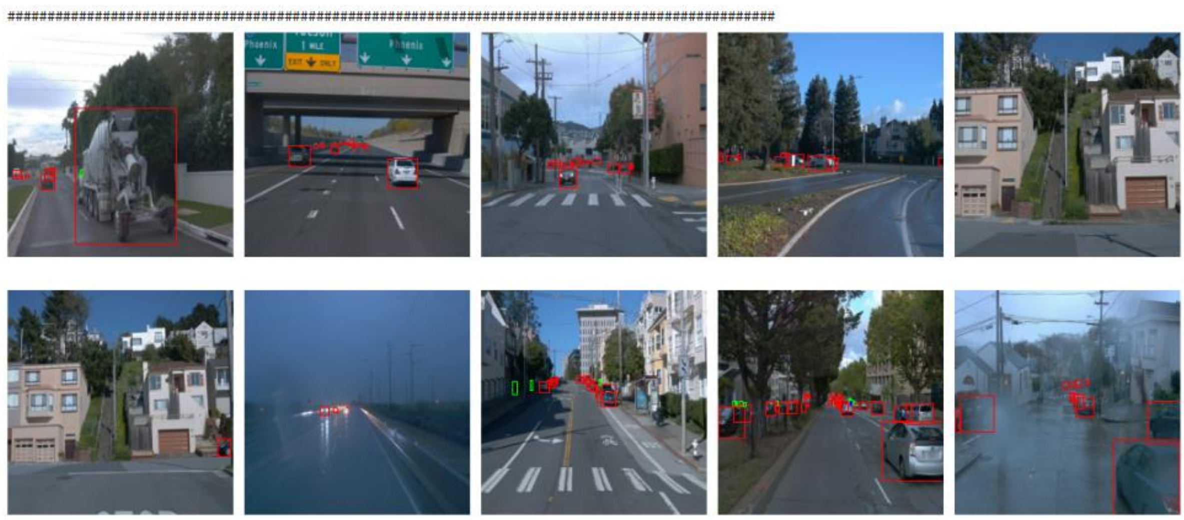
Python package is well match each other only on the Udacity workspace Environment!

The first stage is **the explore the dataset**.

This ipynb is to give a motivation for the students to explore and study dataset.

What is contained on the dataset(trfrecord).

With using display images and dataset_choice functions together,. Finally result is shown below.



These images with bounding boxes with using tensorflow and waymo_open_dataset(dataset_pb2),matplotlib to indicate the vehicles on the images.,

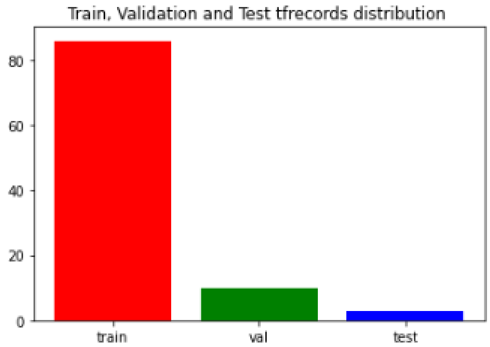
The next step is EDA chapter.

The dataset show train,val,test set's distributions. Absolutely, train dataset is the big one.

With using class_count function, clearly recognize the distributions of 3 classes(vehicle, pedestrian,cyclist) for each train and test dataset. On the train dataset, pedestrian data is much bigger(2.5x)than test dataset.

```
#display the each dataset
xlabel=["train","val","test"]
plt.bar(xlabel,[train_dataset,val_dataset,test_dataset],color=["red","green","blue"])
plt.title("Train, Validation and Test tfrecords distribution ")
```

```
Text(0.5, 1.0, 'Train, Validation and Test tfrecords distribution ')
```

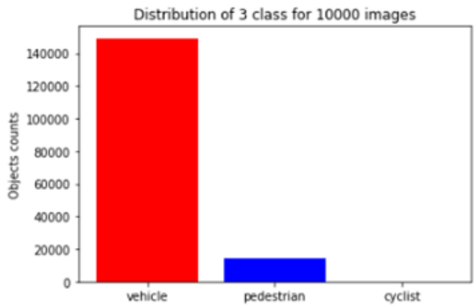



```
class_count(trainset)
```

```
{'car': 173434, 'pedestrian': 48819, 'cyclist': 1246}
```


```
class_count(testset)
```

```
{'car': 149216, 'pedestrian': 14127, 'cyclist': 0}
```



The second step is Explore augmentations.

The result is looks similar with explore the dataset.ipynb. but, this file is focused on the understanding of augmentation(manipulated the dataset to increase the dataset).

In this step, Explore the data augmentation (to increase the dataset) to understanding what is datas Augmentaion.

I just put some of option on the display_batch function.

#plt.subplots(,) -->control image row and column

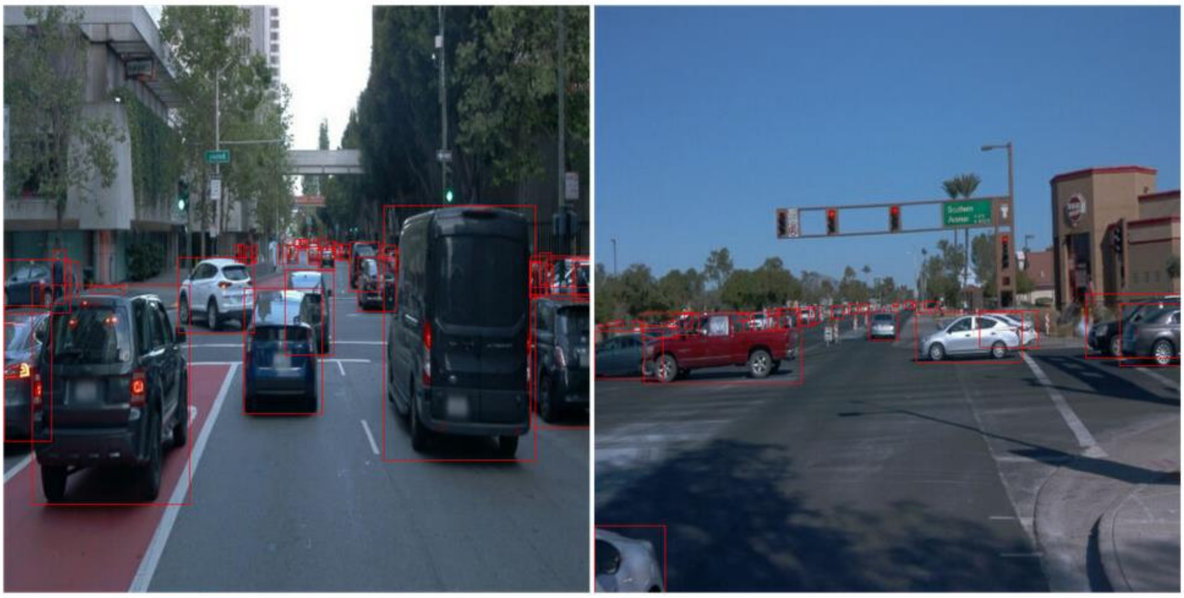
    fig, axes = plt.subplots(1, 2, figsize=(40, 30))

    axes = axes.flatten()

To show the images with 1row and 2 columns intentionally.

```
%matplotlib inline

for batch in train_dataset.take(1):
    display_batch(batch)
```



I thought the aumentation code is included the file below

train_dataset = get_train_input("./experiments/reference/pipeline_new.config")

'pipeline_new.config'

The above file has those kind of sections below:

```
train_config {
  batch_size: 2
  data_augmentation_options {
    random_horizontal_flip {
    }
  }
  data_augmentation_options {
    random_crop_image {
      min_object_covered: 0.0
      min_aspect_ratio: 0.75
      max_aspect_ratio: 3.0
      min_area: 0.75
      max_area: 1.0
      overlap_thresh: 0.0
    }
  }
```

These code indicates horizontal flip to increase the dataset.

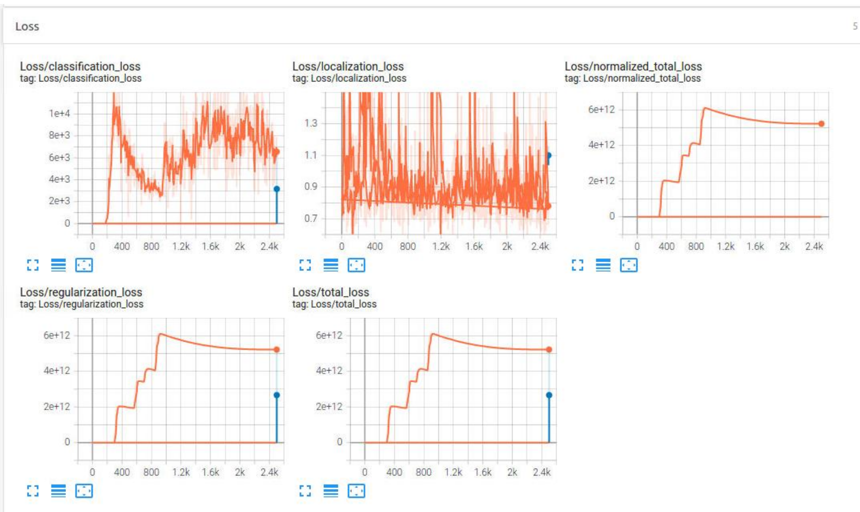
So, My guess was right! This course made a clue to find it and solve it by student by themselves!

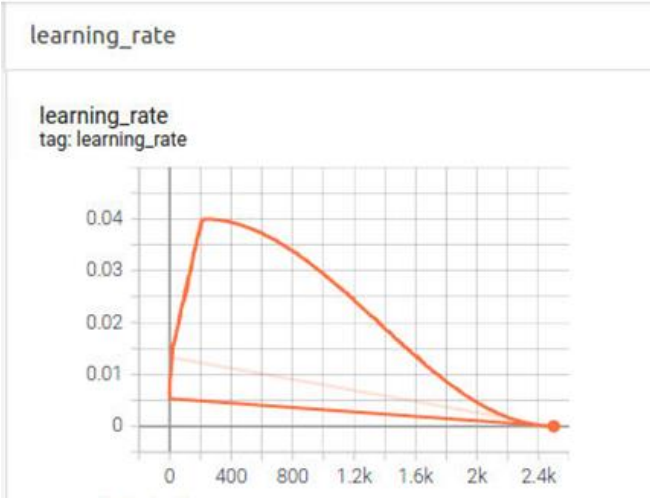
Training

Experiments_00(iteration_00) / pipeline_new_00.config

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

with this command, the result is below.





The results shows, learning rate tends to decline. It is understandable.

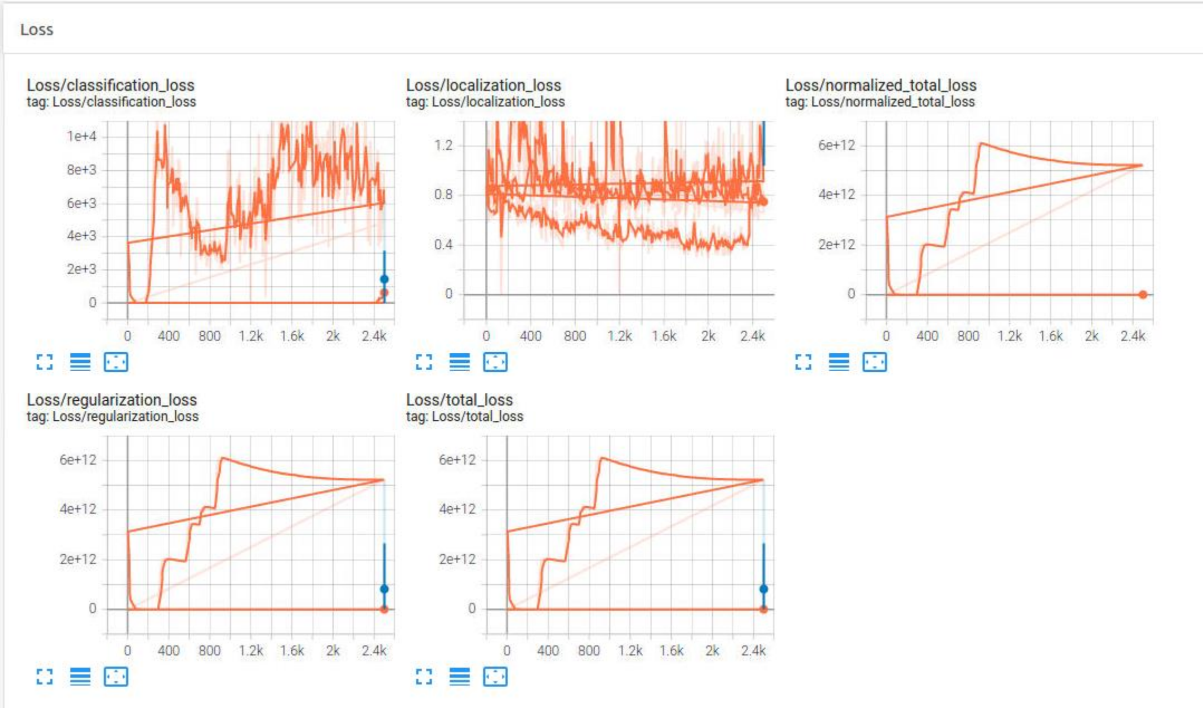
And loss is tends to climb up to the top!   These indicate something wrong in this anlysis.

Experiments_01(iteration_01)

I tuned up the train_config parameters like below.

```
sync_replicas: true
optimizer {
  momentum_optimizer {
    learning_rate {
      cosine_decay_learning_rate {
        learning_rate_base: 0.04
        total_steps: 25000
        warmup_learning_rate: 0.013333
        warmup_steps: 2000
      }
```

Increasing total steps to 25000 and warmup steps to 2000



The learning rate, But results looks very not normal.

I'm considering this kind of result is not clearly reset the previous iteration result.

(home/workspace/experiments/reference/train) → log file

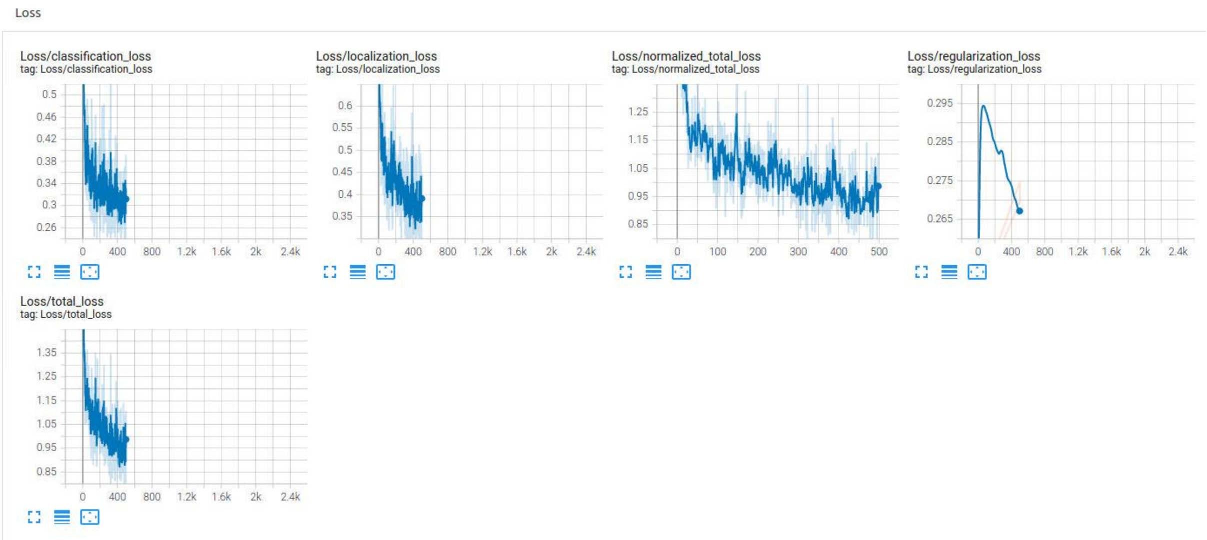
so, I cleaned up the log files from the location.

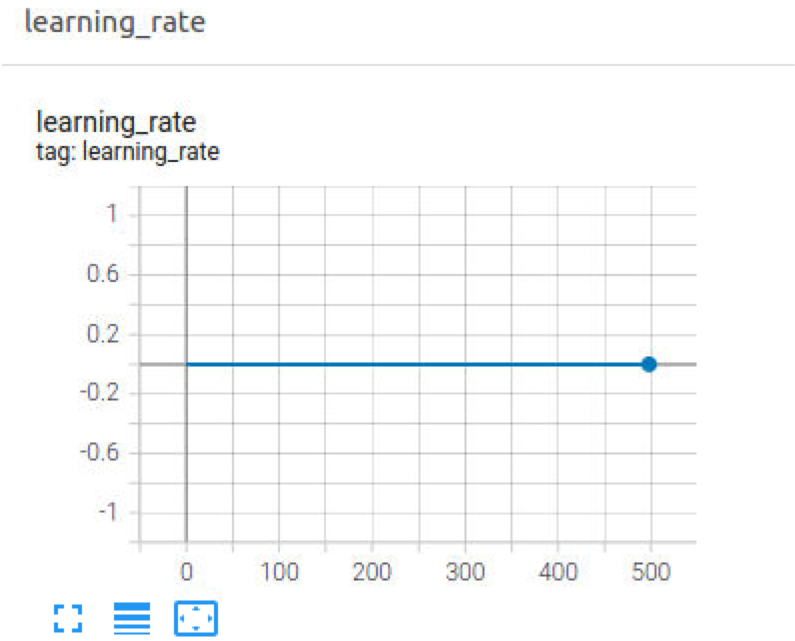
Experiments_02(iteration_02)

I tunded up the parameters like below.

```
train_config {
  batch_size: 8
  data_augmentation_options {
    random_horizontal_flip {
    }
  }
  data_augmentation_options {
    ssd_random_crop {
    }
  }
  data_augmentation_options {
    random_adjust_contrast {
    }
  }
  data_augmentation_options {
    random_black_patches {
      probability: 0.1
      size_to_image_ratio: 0.05
    }
  }
  optimizer {
    adam_optimizer {
```

```
        learning_rate {
          manual_step_learning_rate {
            initial_learning_rate: 0.0005
            schedule {
              step: 1000
              learning_rate: 0.0001
            }
            schedule {
              step: 3000
              learning_rate: 1e-05
            }
          }
        }
      }
      use_moving_average: false
    }
fine_tune_checkpoint:"/home/workspace/experiments/pretrained_model/ssd_resnet50_v1_fpn_640x640_coco17_tpu-8/checkpoint/ckpt-0"    fine_tune_checkpoint_type: "detection"
  fine_tune_checkpoint_version: V2
  use_bfloat16: false
  num_steps: 50000
  startup_delay_steps: 0.0
  replicas_to_aggregate: 8
  max_number_of_boxes: 100
  unpad_groundtruth_tensors: false
}
```





The loss graph is understandable, but learning rate required to be fine tuned.

Experiments_03(iteration_03)

train_config {

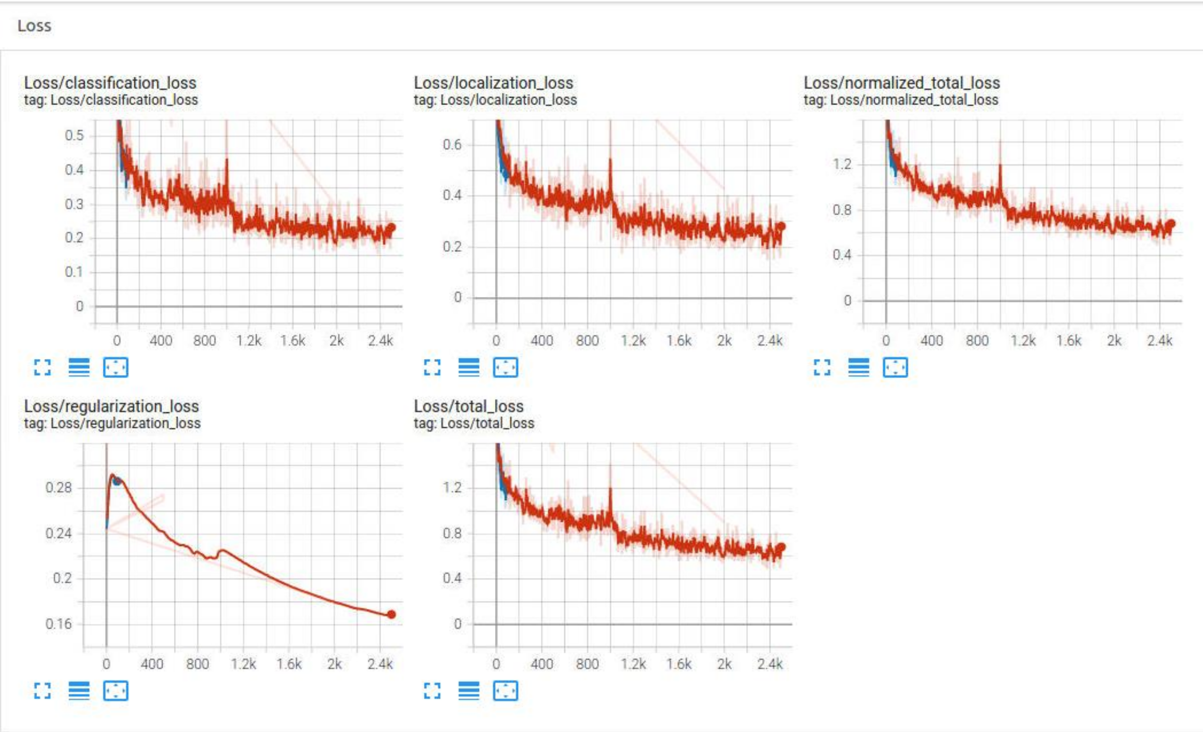
batch_size: 8

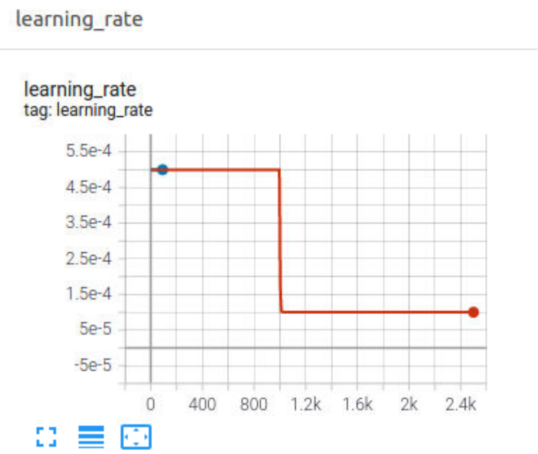
data_augmentation_options {

```
    random_horizontal_flip {
    }
  }
  data_augmentation_options {
    ssd_random_crop {
    }
  }
  data_augmentation_options {
    random_adjust_contrast {
    }
  }
  data_augmentation_options {
    random_black_patches {
      probability: 0.1
      size_to_image_ratio: 0.05
    }
  }
  sync_replicas: true
  optimizer {
    adam_optimizer {
      learning_rate {
        manual_step_learning_rate {
          initial_learning_rate: 0.0005
```

```
            schedule {
              step: 1000
              learning_rate: 0.0001
            }
            schedule {
              step: 3000
              learning_rate: 1e-05
            }
          }
        }
      }
      use_moving_average: false
    }
    fine_tune_checkpoint:
"/home/workspace/experiments/pretrained_model/ssd_resnet50_v1_fpn_640x640_coco17_tpu-
8/checkpoint/ckpt-0"
    num_steps: 5000
    startup_delay_steps: 0.0
    replicas_to_aggregate: 8
    max_number_of_boxes: 100
    unpad_groundtruth_tensors: false
    fine_tune_checkpoint_type: "detection"
    use_bfloat16: false
    fine_tune_checkpoint_version: V2
```

}





The results looks pretty good, but learning rate looks strange.

It was tuned at 1000 steps and 3000steps only.

So, Finally, I updated parameter for the the next trial.

There are also experiments 04 and 05, but I will skip them.

Experiments 06(iteration 06) / pipeline_new_06.config

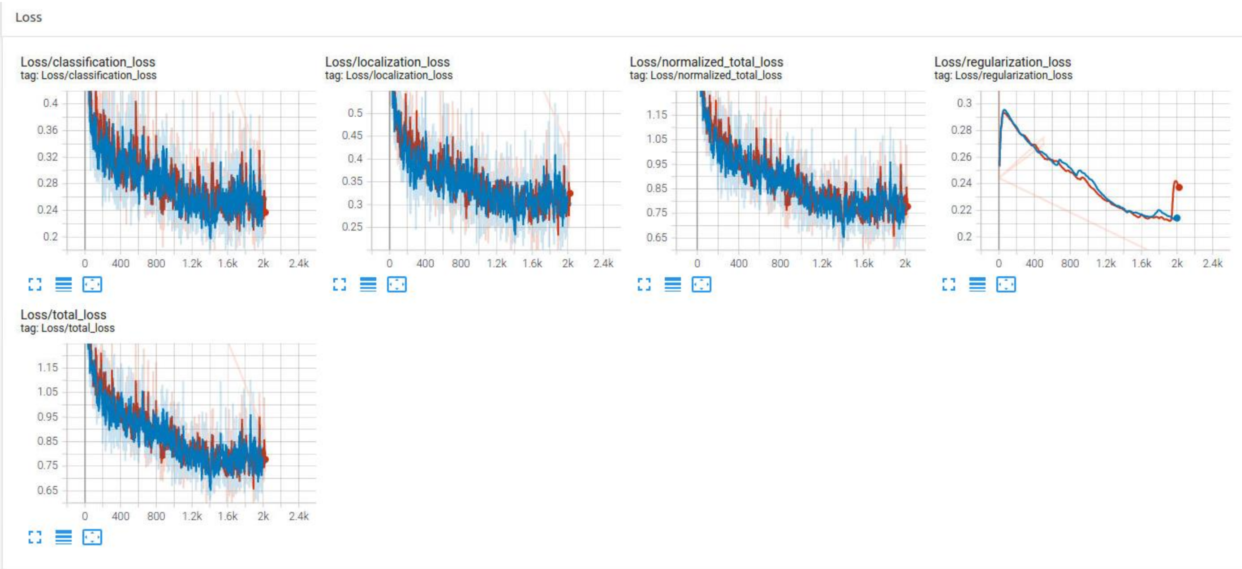
This is the last trial for my project.

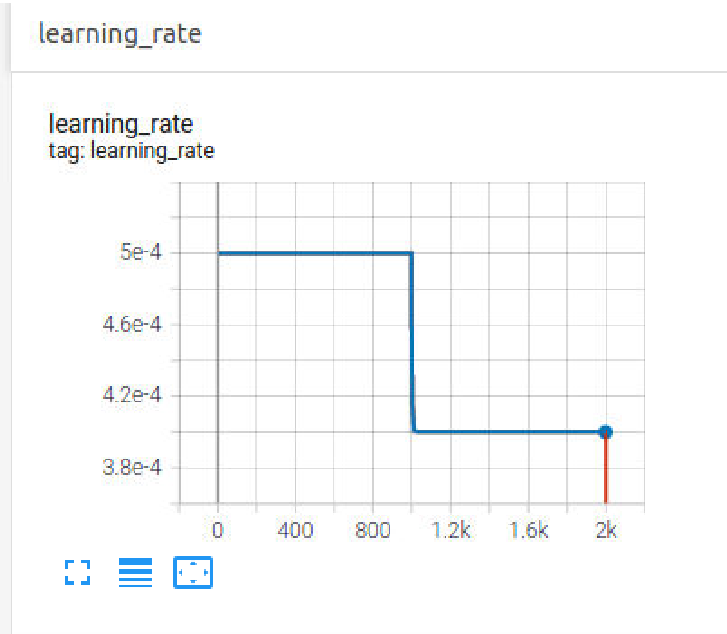
The code is below

```
train_config {
  batch_size: 8
  data_augmentation_options {
    random_horizontal_flip {
    }
  }
  data_augmentation_options {
    ssd_random_crop {
    }
  }
  data_augmentation_options {
    random_adjust_contrast {
    }
  }
  data_augmentation_options {
    random_black_patches {
      probability: 0.1
```

```
      size_to_image_ratio: 0.05
    }
  }
  sync_replicas: true
  optimizer {
    adam_optimizer {
      learning_rate {
        manual_step_learning_rate {
          initial_learning_rate: 0.0005
          schedule {
            step: 1000
            learning_rate: 0.0004
          }
          schedule {
            step: 2000
            learning_rate: 0.0003
          }
          schedule {
            step: 3000
            learning_rate: 0.0002
          }
          schedule {
            step: 4000
```

learning_rate: 0.0001





The declined loss is reasonable. And it means analysis is going well.

I tuned the learning rate from 0.005~0.001. it is 5 stages for entire steps.

Finally result is above image.

This ‘step decay’ is preventing overfitting and enhancing the general performances.

Conclusion (for Learning rate)

In our training process, I used a step-wise learning rate schedule. This means we started with a higher learning rate to help the model learn quickly at the beginning. As training continued, we lowered the learning rate to fine-tune the model and prevent it from making big changes that could miss the best settings.

Research supports this approach. The paper "Learning an Adaptive Learning Rate Schedule" shows that adjusting the learning rate during training can improve results significantly. By following this method, I saw the training loss go down gradually, leading to better and more stable training.

References:

Learning an Adaptive Learning Rate Schedule

https://ar5iv.labs.arxiv.org/html/1909.09712

https://arxiv.org/abs/1909.09712

Summary

Revision 00 (pipeline_new_00.config) :

#1. Basic setting

#2. Set basic learning rate in train_config item

#3. No settings related to adam_optimizer

#4. manual_step_learning_rate Deprecated

Revision 06 (pipeline_new_06.config):

#Add learning rate adjustment

#1. Added manual_step_learning_rate: Use a high learning rate for fast convergence at the beginning of training, then gradually reduce the learning rate to perform more sophisticated optimization.

#2. nitial learning rate: 0.0005, then decreasing step by step (0.0004 at 1000 steps, 0.0003 at 2000 steps, 0.0002 at 3000 steps, 0.0001 at 4000 steps)

#adam_optimizer introduced

#1. Set adam_optimizer as learning optimization method

#2. set use_moving_average to false

What's improved

#1. More detailed learning rate adjustment simultaneously promotes rapid convergence and stable optimization in the early stages of learning.

#2. More efficient optimization possible using adam_optimizer