Progress Review 7

Individual lab report – 06 | January 27, 2016

TEAM DAEDALUS

Submitted by:

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1. Individual Progress

The following responsibilities were taken up by me:

- **Mapping Subsystem -** Study of gmapping S.L.A.M algorithm, familiarization with ROS gmapping package intrinsics and layout of mapping procedure for Xaxxon Oculus Prime platform.
- **Multi-Agent Planning Subsystem -** Developing ranking system for spots, ranking individual spots based on a metric and python code for extracting most optimal spot for a car based on occupancy data and ranks.

MAPPING

The map of the parking lot is critical for localization and path planning subsystems. It was therefore decided to use Xaxxon Oculus Prime API and alongwith robust off-the shelf ROS S.L.A.M packages to build an accurate map of the environment. The ROS gmapping package was found the be the most suitable one after survey of different S.L.A.M methods and packages and consulting with our sponsor.

BRIEF EXPLANATION OF RAO-BLACKWELLISED PARTICLE FILTER S.L.A.M

In order to get started with mapping, it was first necessary to acquaint myself with the S.L.A.M algorithm running under the hood of gmapping ROS package. The gmapping algorithm is a Rao-Blackwellised particle filter based S.L.A.M method that uses odometry data from the robot which is fused with 2D laser scan data. In a Rao-Blackwellised particle filter based approach to S.L.A.M, the conditional independence of landmark locations given the path of the robot in the dynamic Bayes' network of the S.L.A.M problem is used to decouple all landmark locations from one another.

Also, converting the joint posterior of robot location and landmarks into conditional probabilities, the robot's location is fixed. This allows us to represent the robot's location belief independently as a set of particles and each landmark location belief as an independent Gaussian. Then, the predict-correct cycle is initiated using a particle filter approach for the robot pose and an independant EKF for each landmark. The dynamic Bayes' network is illustrated in Figure 1.

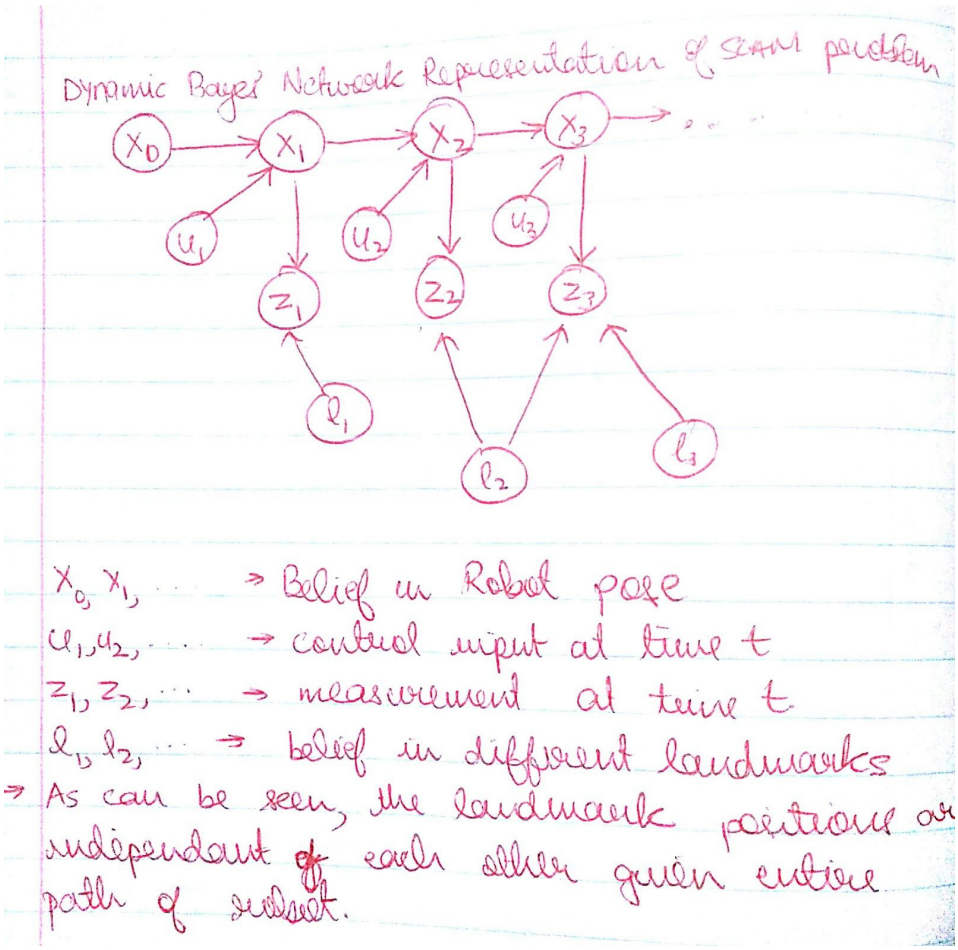

Figure 1: Dynamic Bayes' Network Representation of S.L.A.M problem

MAPPING PROCEDURE

After getting acquainted with gmapping, the Oculus Prime API was to be used for interfacing with ROS. Oculus prime provides an interface through their remote server application to use ros gmapping. Using the navigation interface it is possible to move the robot around starting from docked position make a 2D floor plan type map of the environment. The ROS depthimage_to_laserscan package is used to convert the depth image data of Asus Xtion Pro into laserscan data compatible with gmapping package. This is then fed into the gmapping ROs package with other robot parameters.

When the mapping routine is complete, the map can be stored as a .pgm file. After a satisfactory map is obtained, it can be edited using a BitMap editor to enhance features. Figure 2 shows a flowchart of the mapping procedure for Oculus Prime ROV.

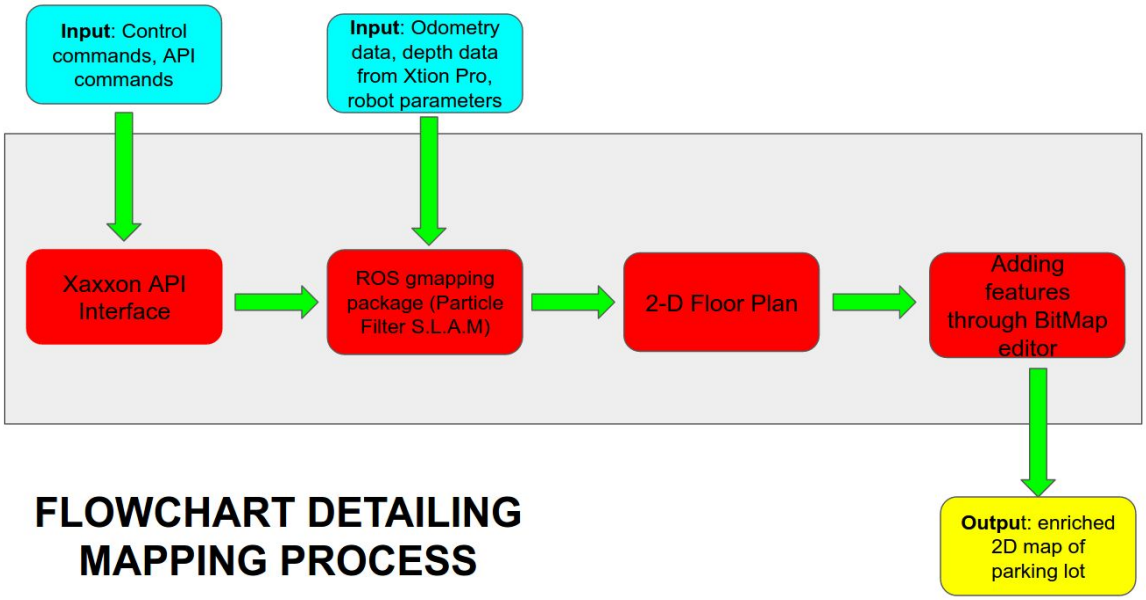

Figure 2: Detailed procedure for mapping using Xaxxon API

Figure 3: Example map created from Oculus Prime website

Source: http://www.xaxxon.com/documentation/view/oculus-prime-making-a-map

MULTI-AGENT PLANNING

The task of the multi-agent based planner is to decide the most optimal spot for a car to park in as soon as it enters the parking lot and receives parking spot occupancy data from other agents in the parking lot. As a baseline implementation, the ranks of different parking spots is pre-processed and the best possible empty spot is assigned to the vehicle from a ranked list of all spots.

Salient Features of Optimal Spot Selection Algorithm:

- **Data of parking spot occupancy** received in form of list of boolean values corresponding to each spot from communication node.
- **Rank Assignment to different spots**: The parking lot is represented as a grid with different cells labelled as 'Parking Spot' and 'Obstacles'. A utility or value for each state or grid cell is calculated to decide the most optimal spot for parking.
- **Metric used to derive utilities**: Number of moves needed to reach exit from that state (taking infrastructure or other known obstacles into account) is used as a metric. The cost metric is generic and can be modified accordingly if different policies are to be enacted.
- Most optimal parking spot coordinates are passed to path planner.

2. Challenges

The challenges that I had to face were:

- Hardware issues regarding non-availability of Asus Xtion Pro and functionality problems with current platform which hindered map generation.
- Ranking spots manually and ensuring that metric is generic holds in different possible scenarios.
- Learning the intricacies of the underlying S.L.A.M algorithm so that it could be used properly without a strong prior knowledge of state estimation.
- Too many dependencies and risks which often slows down the work.
- As the team's new Risk Manager, I have to keep regular checks on the work of all members and plan for unforeseen risks that might arise.

3. Teamwork

The other members of my team were working on the following subsystems:

- **Communication:** Dorothy and Richa worked together on coming up with a generic and robust protocol that would allow different cars to enter and leave the network without disturbing the integrity of the network. Also, they worked on how and when the cars should send and receive data for efficient collaboration.

- **Navigation:** Pranav started work with the ROS Navigation stack to develop the locomotion of mobile platform. He will also be working on integrating the emergency stop feature with the navigation stacks planner to ensure vehicle stops in the case of emergencies.
- **Obstacle Detection:** Shivam has completed the design of the PCB to be used for the obstacle avoidance algorithm and has completed a trade study of new sensors to be ordered for range measurements.

4. Plans

As per the team's schedule, I will be working on completing the map generation, starting with creating maps of different surroundings using the new Asus Xtion Pro. While creating the map, I will also have to keep in mind the design requirements for the parking lot. The multi-agent planner has to be integrated with ROS framework and tested to run robustly on the SBC. Pranav will be working on developing a waypoint navigation node using based on Oculus Prime API and ROS Navigation Stack and also the visualization tool. Dorothy and Richa will be integrating and testing the communication protocol using multiple XBee Pros. Shivam will be working on developing robust obstacle avoidance algorithm. Dorothy wll also start work on the parking lot design and fabrication.

5. References

[1] http://www.xaxxon.com/documentation/view/oculus-prime-making-a-map

[2] http://www.cs.berkeley.edu/~pabbeel/cs287-fa11/slides/gmapping.pdf