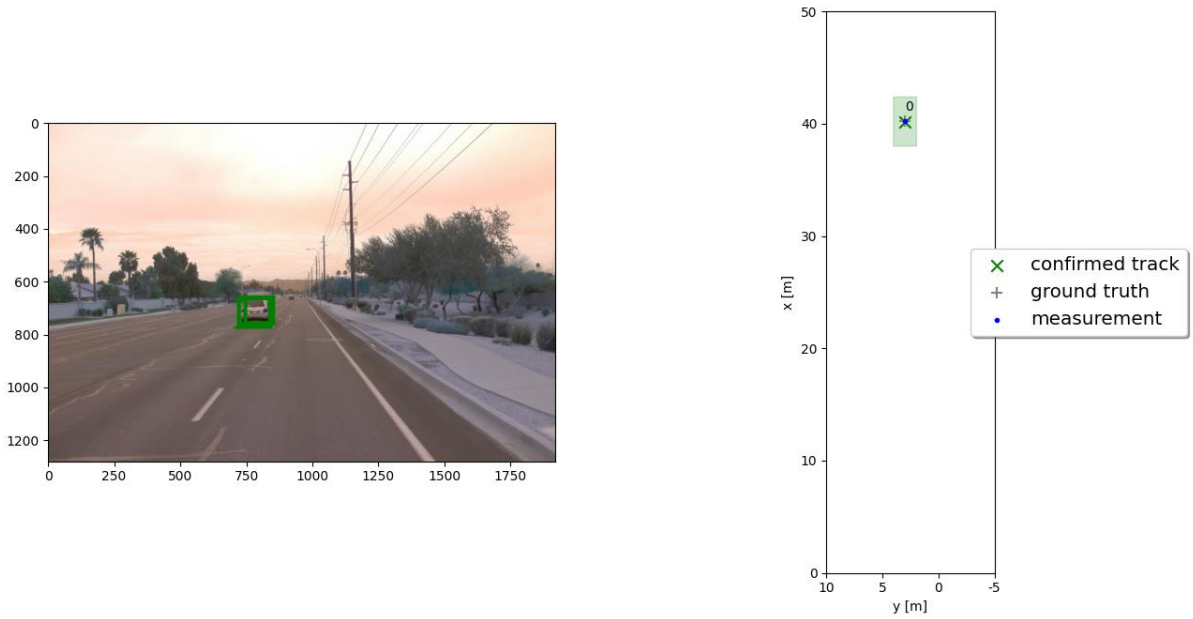
Final Project: Sensor Fusion and Object Tracking

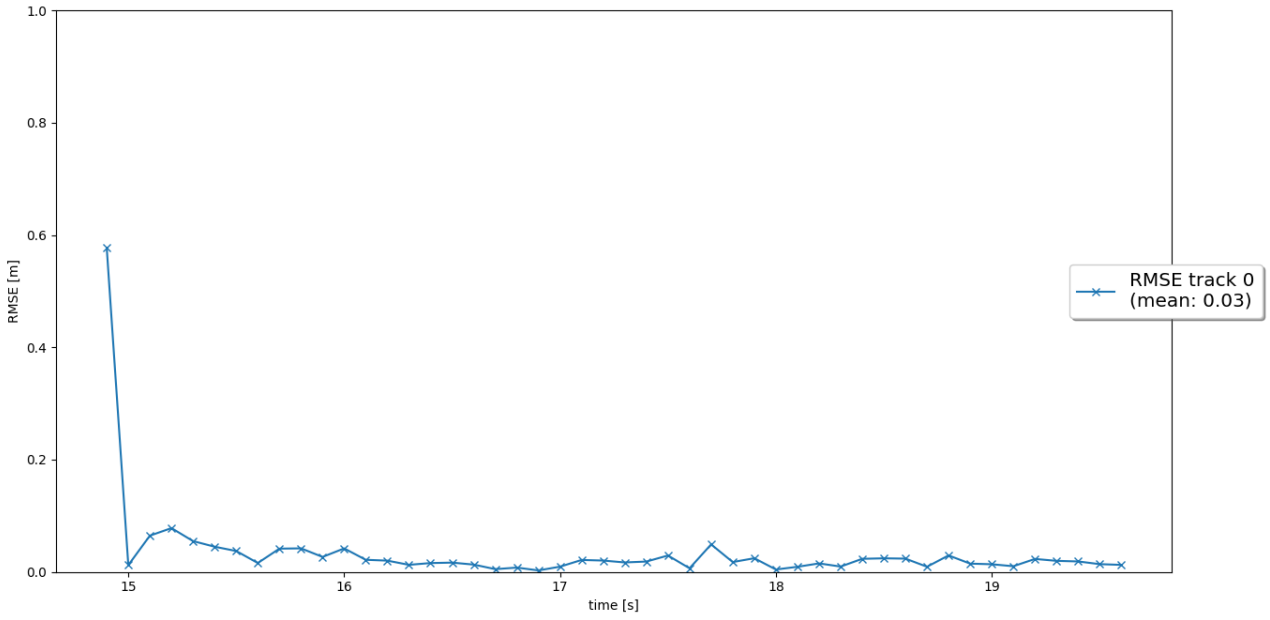
Step 1

In step 1 of the final project, EKF has been implemented to track a single real-world target with lidar measurement input over time.

After completing the required functions for the filter.py file single target tracking results can be shown as in following figure:

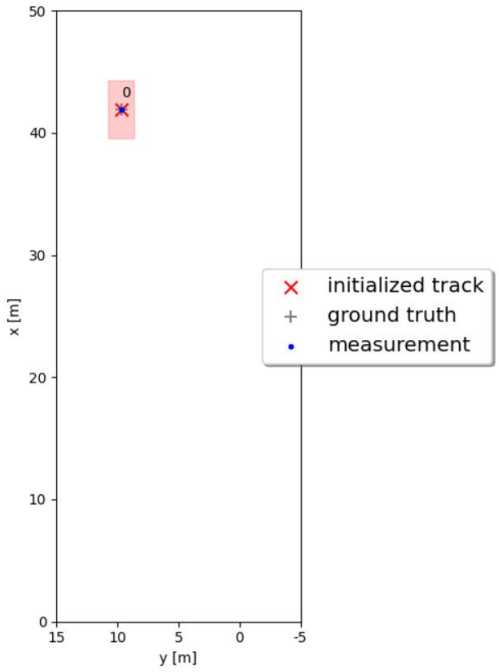


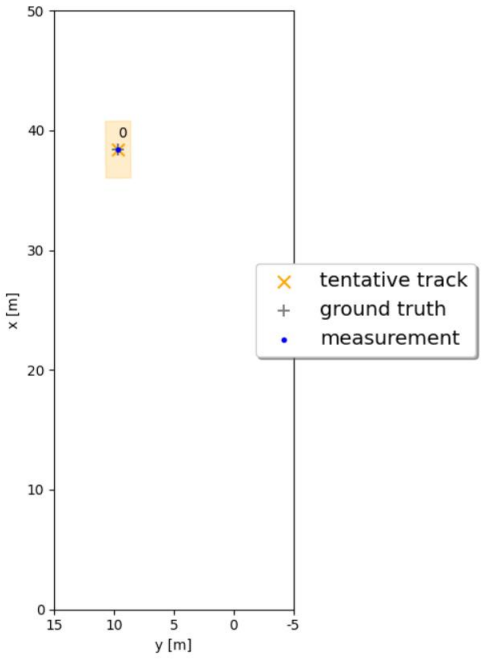
Also RMSE plot can be seen in following figure. The mean RMSE is 0.03.

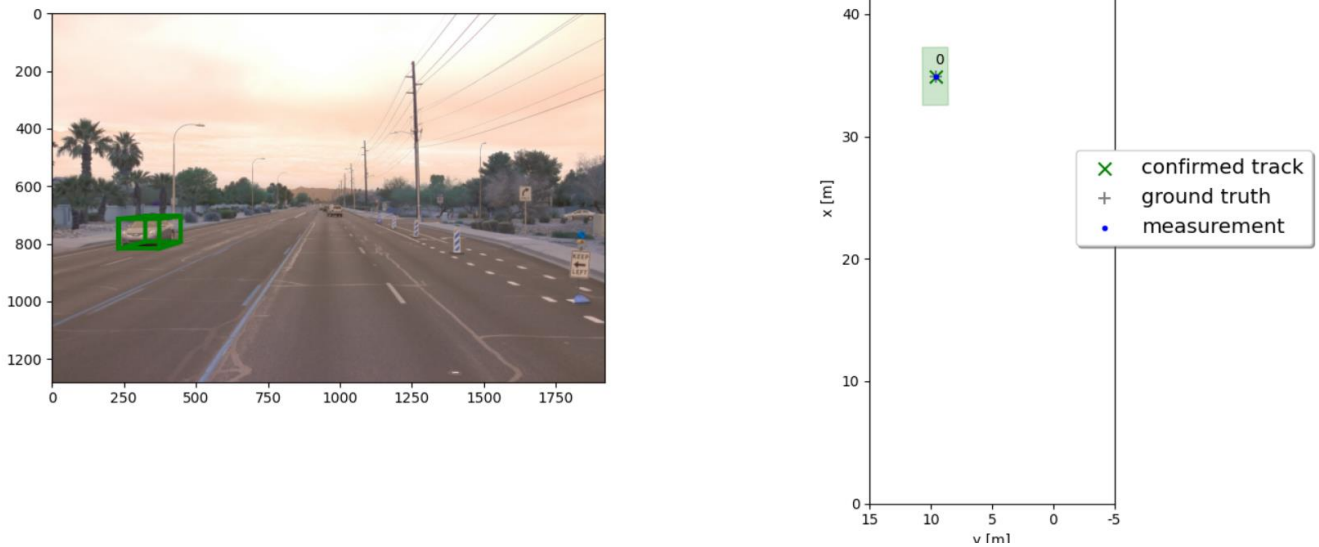


Step 2

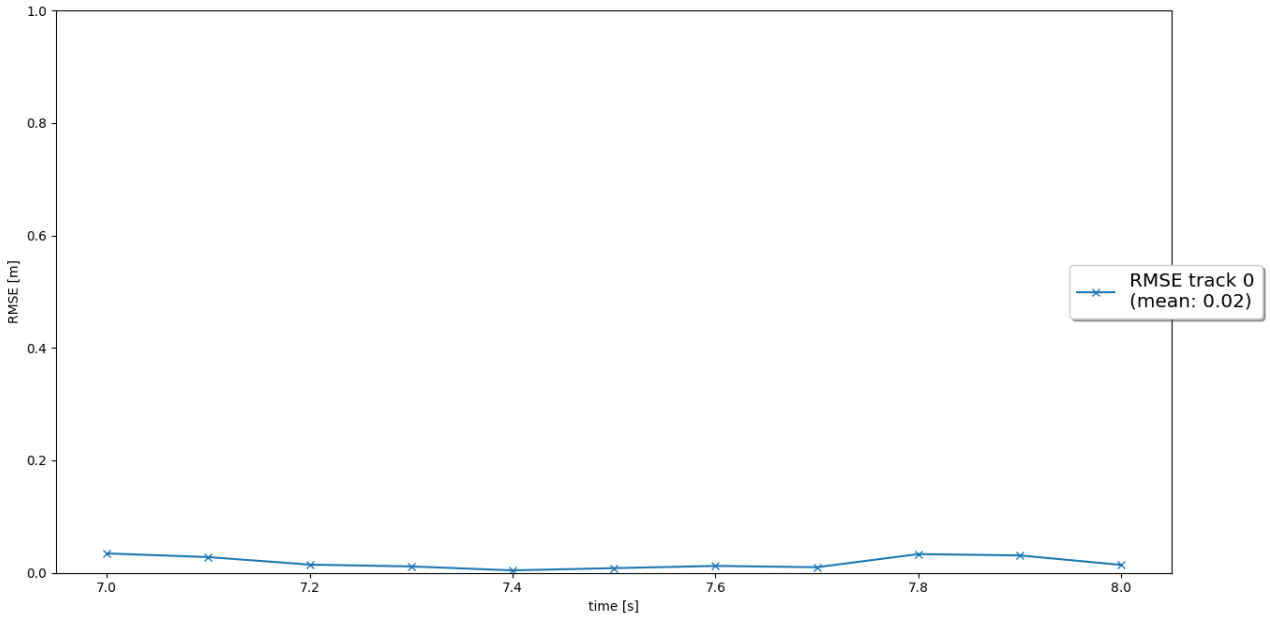
In step 2 of the final project, track management has been implemented to initialize and delete tracks, set a track state and a track score. After implementing methods in Track and TrackManagement classes the results are as given in following figures:





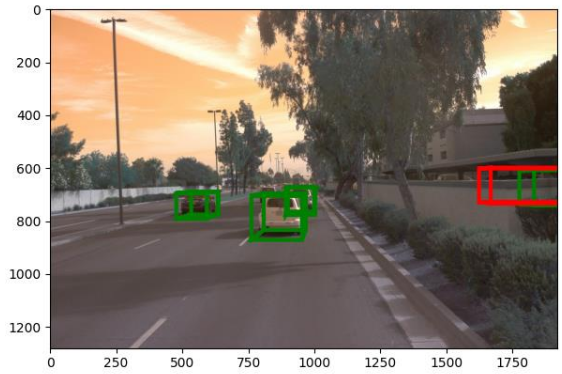


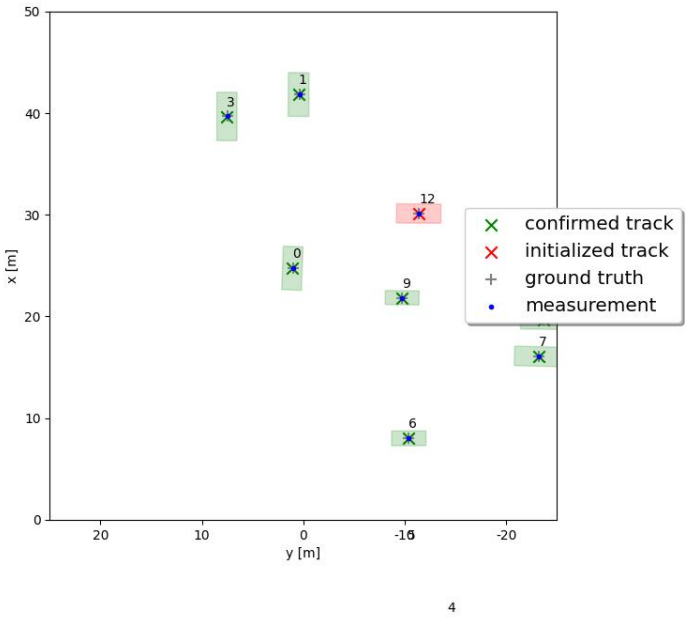
And the RMSE plot for tracking is given as following figure:

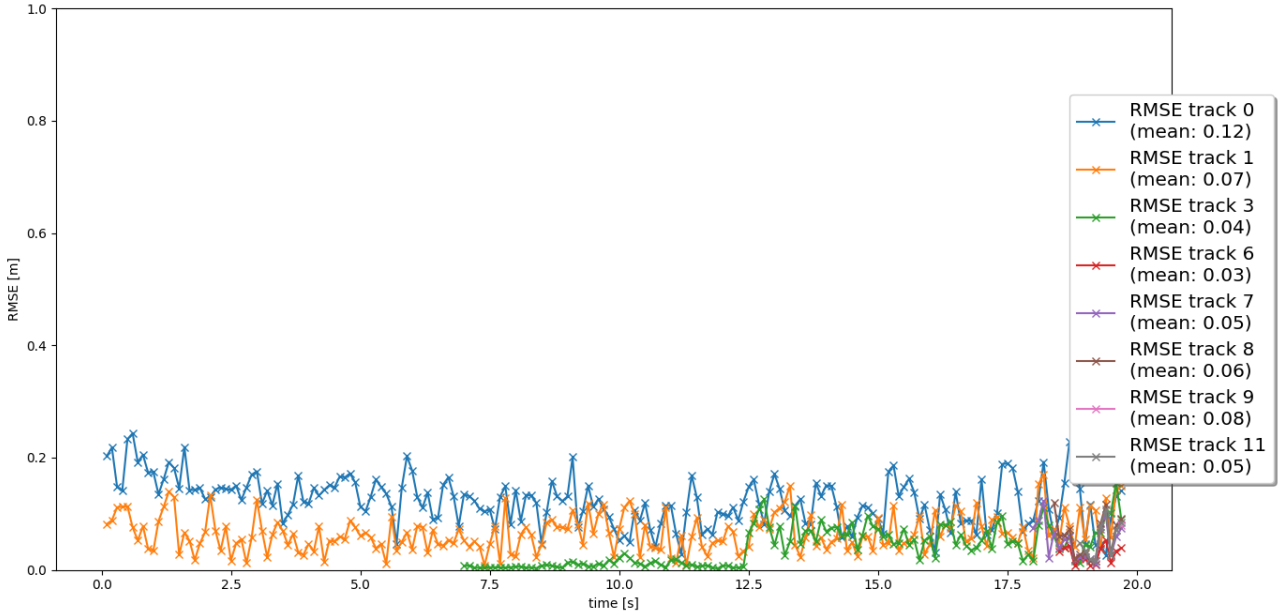


Step 3

In step 3 of the final project, a single nearest neighbor data association is implemented to associate measurements to tracks. Example tracks and the RMSE values can be seen in following figures:

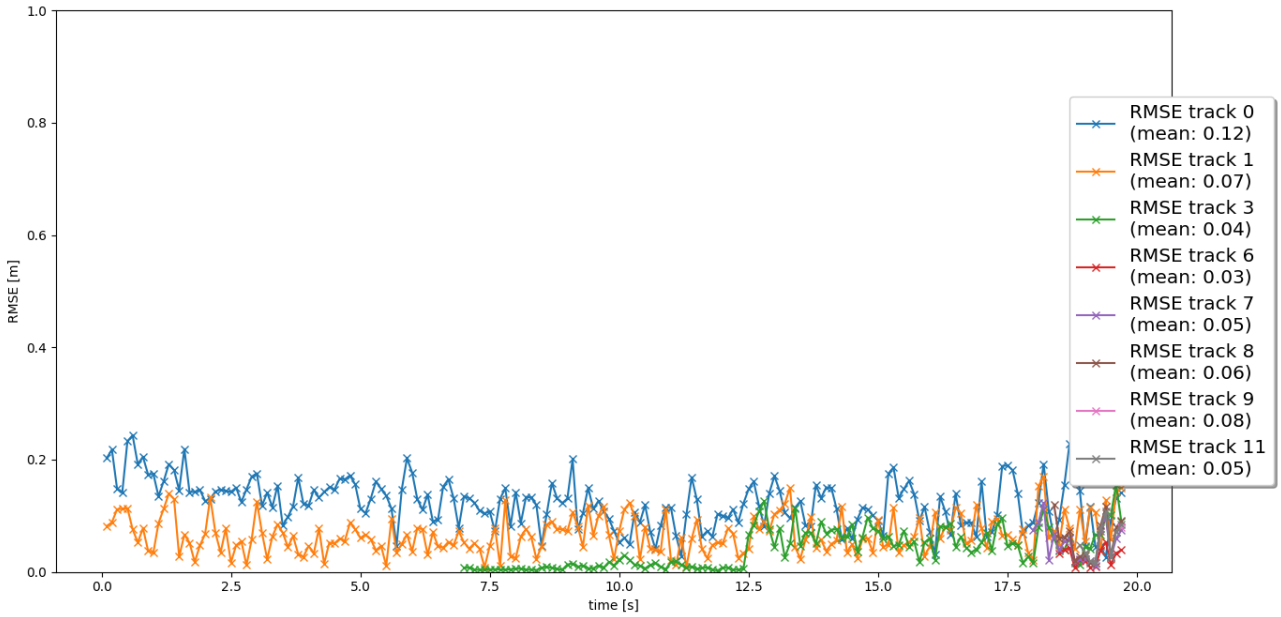






Step 4

In step 4 for the final project, nonlinear camera measurement model has been implemented. The following figures show the RMSE values for tracks.Tracking movie is created by `make_tracking_movie flag.` It can be find in my project repo.



Writeup: Track 3D-Objects Over Time

1. Write a short recap of the four tracking steps and what you implemented there (filter, track management, association, camera fusion). Which results did you achieve? Which part of the project was most difficult for you to complete, and why?

First, the instructions for all the steps in project are explained well. So I've tracked the instructions in all steps. It made my job in this project easier.

Step1: EKF has been implemented.

Step2: Track management has been implemented.

Step3: Single nearest neighbor has been implemented.

Step4: Nonlinear camera measurement model has been implemented.

For all steps, RMSE values are plotted in previous figures. Step 3 and Step 4 are the most difficult steps for me. I've struggled for matrix operations and indexing issues in these steps.

2. Do you see any benefits in camera-lidar fusion compared to lidar-only tracking (in theory and in your concrete results)?

In theory, adding more sensors for evaluation gives better results due to the low uncertainty. Practically, in my results there is no significant change in terms of RMSE values.

3. Which challenges will a sensor fusion system face in real-life scenarios? Did you see any of these challenges in the project?

Some of the challenges for sensor fusion systems are:

- Sensor Calibration

- Data Synchronization

- Varying Environmental Conditions

- Occlusion and Reflections

- Computational Complexity

- Data Noise and Uncertainty

In this study, we've worked under ideal conditions. For the environmental conditions, the weather is clear and does not affect the operations badly. For sensor related problems, in this project sensors are located well and the parameters of sensors have been defined correctly. So I have not seen any of these challenges in the project.

4. Can you think of ways to improve your tracking results in the future?

Tracking results can be improved by:

- Using all the available sensors to create 360 degree view,
- Radar sensor can be added to measure the velocity directly,
- More complicated models can be used for vehicle motion,
- Frame rate can be increased to reduce estimation uncertainty.