Thomas Lux Roanoke College

Robotic Mapping and Adaptive Programming

Advisor: Dr. Bouchard

January 28, 2014

I walk to class in the morning, managing not to collide with any of the objects in my crowded surroundings. I frequently encounter spatial obstacles and avoid them effectively without a second thought, but a robot may not be capable of adapting quite so easily. The idea of integrating robotic technology into our lives is becoming a reality. To date we have used robots to manufacture, to explore other planets, and to perform precise surgeries. These robots are highly functional, but for any new performance to be brought to the real world they must be able to function in a constantly changing environment. Machines tasked with real world objectives must be able to effectively and efficiently navigate spatial obstacles. Various forms of sensor input, path planning, and higher level objectives must all be integrated into one functional program to enable a robot to successfully navigate and complete its task.

This concept of bringing programming to the world through robots has opened up many fields of research. In order for robots to navigate their environments, they need representations of them. Stochastic mapping[1], either linked or grid structured, has provided a foundation for modern robotics scientists. In order to build these two-or-three dimensional representations, simultaneous localization and mapping[4] (SLAM) was introduced. In order to perform SLAM and achieve higher accuracy, the Kalman filter[5], the Extended Kalman filter, and other variants were designed to combine position predictions with position measurements. Robotic mapping welcomes research.

Much is to be learned about the current standing field of robotics. In a relatively short time the technology available to gather data from the real world has significantly changed. I took on a research project this past summer with the purpose of comparing modern sensors for robotic mapping. Using a pre-built robotic platform, I evaluated and compared the overall performance of the Microsoft Kinect, RGB web cameras, and a pair of ultrasonic sensors. I wrote all the code for performing autonomous robotic mapping from the ground up with the intent of adequately measuring the amount of time required to make a robot map a room with each of the sensors. The project revealed a lot about the nature of different sensors that can be used for mapping. It made clear the advantages and disadvantages of using infrared dot projection, color matching, and sound wave projection.

The form of map representation that I chose after much experimentation is becoming a standard in the field. The occupancy grid[3] has gained popularity for its adversity. The engrained functionalities of this style map include, but are not limited to, three-dimensional sensor input, multi-robot mapping, multi-sensor mapping, multi-map integration, path planning, and obstacle avoidance. I experimented with the ability to close loops in locally produced maps by using past scans and sensor data. This process utilized the occupancy grid's ability to integrate multiple maps and the hierarchical structure made for more convergent results over the course of multiple scans. Incorporating a global position re-estimation proved vital to maintaining map consistency. By holding locally produced maps and manipulating them until they best fit the global map, I was able to more accurately estimate the current pose of the robot. This data representation's ability to combine all of these fields of robotics is pivotal and will lead to advances in robots' ability to communicate and cooperate.

The applications of robotic mapping are not always clear, but they are many. Robots now are primarily used in industrial settings where they can be guaranteed consistent working environments.

While these robots provide a substantial foundation for the technology, they are also limited by their lack of mobility and versatility. With intelligent robots capable of functioning in dynamic environments we would be able to automate complicated processes that can pose dangers to people. Construction, mining, shipping, and transport are fields ripe with opportunity for advanced robotic platforms.

Aside from my desire to create higher functioning computer programs, many real world applications of this research exist. Commonly cited objectives of mapping robots are gathering geographic data about environments hazardous to people, for instance, abandoned mines, post-disaster sites, irradiated facilities, and the deep sea. One of the most exciting and to date less explored is that of using robots to map the surface of asteroids, planets, and other celestial bodies that we do not or cannot send people to.

After achieving my Ph.D., I would be involved in continuing research in the field of autonomous mapping, focusing on discovery oriented algorithms. My work would be with analyzing map data that has already been gathered to attempt to maximize new discovery. The difficult problem is that of deciding which areas to explore first when there are multiple openings in the map. The research in exploration-based algorithms is interesting simply because it involves making calculations without any data on the area. Given this problem, there is a need for a set of algorithms that can adapt and be applied to different realistic scenarios. AI laboratories have performed a good deal of research on exploration algorithms. Some of the promising projects involved frontier-based[6] exploration algorithms that focus on boundaries between areas measured to have open space and areas who's occupancy state is unknown. More recently, biology has inspired approaches to robotic exploration that better utilize multi-robot cooperation[2]. Mapping, path planning, and navigation are vital components to the future of robotics. By continuing to research these topics and finding new better ways to accomplish these tasks, we can create more functional and useful robotic systems.

References

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