# ILR #11: Progress Review 12

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# 1. Individual Progress:

## 1.1 Tasks:

For this progress review our team had the following tasks accomplish:

1. Sensor fusion of stereo vision and radar
2. Tracking from the clustered radar data
3. Improvements to real-time performance of the integrated system

I worked on the clustering of the detection-level radar data, and I also worked towards system integration by enabling hardware-triggering of the camera in ROS. Amit and I studied a few suggested algorithms for filtering and clustering of the radar data points but have yet to successfully implement it ROS. I created a robust way to trigger the cameras simultaneously in ROS via the cameras' GPIO inputs using an Arduino Micro. This will make our system more compact and streamlined and therefore easier to integrate into the test vehicle. Overall, we are almost ready for sensor fusion testing using ROS.

## 1.2 Implementation:

### 1.2.1 Data filtering and clustering for the radar:

I reviewed some filtering techniques used specifically for radar vehicle tracking, specifically techniques to solve the non-linearity of the measurement space. A comparative study (Floudas, N., Polychronopoulos, A., and Amditis, A. *A survey of filtering techniques for vehicle tracking by radar equipped automotive platforms,* IEEE, 2005, **ISBN:** 0-7803-9286-8) found that Kalman based filters tended to beat Particle Filters in both speed and performance for radar tracking applications, while Particle Filters were better suited to single object tracking such as for vehicle egomotion using GPS data. Fig 1. below shows tables comparing various example techniques.

Table 1 : Performance of Kalman based solutions

| Filter type | Time Delay (~norm.) | Position RMS error (m) | Velocity RMS error (m/s) | Scans of misses (%) | Perform-ance | Rank |
|---|---|---|---|---|---|---|
| EKF-1 | 1 | 0.281 | 0.281 | 0 | 1.000 | 3 |
| EKF-2 | 1 | 0.282 | 0.289 | 0 | 0.992 | 5 |
| LKF-1 | 1 | 0.302 | 0.319 | 0 | 0.950 | 7 |
| LKF-2 | 1 | 0.237 | 0.902 | 0 | 0.660 | 9 |
| LKF-3 | 1 | 0.325 | 0.359 | 0 | 0.902 | 8 |
| LKF-4 | 1 | 0.265 | 0.294 | 0 | 1.003 | 2 |
| IMM-1 | 1.01 | 0.278 | 0.289 | 0 | 0.992 | 4 |
| IMM-2 | 1.01 | 0.275 | 0.280 | 0 | 1.003 | 1 |
| IMM-3 | 1.01 | 0.268 | 0.311 | 0 | 0.982 | 6 |

Table 2 : Results for 1000 particles

| PF (1000) | Gen | SIR | ASIR | Reg | LLEKF |
|---|---|---|---|---|---|
| TD | 2.816 | 2.816 | 4.974 | 3.526 | 3.711 |
| PE (m) | 0.437 | 0.455 | 0.403 | 0.505 | 0.373 |
| VE(m/s) | 1.146 | 1.332 | 1.295 | 1.613 | 1.210 |
| M (%) | 0 | 0 | 0 | 0.004 | 0 |
| Estimation | 0.452 | 0.408 | 0.426 | 0.352 | 0.452 |
| Overall | 0.423 | 0.393 | 0.333 | 0.331 | 0.387 |

**Fig. 1:** Comparison of Time Delay, Position Error, Velocity Error for selected Kalman based filters and Particle filters.

Now that we have setup our sensors to be easy to install and power and test, we will begin on-road testing soon to determine our radar clustering performance in real time. Based on our literature review and initial testing, we hope to accomplish this in the next few days. Once the stereo vision subsystems are set up in ROS, we can begin sensor fusion testing using our chosen radar data point-clustering algorithm.

### 1.2.2 Camera triggering in ROS:

I used an Arduino Micro and a 12 V DC regulation circuit (see Fig. 2) in line with the camera power source, and programmed publisher and subscriber nodes to trigger the cameras and read the images in ROS. By tidying up our wiring for powering and triggering our sensors, I aim to make installation and maintenance in our test vehicle easy and efficient.

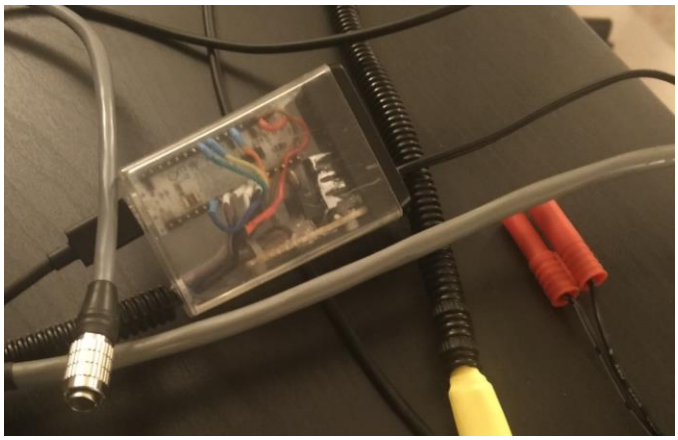

**Fig. 2:** New hardware trigger solution that is robust and compact and works in ROS.

## 2. Challenges:

We are far behind schedule and are not making much progress overall. The sensor integration is taking longer than expected. The tracking and depth-estimation nodes are still being worked on in ROS, and the clustering and tracking testing is not yet completed on the radar. I also think that every member on the team will need to clearly and frankly communicate daily goals and progress from now until the SVE, which I feel has not been very clear between teammates so far. Despite the improvement in management by Amit recently, I still feel that some members of the team are “scared” to ask me for help sometimes. Although, arguably, I might have brought this upon myself, I am not sure how to “un-scare” them now.

## 3. Teamwork:

There is still a large amount of work that needs to be done by the SVE. We will have to communicate well as a team and manage our progress in the days to come. We have distributed the workload among teammates and assigned specific tasks and we will review and update daily.

Amit and I will work on the radar data-clustering, tracking, and real-world testing. Zihao and Yihao and Menghan will complete the ROS setup of the stereo vision system so that we can achieve sensor fusion between the cameras and the radar. Additionally, they will make improvements to the real-time performance of our system. By the SVE, we hope to demonstrate meaningful sensor fusion in real time using ROS. We may still be able to achieve this if we try like really really hard. Go Team A!

## 4. Future Plans:

By the SVE, we hope to accomplish the following:

1. Sensor fusion of stereo vision and radar

I will be working on as much as possible until the SVE, as will the test of the team.