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Sensing Perception of an Omnidirectional Ground Vehicle With a Laser Scanner [1]

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Abstract

This paper presents a sensoring perception scheme for an omnidirectional ground vehicle equipped with a laser scanner. With a structured environment, a revised Hough transform is deveoped for an effective segmentation of raw data set into different subsets with known attributes. Each subset of data is then fit by a known template shape through either algebraic fitting or geometrical fitting schemes. With these medium level information, we propose to estimate the ego-motion of the vehicle for the high-level controller/planner.

Key Words: Segmentation; Hough transform; line fitting; corner fitting; arc/circle fitting; ellipse fitting; algebraic fitting; weighted circle fitting; Omni directional vehicle.

1 Introduction

To be finished by Dr Chen.

The rest of the paper is organized as follows. Sec. 2 presents a revised Hough transform method for efficient segmentation of the laser scan raw data set. In Sec. 3, several template fitting algorithms are presented with detailed formulae. With the fitted results and the assumption that the environment is static, an algorithm for mobile robot ego-motion estimation is presented in Sec. 4. Some experimental results are presented in Sec. 5. Finally, Sec. 6 concludes this paper with some remarks on further research efforts.

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2 Segmentation Using Revised Hough Transform

To be finished by Song, Zhen.

3 Fitting Algorithms

To be finished by Dr Chen.

3.1 Line Fitting

To be finished by Lili Ma.

3.2 Corner/Rectangle Fitting

To be finished by Lili Ma.

3.3 Circle Fitting

To be finished by Dr Chen.

3.4 Ellipse Fitting

To be finished by Dr Chen.

3.5 Weighted Circle Fitting

To be finished by Dr Chen.

4 Ego-Motion Estimation

With a static environment, using the temporal series of laser scan data, we can estimate the ego-motion of the autonomous vehicle.

To be finished by Song, Zhen.

5 Experimental Results

5.1 A Brief Introduction to ODIS Platform

The USU ODIS robot is a small, man-portable mobile robotic system that can be used for autonomous or semi-autonomous inspection under vehicles in a parking area [1]. Customers for such a system include military police (MP) and other law enforcement and security entities. The robot features (a) three "smart wheels" in which both the speed and direction of the wheel can be independently controlled, (b) a vehicle electronic capability that includes multiple processors, and (c) a sensor array with a laser, sonar and IR sensors, and a video camera. ODIS employs a novel parameterized command language for intelligent behavior generation. A key feature of the ODIS control system is the use of an object recognition system that fits models to sensor data. These models are then used as input parameters to the motion and behavior control commands. Fig. 1 shows the mechanical layout of the ODIS robot. The robot is 9.8 cm tall and weighs approximately 20 kgs. Key ODIS subsystems include its mechanical, vehicle electronics (vetronics) and sensor systems. For more detailed description, see [2].

Figure 1: The mechanical and vetronics layout of ODIS

Fig. 2 shows the behavior control architecture that has been developed. Starting from the "inside out," the control architecture contains two inner motion-control loops. The inner most loop is the wheel-level control, which acts to drive each smart wheel to its desired steering and drive speed set-points. The wheel-level controller uses simple PID control algorithms. Around the inner loop is the path-tracking controller. This loop derives the set points need by the wheel-level control in order to force the vehicle to follow a desired path in space, where a path is defined as an arc in inertial space (with a prescribed velocity along the arc) and an associated vehicle yaw motion. The path-tracking controller uses a newly-developed spatial tracking control algorithm that is described in more detail in [3].

5.2 Typical Laser Scans in Parking Environment

5.3 Ego-motion Estimation

6 Concluding Remarks

Future efforts include the motion estimation of dynamic obstacle(s), fusion with sonar and image sensoring information and local map building.

Figure 2: The behavior control system architecture of ODIS

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References

[1] K. L. Moore and N. S. Flann, "A six-wheeled omnidirectional autonomous mobile robot," *IEEE Control Systems*, vol. 20, no. 6, pp. 53–66, 12 2000.

[2] K. Moore, N. Flann, Rich S., M. Frandsen, Y. Chung, J. Martin, M. Davidson, R. Maxfield, and C. Wood, "Implementation of an omni-directionsl robotic inspection system (ODIS)," in *Proceedings of SPIE Conference on Robotic and Semi-Robotic Ground Vehicle Technology*, Orlando, FL., May 2001, SPIE.

[3] M. Davidson and Bahl V., "The scalar ϵ-controller: A spatial path tracking approach for ODV, Ackerman, and differentially-steered autonomous wheeled mobile robots," in *Proceedings of IEEE Int. Conference on Robotics and Automation (to appear)*, Seoul, Korea, 2001, IEEE.