An Intelligent Low-Cost Scanning Range Finder

Michael Ferguson
Vanadium Labs LLC
Albany NY, USA
mferguson@vanadiumlabs.com

Abstract

A typical prerequisite for both autonomous robots and telepresence systems to operate in the real world, alongside humans, is that they be able to navigate safely. Such safe navigation requires that a system be aware of obstacles around them, especially highly dynamic ones, such as people. Obstacle awareness is typically provided by robust sensors, such as laser range finders, which scan the plane and gather thousands of data points each second. However, such laser range finders are expensive, typically costing several thousand dollars.

In this paper we propose an alternative, lower-cost approach. Noting that much of the data collected by a traditional laser range finder will be irrelevant to current planning tasks, we develop a low cost scanning range finder which collects fewer data points, but in a more intelligent manner. We do so by exploiting both the regularities typically found in home and office environments, and by further considering the needs of the planning tasks that will use the data. We derive methods for intelligent sampling of the environment given the constraints imposed by such planning tasks. Specifically we explore the planning required for assisted control of a telepresence system and autonomous navigation of a mobile robot.

We have prototyped our low cost scanning range finder using off-the-shelf components and open source software technologies. The range finder works by sweeping an IR-based sensor using a low-cost servo. While a typical laser range finder may collect four- to six-hundred range readings per 180 degree forward scan, and complete scans at 10-40hz, our range finder collects only thirty range readings per second. However, we can adjust where those readings are taken, and we show that by intelligently selecting the scan area, based on planning needs, we can still accomplish the final goal of obstacle avoidance. Timing of servo movements and sensor sampling is handled by a microcontroller, which then connects to a computer through a USB connection. Data is piped into the open-source Robot Operating System (ROS), where it can be stored and used for navigation path planning. The range finder broadcasts it's data as a laser scan topic within ROS, allowing it to be plug and play compatible with a number of software packages, such as ROS's navigation stack.

To show the effectiveness of our sensor and planning-aware sampling methods, we deployed our prototype system in two navigation tasks: as an obstacle avoidance aid in assisted control of a telepresence system, and as the primary obstacle avoidance sensor in an autonomous navigation system. While both systems use similar local planning strategies, the different planning needs for a globally consistent solution gives rise to different sampling strategies.

While there has been increasing interest in telepresence systems, most existing commercial models are prohibitively expensive. Due to the inherit lag in wide-area networks, and the limitations imposed on a user's perceptual ability, telepresence systems typically require local intelligence to assist a human pilot in moving safely and reliably about an area. As such, most devices carry expensive laser range finders. We therefore deployed our sensor on a prototype telepresence robot to show that our sensor can effectively aid human pilots to carry out safe and reliable navigation, at much lower cost. In such a

system, global path planning is clearly handled by the human pilot based on their view of the environment, and as such, the range finder is only necessary for local planning to avoid obstacles. A local planner, in our case the Dynamic Window Algorithm, must then plan a route that closely follows the desired path without colliding with obstacles. Given both the operator's desired velocity commands and knowledge of how DWA will compute output commands, we can narrow the area that must be scanned, and intelligently sample the environment, making the most of each data point sampled while meeting the needs of the planning algorithm.

Within the realm of autonomous robot navigation, laser range finders have typically served two purposes: to enable path planning around obstacles, and to localize the system in the wake of odometry imprecision. While our range finder has limited localization abilities, other more interesting means of localization exist. As we were not primarily concerned with localization aspects for these experiments, we allowed the robot to localize itself using signs and waypoints throughout the environment. Unlike the situation with a telepresence system, when operating on an autonomous robot, our sensor must generate information not only for local obstacle avoidance, but also for more general global planning tasks. In this case, the sensor scan area cannot be reduced as drastically as we must also meet the longer term needs of the global planner.

This paper fits within the conference theme as the availability of lower cost sensing technologies, range finders in particular, may speed the deployment of lower-cost platforms in many applications. While the actual prototype implementation is more suited to research or educational deployment than commercial robots, we believe the underlying methods can be applied more broadly.

Future work with this system includes further refinements to both hardware and software. From a hardware perspective, we must address the overall noise of the scanning servo, as well as the size of the sensor. Such work would transform our prototype system into a system more ready for deployment into commercial robots and telepresence systems.