PROGRESS REVIEW #8

INDIVIDUAL LAB REPORT [ILR07]

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INDIVIDUAL PROGRESS

In this report I have summarized the successes and the failures that we encountered in the last field test (I will focus on path planning features that I worked on) and list the improvements that I have made in for re-planning the path more efficiently.

a. Field Test 3

Features that work as expected:

I. One time planning

As I had re-written the code to separate it into different modules, there was a need to test that all modules are working as expected. To verify this, we gave the goal (GPS waypoints) to the boat which was around 2.4 Km from the start location. The boat was able to reach to the goal successfully. This verified that all the components (low level controller, IMU subscriber, fake obstacles generator and the path planner) were integrated successfully.

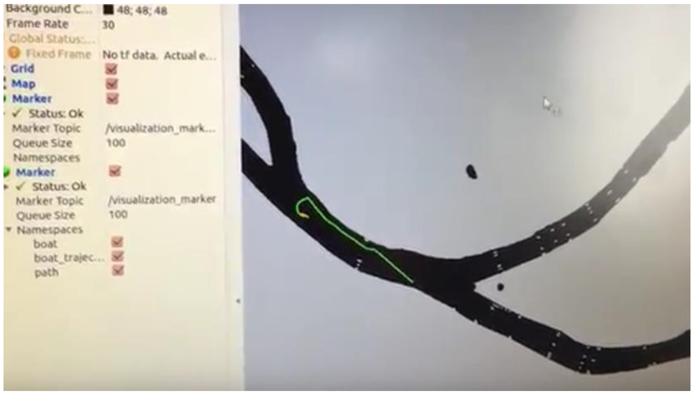
II. Distance from shores

During the field test, the boat maintained minimum of 15-20 meters distance from shores which was considered safe and comfortable both by us and the safety driver.

Features that didn't work as expected:

I. Trajectory of path (Influenced by motion primitives)

The boat was able to traverse the trajectory generated by the path planner without any difficulty. However, there were instances when the trajectory of the planned path could have been better (especially with the turns). This was because at present the only motion primitives that are provided to the planner for turning are eight blocks ahead and turn. To solve this issue, we would be adding a couple of more primitives for taking slightly sharper turns. *Figure 1* shows the planned path which includes a U-turn (not that good).



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Fixed Frame	No tf data. Actual e...
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Map	☑
Marker	☑
✓ Status: Ok	
Marker Topic	/visualization_mark...
Queue Size	100
Namespaces	
Marker	☑
✓ Status: Ok	
Marker Topic	/visualization_marker
Queue Size	100
Namespaces	
boat	☑
boat_trajec...	☑
path	☑

Figure 1: Trajectory of the planned path (U-turn)

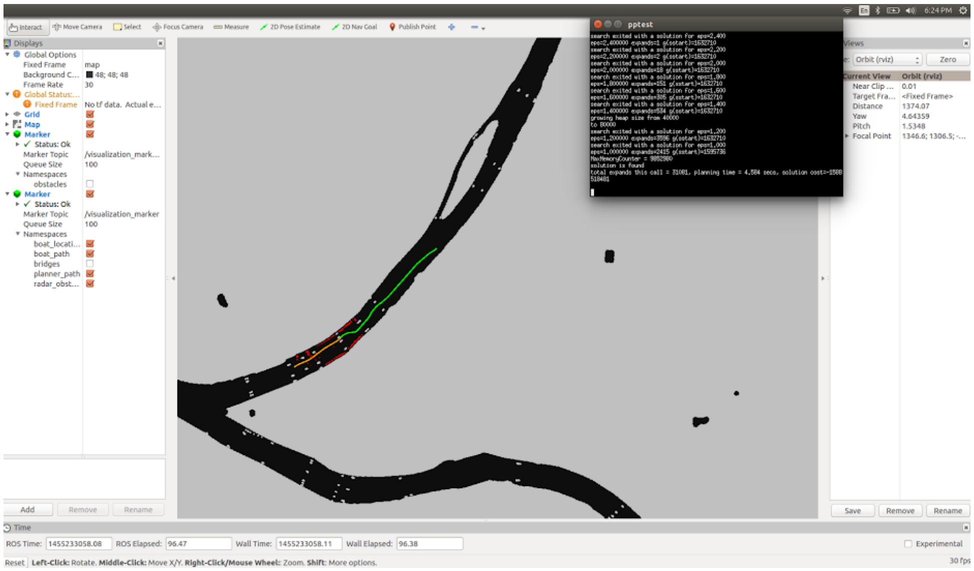
II. Re-Planning

We tested re-planning with a time interval of 5 seconds. The boat maneuvered appropriately in paths with small radii of curvature but could not achieve the same accuracy for larger radii of curvature. This problem was caused because the new planner doesn't take into account the old path. We were able to solve this problem during the field test by removing first four waypoints from the list of waypoints of the planned path and passing the rest to low level controller. The system performance was satisfactory. But to make it better and robust, I am working to combine this solution with new ways of re-planning (explained in next section) and adding new motion primitives for turns. We will be testing this again in the next field test.

b. Continuous Re-planning

Earlier in order to solve the problem of memory accumulation with SBPL, I had to delete the environment and the planner objects and pointers. This was computing intensive and a bit slow. In addition to this, the new path given by the planner was usually different from the old path (depending on our present location and orientation).

I have solved this issue and the environment and planner objects are not being deleted now. Other than this, I am now using AD* Planner which is incremental planning. This planner takes location of the new obstacles and does incremental planning which is faster and more efficient. *Figure 2 and figure 3* demonstrates continuous re-planning with integration of radar obstacles. It can be seen that paths at both the instances are quite similar as this is incremental planning.



pptest

```
search exited with a solution for eps=2.400
eps=2.400000 expands=1 g(sstart)=1632710
search exited with a solution for eps=2.200
eps=2.200000 expands=2 g(sstart)=1632710
search exited with a solution for eps=2.000
eps=2.000000 expands=18 g(sstart)=1632710
search exited with a solution for eps=1.800
eps=1.800000 expands=151 g(sstart)=1632710
search exited with a solution for eps=1.600
eps=1.600000 expands=305 g(sstart)=1632710
search exited with a solution for eps=1.400
eps=1.400000 expands=534 g(sstart)=1632710
growing heap size from 40000
to 80000
search exited with a solution for eps=1.200
eps=1.200000 expands=3596 g(sstart)=1632710
search exited with a solution for eps=1.000
eps=1.000000 expands=2415 g(sstart)=1595736
MaxMemoryCounter = 9852980
solution is found
total expands this call = 31081, planning time = 4.584 secs, solution cost=-1588
518481
```

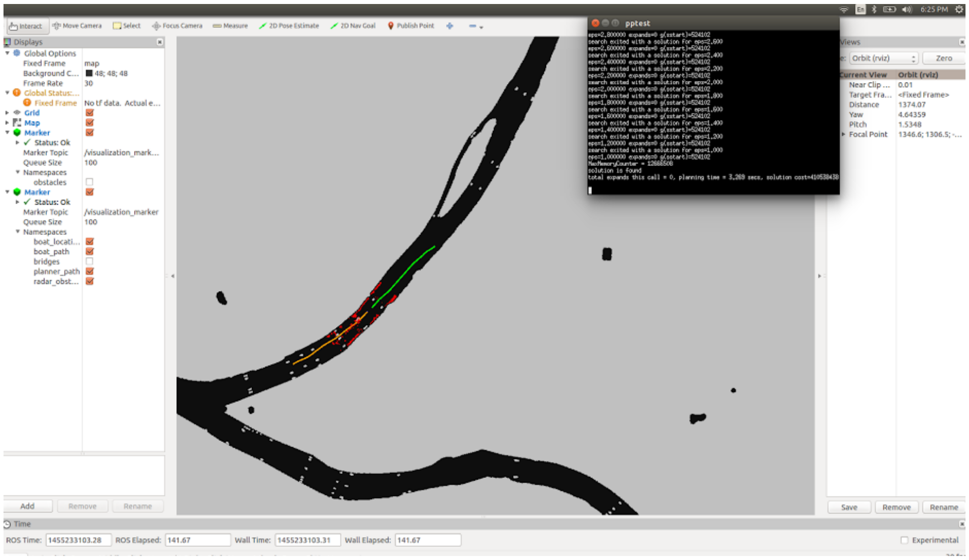
Global Options
Fixed Frame: map
Background C...: ■ 48; 48; 48
Frame Rate: 30
Global Status:...
Fixed Frame: No tf data. Actual e...
Grid ☑
Map ☑
Marker ☑
Status: Ok
Marker Topic: /visualization_mark...
Queue Size: 100
Namespaces
obstacles ☐
Marker ☑
Status: Ok
Marker Topic: /visualization_marker
Queue Size: 100
Namespaces
boat_locati... ☑
boat_path ☑
bridges ☐
planner_path ☑
radar_obst... ☑

Orbit (rviz)
Current View: Orbit (rviz)
Near Clip ...: 0.01
Target Fra...: <Fixed Frame>
Distance: 1374.07
Yaw: 4.64359
Pitch: 1.5348
Focal Point: 1346.6; 1306.5; -...

ROS Time: 1455233058.08 ROS Elapsed: 96.47 Wall Time: 1455233058.11 Wall Elapsed: 96.38 ☐ Experimental

Reset **Left-Click:** Rotate. **Middle-Click:** Move X/Y. **Right-Click/Mouse Wheel:**: Zoom. **Shift**: More options.

Figure 2: Continuous Re-plan 1



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search exited with a solution for eps=2.400
eps=2.400000 expands=0 g(sstart)=524102
search exited with a solution for eps=2.200
eps=2.200000 expands=0 g(sstart)=524102
search exited with a solution for eps=2.000
eps=2.000000 expands=0 g(sstart)=524102
search exited with a solution for eps=1.800
eps=1.800000 expands=0 g(sstart)=524102
search exited with a solution for eps=1.600
eps=1.600000 expands=0 g(sstart)=524102
search exited with a solution for eps=1.400
eps=1.400000 expands=0 g(sstart)=524102
search exited with a solution for eps=1.200
eps=1.200000 expands=0 g(sstart)=524102
search exited with a solution for eps=1.000
eps=1.000000 expands=0 g(sstart)=524102
MaxMemoryCounter = 12688508
solution is found
total expands this call = 0, planning time = 3.269 secs, solution cost=410538438
```

Global Options
Fixed Frame map
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Frame Rate 30
Global Status:...
Fixed Frame No tf data. Actual e...
Grid ☑
Map ☑
Marker ☑
Status: Ok
Marker Topic /visualization_mark...
Queue Size 100
Namespaces
obstacles ☐
Marker ☑
Status: Ok
Marker Topic /visualization_marker
Queue Size 100
Namespaces
boat_locati... ☑
boat_path ☑
bridges ☐
planner_path ☑
radar_obst... ☑

e: Orbit (rviz)
Current View Orbit (rviz)
Near Clip ... 0.01
Target Fra... <Fixed Frame>
Distance 1374.07
Yaw 4.64359
Pitch 1.5348
Focal Point 1346.6; 1306.5; -...

ROS Time: 1455233103.28 ROS Elapsed: 141.67 Wall Time: 1455233103.31 Wall Elapsed: 141.67 ☐ Experimental

Figure 3: Continuous Re-plan 2

CHALLENGES

a. Testing continuous re-planning

I have implemented continuous planning but it has not been tested in the field test. The success of continuous re-planning is also dependent on the way we have decided to send the waypoints to low level controller, motion primitives, noise from radar data and cost of inflation of pylons and shores. As mentioned in 'individual work section', we are omitting first four waypoints. So, the start location for the re-plan is the fifth waypoint rather than the present location from the boat. In addition to this, we are not sending orientation in this case (which we were sending in case of present location). This can have a decent effect on the path generated by the planner. This would be solved by varying one parameter at a time during the next field test.

TEAM WORK

The last field test was quite successful because of the efforts invested by the entire team. Shiyu created the plan for the last field test which was quite helpful.

a. **Shiyu Dong:** Shiyu experimented with the motion primitives in order to tune them to create a smoother path.
b. **Bikram Hanzra:** Bikram created the module to dynamic fake obstacles which can move randomly in the river and can help us to visualize how our system will behave in such cases.
c. **Tae-Hyung Kim:** Taehyung proposed variable velocity path planning and how can follow rules of the road by using right handed navigation.

d. **William Seto:** William manipulated the cost map to try and follow the rules of the road. He worked on filtering the radar data. In addition to this. In addition to this, he helped with continuous re-planning.

FUTURE WORK

I would be mainly focusing on following:

a. **Making planner more stable**

- The first task is to solve the challenges with continuous re-planning as mentioned in the 'challenges' section.
- The second tasks is to go deeper in understanding of SBPL planners and try to make sure that the path generated by the planner are smooth.

b. **Testing during next field test**

- Testing continuous re-planning with one parameter at a time and identifying the areas of improvement.