Capstone Project

This is the Third and final project in third term of Self Driving Car Nano Degree program.

Team:

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The goal of this project is to develop system integration using ROS Kinetic, the Udacity System Integration Simulator, and code written in C++ and Python . The code developed will be tested on Udacity's real-world test vehicle (a Lincoln MKZ that the company has named "Carla") .

ROS Node Description:

Waypoint Updater Node:

This node publishes next 200 waypoints that are closest to the vehicle's current position and ahead of the vehicle. This node also considers the traffic lights to set the velocity of each waypoint.

This node subscribes to the following topics:

/base_waypoints: Waypoints for the entire track are published to this topic, this is one time operation. Waypoint updater node recieves these waypoints stores them to publish next 200 waypoints based the the current car's position.

/traffic_waypoint: Index of the waypoint in ht ebase waypoints list which is closes to the red traffic light. The waypoint updater node calcuates the distance to this waypoint and sets the velocity of the waypoints to stop the car at the red light.

/current_pose: To receive current position of the vehicel.

/Curremt_velocity: To receive current velocity of the car which will be used in the acceleration and deceleration decision in the waypoint updater node.

This node publishes to following topics:

/final_waypoints: Publishes 200 waypoints closes and ahead of the car includign velocity of the each waypoint.

DBW Node:

This node is responsible for vehicle control (Accelearation, break and steering)

This node subscribes to the following:

/current_velocity:To receive current velocity of the car.

/twist_cmd: Target vehicle liear and angualr velocities are published to this /vehicle/dbw_enabled: Indicate Manual or DBW control.

This node publishes to following topics:

/vehicle/steering_cmd: Steering commands are published to this topic.

/vehicle/brake_cmd: Brakecommands are published to this topic.

/vehicle/throttle_cmd: Throttlecommands are published to this topic.

To calculate vehicle commands for steering,throttle and brake used the PID control and a low pass filter.

Hyper Parameters used:

Velocity KP=0.6, ki=0.0 and kd =0.0

Steering and Acceleartion Tau and Ts is 0.5

Traffic light detection node:

This node is responsible for detecting and classifying traffic lights.

This node subscribes to the following:

/base_waypoints: Waypoints for the entire track published to this topic
/current_pose: the current position of the car
/image_color: Camera image to identify the light color.
/vehicle/traffic_lights: This topic provides the location of the traffic light in 3D map space and helps acquiring an accurate ground truth data source for the traffic light classifier by sending the current color state of all traffic lights in the simulator. When testing on the vehicle, the color state will not be available. You'll need to rely on the position of the light and the camera image to predict it.

This node publishes to following topics:

/traffic_waypoint: Publishes the index of closes waypoint to the red traffic lights stop line.

To Classify used the Squeezenet model .Adam Optimizer is used.

The summary of the model as follows:

```
Layer (type)                 Output Shape       Param #     Connected to
==================================================================================================
input_1 (InputLayer)         (None, 227, 227, 3)  0
__________________________________________________________________________________________________
conv1 (Conv2D)               (None, 113, 113, 64) 1792       input_1[0][0]
__________________________________________________________________________________________________
relu_conv1 (Activation)       (None, 113, 113, 64) 0         conv1[0][0]
__________________________________________________________________________________________________
pool1 (MaxPooling2D)          (None, 56, 56, 64)   0         relu_conv1[0][0]
__________________________________________________________________________________________________
fire2/squeeze1x1 (Conv2D)     (None, 56, 56, 16)   1040      pool1[0][0]
__________________________________________________________________________________________________
fire2/relu_squeeze1x1 (Activati (None, 56, 56, 16)   0         fire2/squeeze1x1[0][0]
__________________________________________________________________________________________________
fire2/expand1x1 (Conv2D)      (None, 56, 56, 64)   1088      fire2/relu_squeeze1x1[0][0]
__________________________________________________________________________________________________
fire2/expand3x3 (Conv2D)      (None, 56, 56, 64)   9280      fire2/relu_squeeze1x1[0][0]
__________________________________________________________________________________________________
fire2/relu_expand1x1 (Activatio (None, 56, 56, 64)   0         fire2/expand1x1[0][0]
__________________________________________________________________________________________________
fire2/relu_expand3x3 (Activatio (None, 56, 56, 64)   0         fire2/expand3x3[0][0]
__________________________________________________________________________________________________
fire2/concat (Concatenate)    (None, 56, 56, 128)  0         fire2/relu_expand1x1[0][0]
                                                               fire2/relu_expand3x3[0][0]
__________________________________________________________________________________________________
fire3/squeeze1x1 (Conv2D)     (None, 56, 56, 16)   2064      fire2/concat[0][0]
__________________________________________________________________________________________________
fire3/relu_squeeze1x1 (Activati (None, 56, 56, 16)   0         fire3/squeeze1x1[0][0]
__________________________________________________________________________________________________
fire3/expand1x1 (Conv2D)      (None, 56, 56, 64)   1088      fire3/relu_squeeze1x1[0][0]
__________________________________________________________________________________________________
fire3/expand3x3 (Conv2D)      (None, 56, 56, 64)   9280      fire3/relu_squeeze1x1[0][0]
__________________________________________________________________________________________________
fire3/relu_expand1x1 (Activatio (None, 56, 56, 64)   0         fire3/expand1x1[0][0]
__________________________________________________________________________________________________
fire3/relu_expand3x3 (Activatio (None, 56, 56, 64)   0         fire3/expand3x3[0][0]
__________________________________________________________________________________________________
fire3/concat (Concatenate)    (None, 56, 56, 128)  0         fire3/relu_expand1x1[0][0]
                                                               fire3/relu_expand3x3[0][0]
__________________________________________________________________________________________________
```

pool3 (MaxPooling2D) (None, 27, 27, 128) 0 fire3/concat[0][0]

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fire4/squeeze1x1 (Conv2D) (None, 27, 27, 32) 4128 pool3[0][0]

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fire4/relu_squeeze1x1 (Activati (None, 27, 27, 32) 0 fire4/squeeze1x1[0][0]

---

fire4/expand1x1 (Conv2D) (None, 27, 27, 128) 4224 fire4/relu_squeeze1x1[0][0]

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fire4/expand3x3 (Conv2D) (None, 27, 27, 128) 36992 fire4/relu_squeeze1x1[0][0]

---

fire4/relu_expand1x1 (Activatio (None, 27, 27, 128) 0 fire4/expand1x1[0][0]

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fire4/relu_expand3x3 (Activatio (None, 27, 27, 128) 0 fire4/expand3x3[0][0]

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fire4/concat (Concatenate) (None, 27, 27, 256) 0 fire4/relu_expand1x1[0][0]
fire4/relu_expand3x3[0][0]

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fire5/squeeze1x1 (Conv2D) (None, 27, 27, 32) 8224 fire4/concat[0][0]

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fire5/relu_squeeze1x1 (Activati (None, 27, 27, 32) 0 fire5/squeeze1x1[0][0]

---

fire5/expand1x1 (Conv2D) (None, 27, 27, 128) 4224 fire5/relu_squeeze1x1[0][0]

---

fire5/expand3x3 (Conv2D) (None, 27, 27, 128) 36992 fire5/relu_squeeze1x1[0][0]

---

fire5/relu_expand1x1 (Activatio (None, 27, 27, 128) 0 fire5/expand1x1[0][0]

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fire5/relu_expand3x3 (Activatio (None, 27, 27, 128) 0 fire5/expand3x3[0][0]

---

fire5/concat (Concatenate) (None, 27, 27, 256) 0 fire5/relu_expand1x1[0][0]
fire5/relu_expand3x3[0][0]

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pool5 (MaxPooling2D) (None, 13, 13, 256) 0 fire5/concat[0][0]

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fire6/squeeze1x1 (Conv2D) (None, 13, 13, 48) 12336 pool5[0][0]

---

fire6/relu_squeeze1x1 (Activati (None, 13, 13, 48) 0 fire6/squeeze1x1[0][0]

---

fire6/expand1x1 (Conv2D) (None, 13, 13, 192) 9408 fire6/relu_squeeze1x1[0][0]

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fire6/expand3x3 (Conv2D) (None, 13, 13, 192) 83136 fire6/relu_squeeze1x1[0][0]

---

fire6/relu_expand1x1 (Activatio (None, 13, 13, 192) 0 fire6/expand1x1[0][0]

---

fire6/relu_expand3x3 (Activatio (None, 13, 13, 192) 0 fire6/expand3x3[0][0]

---

fire6/concat (Concatenate) (None, 13, 13, 384) 0 fire6/relu_expand1x1[0][0]
fire6/relu_expand3x3[0][0]

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fire7/squeeze1x1 (Conv2D) (None, 13, 13, 48) 18480 fire6/concat[0][0]

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fire7/relu_squeeze1x1 (Activati (None, 13, 13, 48) 0 fire7/squeeze1x1[0][0]

---

fire7/expand1x1 (Conv2D) (None, 13, 13, 192) 9408 fire7/relu_squeeze1x1[0][0]

---

fire7/expand3x3 (Conv2D) (None, 13, 13, 192) 83136 fire7/relu_squeeze1x1[0][0]

fire7/relu_expand1x1 (Activatio (None, 13, 13, 192) 0 fire7/expand1x1[0][0]

fire7/relu_expand3x3 (Activatio (None, 13, 13, 192) 0 fire7/expand3x3[0][0]

fire7/concat (Concatenate) (None, 13, 13, 384) 0 fire7/relu_expand1x1[0][0]
fire7/relu_expand3x3[0][0]

fire8/squeeze1x1 (Conv2D) (None, 13, 13, 64) 24640 fire7/concat[0][0]

fire8/relu_squeeze1x1 (Activati (None, 13, 13, 64) 0 fire8/squeeze1x1[0][0]

fire8/expand1x1 (Conv2D) (None, 13, 13, 256) 16640 fire8/relu_squeeze1x1[0][0]

fire8/expand3x3 (Conv2D) (None, 13, 13, 256) 147712 fire8/relu_squeeze1x1[0][0]

fire8/relu_expand1x1 (Activatio (None, 13, 13, 256) 0 fire8/expand1x1[0][0]

fire8/relu_expand3x3 (Activatio (None, 13, 13, 256) 0 fire8/expand3x3[0][0]

fire8/concat (Concatenate) (None, 13, 13, 512) 0 fire8/relu_expand1x1[0][0]
fire8/relu_expand3x3[0][0]

fire9/squeeze1x1 (Conv2D) (None, 13, 13, 64) 32832 fire8/concat[0][0]

fire9/relu_squeeze1x1 (Activati (None, 13, 13, 64) 0 fire9/squeeze1x1[0][0]

fire9/expand1x1 (Conv2D) (None, 13, 13, 256) 16640 fire9/relu_squeeze1x1[0][0]

fire9/expand3x3 (Conv2D) (None, 13, 13, 256) 147712 fire9/relu_squeeze1x1[0][0]

fire9/relu_expand1x1 (Activatio (None, 13, 13, 256) 0 fire9/expand1x1[0][0]

fire9/relu_expand3x3 (Activatio (None, 13, 13, 256) 0 fire9/expand3x3[0][0]

fire9/concat (Concatenate) (None, 13, 13, 512) 0 fire9/relu_expand1x1[0][0]
fire9/relu_expand3x3[0][0]

drop9 (Dropout) (None, 13, 13, 512) 0 fire9/concat[0][0]

conv10 (Conv2D) (None, 6, 6, 400) 1843600 drop9[0][0]

relu_conv10 (Activation) (None, 6, 6, 400) 0 conv10[0][0]

flatten_1 (Flatten) (None, 14400) 0 relu_conv10[0][0]

dense_1 (Dense) (None, 1024) 14746624 flatten_1[0][0]

dropout_1 (Dropout) (None, 1024) 0 dense_1[0][0]

dense_2 (Dense) (None, 512) 524800 dropout_1[0][0]

dense_3 (Dense) (None, 4) 2052 dense_2[0][0]

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Total params: 17,839,572
Trainable params: 17,117,076
Non-trainable params: 722,496

Results:
Programs are compiled and executed without any errors.
Car is running fine on the simulator track with no Camera turned on.
When Camera is turned on it is having lots of latency issues and could not test it properly with the traffic light detection and classification.

Files Attached:
CarND-Capstone - This has the code in the ros/src directory.
Readme.pdf - This file