Environment Mapping for Autonomous Driving into Parking Lots

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Presentation Outline

1. Introduction
2. Related Work
3. Hardware/software utilized
4. Algorithms
5. Conclusion

Figure 2. Autonomous vehicle equipped with the SICK LD laser scanner, ultra-sonic sensor cells and the PC-104 system.

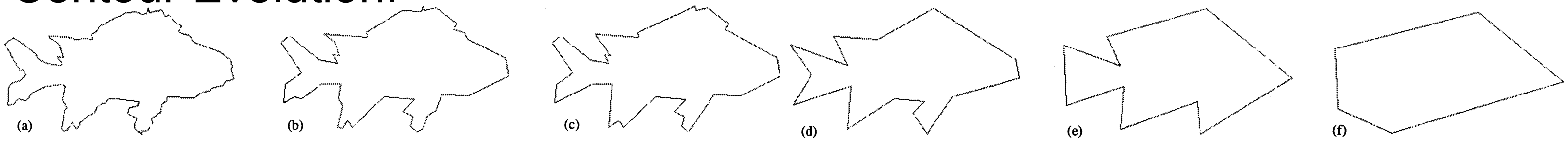
Introduction

Problem: How to collect information and utilize in a Simultaneous Localization and Mapping (SLAM) algorithm?

- End use: Navigate in unknown environment with the aim of safe self parking on a standard parking lot, through the use of external sensors.
- Main Focus: Reduce data, by algorithms, while maintaining enough map complexity to accomplish task.

Related Work

- Identification Convexity Rule for Shape Decomposition Based on Discrete Contour Evolution.



- Map building for a mobile robot equipped with a 2d laser rangefinder.

  Integration of numerous local maps into one global map to represent the whole environment observed by the robot during navigation.

- Precise positioning using model-based maps.

  The basis for this paper is using the environment and location of matching previous scans to interpret the position of the mobile robot with respect to fixed landmarks.

- A comparison of Line Extraction Algorithms using 2D Laser Rangefinder for indoor mobile robots.

  compare 6 popular algorithms for speed, complexity, correctness and precision in robots

- A Method for Building Small-Size Segment-Based Maps

  using a map manager to organize smaller maps into a global map.

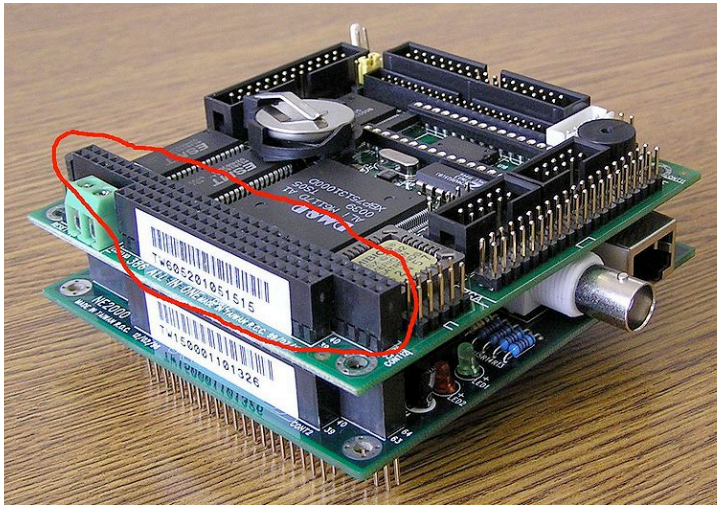
Hardware/Software Utilized

SICK LD1000
Laser Measurement System

- Rotating scanner head
  - 5-10 Hz
  - Angular resolution 0.125°
- Supports CAN standard 2.0A
  - Data transmission between 10 bit/s and 1 Mbit/s.
  - Can configure ID for priority on bus
  - Used to transmit distances only
- Digital Outputs
- Emits laser pulses at a max frequency of14.4 kHz (14,400 per second)
  - Measurement range up to 250m (~820 ft.)

Hardware/Software Utilized

PC/104



- An Embedded Computer Standard
  - Defined form factor and bus.
  - Intended for specialized embedded computing environments dependent on reliable data acquisition.
- Modules stack together like building blocks
  - Typically includes a motherboard, analog-to-digital converter and digital I/O for data acquisition.

- Constraints
  - 3.55 x 3.775 inches
  - Height is typically constrained to the boundaries of the connectors.

Hardware/Software Utilized

xPC Target

- Enables the execution of Matlab/Simulink models on the PC104 system for real-time testing.
- It provides a library of drivers, a real-time kernel and a host target interface for real time monitoring.
- Download code generated by Simulink to the PC104 target via the communications link.

Map Building Procedure

1. 180° scans of the environment as an input to the system.

2. Creates an array of points which is sorted by the laser angle.

3. Array structure

$$DS1 = [n, x_1, y_1, \ldots, x_n, y_n]$$

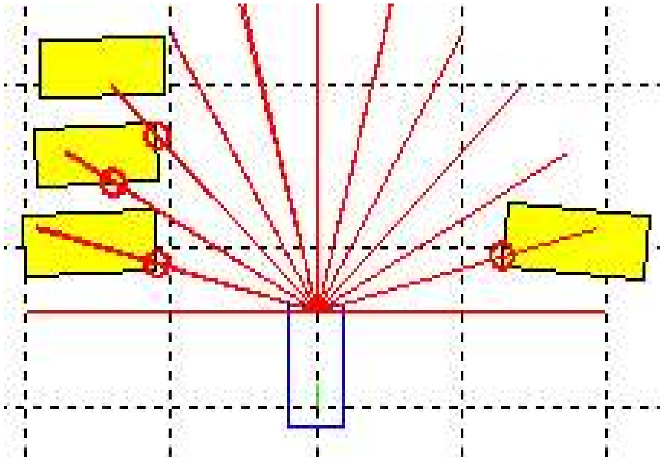


Figure 3. Laser beam sensing area

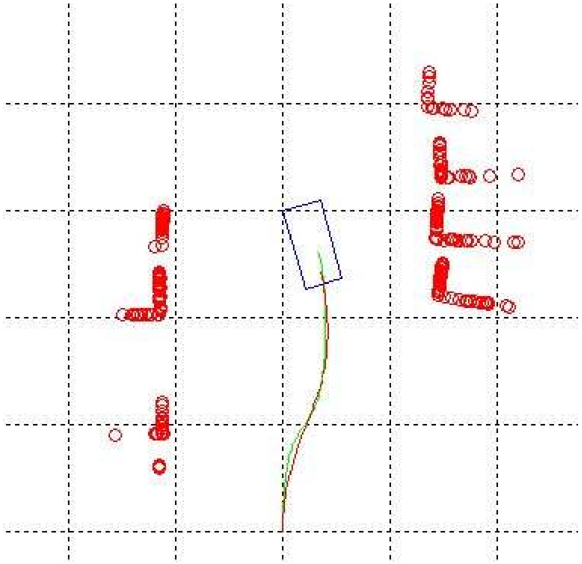


Figure 5. DS1 Data representation

Map Building Procedure

4. Clustering Module
   - Grouping of neighbors
   - New clusters begin when the distance is greater than a predefined parameter.
   - Sorts the clusters.

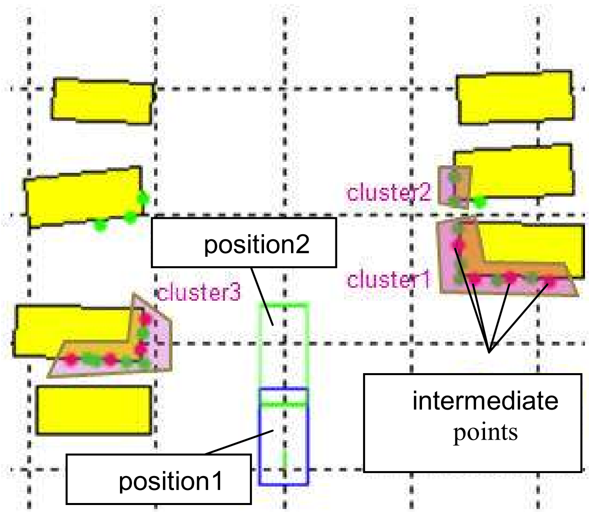


Figure 6. Theoretical cluster formation on obstacle edges

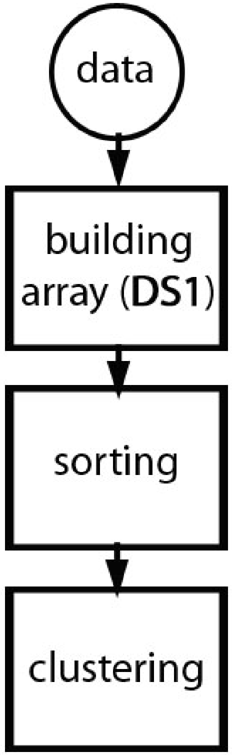


Figure 4. Obtaining the sorted DS1

Map Building Procedure

5. Lines Module
   - Discrete Contour Evolution, DCE, algorithm
   - First remove doubled data
   - Linear regression is applied
   - Endpoints maintained, intermediate forgotten.
6. DS2 matrix created

$$DS2 = [n1, x_1, y_1, \ldots, x_{n1}, y_{n1}; \\ n2, x_1, y_1, \ldots, x_{n2}, y_{n2}; \ldots]$$

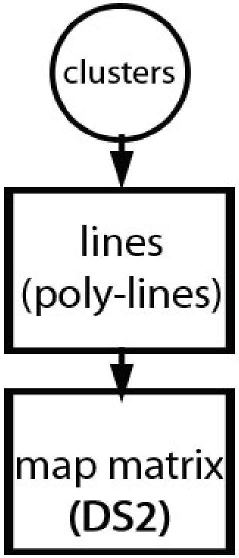


Figure 8. Reducing DS1 to relevant data DS2

Figure 7. Reducing DS1 to relevant data DS2

Map Building Procedure

7. Map Manager
   - Vehicle Odometry Correction
     uses previous lines to reskew
   - Segmented Maps
     for occlusion and doubled data(segmented)

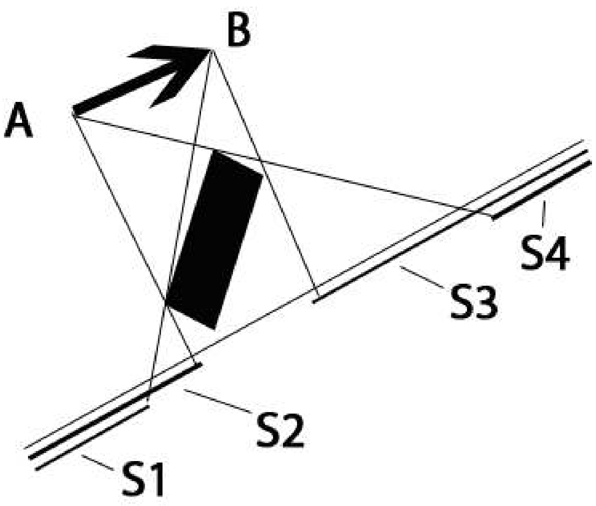


Figure 10. Occlusion effect

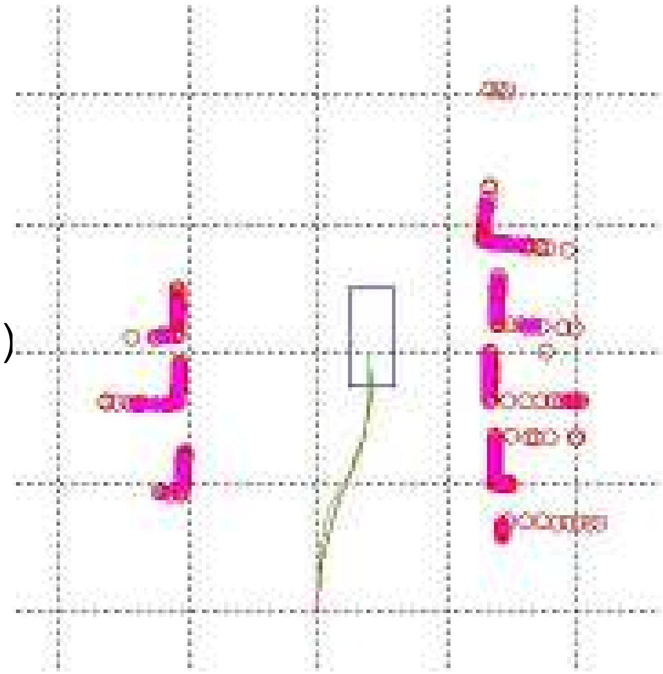


Figure 9. DS2 data representation reduced by lines and poly-lines.

Further Use/Research

- Implement an algorithm responsible for object avoidance and for the calculation of the shortest path during parking procedures

- Remove laser scanner and replace with network of ultrasonic sensor cells.

- Be able to safely autonomously drive the vehicle to a parking lot, based off potential field theory.

Conclusion

- Data reduction represents a common solution to mobile robot navigation
- Utilizing real time computation using embedded software data reduction is accomplished.
- Object identification and data reducing algorithms are used and intermediate points/lines are discarded, reducing memory required.

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