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AUTONOMOUS PARKING PROCEDURES USING ULTRASONIC SENSORS

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Abstract: *Having the aim of developing an autonomous parking system for car-like vehicles used in the industrial areas and real traffic environment, a description of the actual system is made. The exploration of specific environments is made using a sensor infrastructure and an embedded algorithmic approach. A virtual map of the environment is generated in real time navigation conditions based on a minimalist feature extraction and data reduction; only relevant data is further processed. Next to mapping an integrated path planer takes the control of the vehicle and guides it safely into a standard parking lot. Random scenarios are analysed for data representation of the feature extraction.*
Key words: *feature extraction, autonomous parking, ultrasonic mapping ,real-time processing, scaled vehicles*

1. INTRODUCTION

Autonomous navigation systems represent a challenge for the automotive and industrial engineering. The research at the Automotive Competence Centre (ACC) from Hochschule Heilbronn/Germany relies since 2004 on developing driver assistance systems and mobile robots for the automotive industry (Pozna & Troester, 2005). The describing application is relying on the capability of the designed system to be able to accomplish specific tasks that allows a driverless car-like vehicle to fully autonomously execute parking procedures on standard parking lots. The problem delimitation refers to using ultrasonic sensor cells to register reliable data and use the relevant information for further navigation by calculating an optimal path. The tested environment represents a static area.

A three layer approach describes the developed system. Firstly a Matlab/Simulink Embedded programmed software analyses the behaviour of the sensors and of the vehicle (layer 1). Next to this (layer 2) the software is transferred to a scaled embedded system for testing the algorithms in the laboratory. The final step (layer 3) represents a 1:1 real vehicle capable of completing the specific tasks. The result of the second layer is a system architecture (software and hardware) that can deal in fast and reliable ways with problems caused by the testing of different path-planning and SLAM (Simultaneous Localization and Mapping) algorithms in laboratory conditions.

2. RELATED WORK

During the last years similar autonomous systems have been developed to progress the knowledge in the field of autonomous navigation. The MERLIN project developed at the University of Wuerzburg represents a platform for testing semi-autonomous object avoidance algorithms. A similar approach of evaluating ultrasonic sensory information is described by (Wu, 2001). There is no sensor cell/cluster approach for different ranges which we consider to be relevant for a precise determination of the object similar to the principles of laser sensors. The mapping process is described in a segment based approach by (Amigoni et. al. 2006). The segment based mapping requires predefined data, although we are considering of evaluating data dynamically, during the on-line scanning of the environment. Also we provide a data simplification and selection before processing the algorithms for map generation.

3. THE NAVIGATION SYSTEM

For the testing facility (layer 2) a user specified decomposition of tasks is done. The PC104 main unit mounted on the vehicle works independently of all other processing units. In this way a real time embedded system is developed to run independently on the platform. The command of the robotized vehicle is done by various methods. The user can operate the vehicle directly via a wireless game-pad, attached to the host laptop or by using a virtual control module from the Graphical User Interface (GUI). The vehicle proceeds to a full autonomous behaviour during the parking procedure. The communication between the system components is described in the figure below. The wireless communication (WLAN) is used not only to download the developed computing algorithms into the Target PC it also makes possible the visualization of the results during the map generation.

The scaled vehicle was complementary equipped with ultrasonic sensor clusters for the object identification in range of up to 700 [mm], a PC-104 unit interface for computing the real time embedded algorithms using the xPC tool from Matlab and odometry sensors as represented in the figure below.

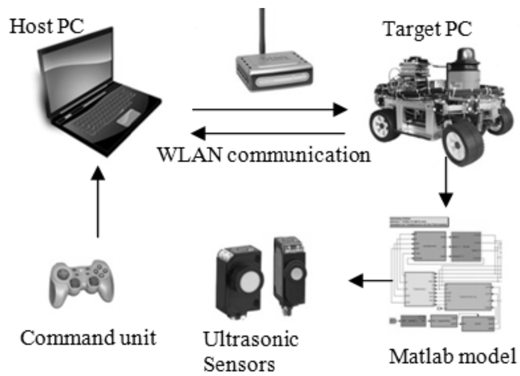


Fig. 1. System communication of the components

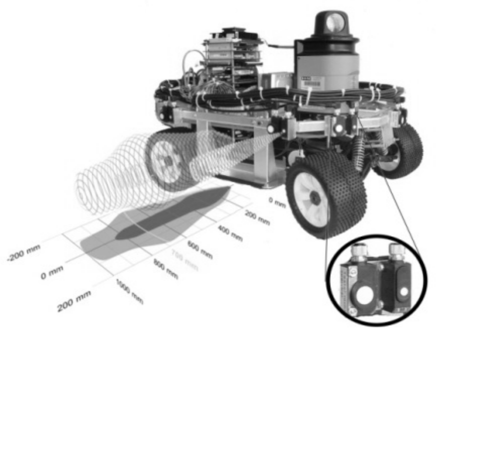
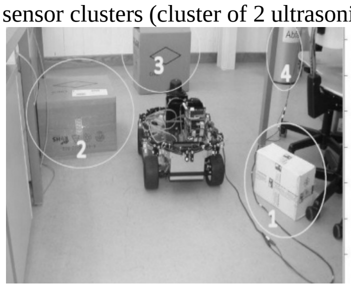


Fig. 2. Scaled autonomous vehicle with surrounding ultrasonic sensor clusters (cluster of 2 ultrasonic sensors in detail)



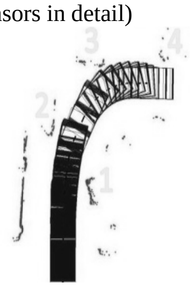


Fig. 3.Transformed data representation of the vehicles surrounding

Each cluster compounds of two ultrasonic sensors. One for ranges between *[20…150] mm* and one for ranges defined in the interval of *[120…700] mm.* Within these cells, the surrounding area is scanned and data are being represented in a global map. For wide range scanning a laser scanner is used. Having the aim of parking, the diagnostic of the immediate surrounding of the vehicle becomes priori. The raw captured data is defined as a sorted array of intersection points in the Cartesian space.

4. THE FEATURE EXTRACTION

The nearest neighbour method is used to proof the limits of the represented points and merge them into clusters. The sorted clusters are further processed in the line extraction algorithm. An extended Discrete Contour Evolution (DCE) approach is responsible for data reduction during the environment scanning (Latecki & Lakamper, 1998) and (Luca et. al. 2009). This is how the points are processed into lines by keeping only relevant data. Figure 4 shows a merging of points into lines by specific DCE algorithm criteria computed in the Matlab/Simulink environment.

By dynamical vehicle movement, map segments are resulting. To compensate errors, recognizing features that have come across previously and re-skewing recent parts of the map to make sure the instances of that feature become one is required. (Siegwart & Nourbakhsh, 2004). A scan matching method assumes that generated lines can be compared and matched together. The orientation of the merged lines is having similar values. By merging line segments together a new data reduction similar to the first step is obtained. The map is being simplified by comparing map segments, creating a scan fusion for maintaining only relevant data and finally reaching only ~ 10% of relevant information which is stored in a matrix representing the generated map.

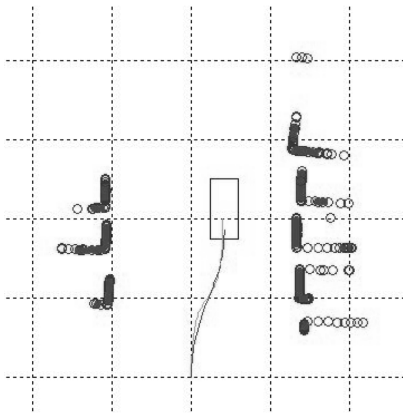


Fig. 4. Line formation and data reduction by applying the Discrete Contour Evolution (DCE) algorithm on a random parking place

5. CONCLUSION AND FURTHER RESEARCH

This paper presents the problematic of data reduction to relevant points (lines) for a real-time map generation of an unknown environment with the aim of developing a system capable of dealing with autonomous parking procedures. This step also represents the second development layer of our research, in which the testing environment becomes a scaled medium dealing with static objects. The resulting map becomes effective by maintaining only relevant data for further processing of autonomous manoeuvres trough the environment. For the future research the platform needs to be improved with the following:

- calculate and drive a trajectory in fully autonomous mode by using the mapping data;
- identify a parking spot and make autonomous parking procedure by integrating the existent semi-automated module;
- identify the contour of the marked lines/parking shapes on the ground by a vision system;
- improve the Mapping algorithm to a full Simultaneous Localisation and Mapping (SLAM) algorithm, by implementing a landmark identification for better odometry

The implementation on the real vehicle maintains the same infrastructure characteristics and is to be made in the parallel session of the third development layer of the project.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

Amigoni F., Fontana G. & Garigiola F. (2006) A Method for Building Small-Size Segment-Based Maps, *Conference on Distributed Autonomous Robotic Systems.* Springerlink, 2006

Latecki, J. L. & Lakamper R. (1998). Convexity Rule for Shape Decomposition Based on Discrete Contour Evolution, *Available from: http://www.cis.temple.edu/~latecki/Papers/cviu99.pdf*

Luca R., Troester F., Simion C. & Gall R. (2009) Data merging and sorting method based on Discrete Contour Evolution with application on SLAM, *Annals of DAAAM for 2009 & Proceedings of the 20th Symposium "Intelligent Manufacturing & Automation: Focus on Theory, Practice and Education*, ISBN 978-3-901509-70-4, page numbers (253-254) Vienna, Austria

Pozna C. & Troester F. (2005). The inverse cinematic of the ACC mobile robot, *Proceedings of the ninth IFTOMM international symposium on theory of machines and mechanisms*, Vol. 1 page numbers (358-366) Bucharest, 2005

Siegwart, R. & Nourbakhsh, I. R. (2004). *Introduction to Autonomous Mobile Robots*, the MIT Press, ISBN 0-262-19502-X, Cambridge, Massachusetts

Wu C-J. (2001) Localization of an Autonomous Mobile Robot Based on Ultrasonic Sensory Information. *Journal of Intelligent and Robotic Systems*, Vol.30 , No. 3, page numbers (267-277), ISSN 1573-0409