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БЕЗЖИЧНО БАЗИРАНА ВИЗУАЛИЗАЦИЯ НА КАРТОГРАФИРАНЕ НА ЗАТВОРЕНИ ПРОСТРАНСТВА

WIRELESS BASED VISUALIZATION OF INDOOR MAPPING

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Abstract

The current article deals with the development, functioning and implementation of a laser scanner for indoor exploring as part of actively-compliant-sensors built in a mapping system. The overall mapping system is designed to assist the navigation of the mobile platform.

The recent stage of development shows a wireless-based mapping system offering the possibility for mobile visualisation and touch-screen-manipulation of objects of interest. Shared are parts of the visualization and the obtained test results.

Keywords: mobile robot, *mapping system, indoor navigation*, SLAM, ROS.

INTRODUCTION

The basic assignment of mobile robotics is to plan unrestricted movements of complex platforms within a space and toward a certain target point among a set of obstacles. The planning of movements or geometric trajectories encompasses both the robot's and the working area's trajectory. The latter represents a predefined environment saturated with static and non-static obstacles.

One of the biggest challenges for autonomous robots is the **S**imultaneous **L**ocalization **a**nd **M**apping (SLAM) problem. Although significant progress in this area has been made it is still a challenge because of the fusion between different sensors. In this paper we describe only the mapping process. There are three types of laser-based range sensors in common use:

- triangulation sensors
- phase-modulation sensors
- time-of-flight sensors

The principle of distance measurement is based on calculating of the phase difference, due to which it is possible to obtain stable measurement with minimum influence from object's color and reflection.

For our purpose we use a laser scanner and our efforts are in the direction to combine a mobile platform and a laser scanner. The mobile platform is equipped with a display on which the mapping process is visualized. Because of poor open GL support for ARM based boards the visualization is calculated on a separate pc and shown on the display through an ssh connection. The calculation for the mapping process is done on the mobile platform. For mapping we used rooms and corridors in building 4 of the Technical University Sofia.

HARDWARE DESIGN

Creating a map of the environment is important for high level autonomous behavior and path planning. Fig 1. Shows our whole mapping system. Consisting of a CPU, several microcontrollers used for collecting data from sensors or for driving motors, different type sensors:

- laser scanner,
- magnitometers,
- infrared distance switches,
- Quadratur encoders and servo controller.

In this paper we will cover the creation of a purely geometric map like an occupancy grid map, which should be used for navigation and obstacle avoidance. We also don't talk about points of interest or discussion of path finding algorithms.

We used a panda board with ARM Cortex 8 and UbuntoARM installed. The biggest advantage of this board is its build in wlan and Bluetooth. The biggest challenge in this work was that the ARM based board have limited or no OpenGL support as shown by [7]. Because of this, the map visualization calculation is done on a separate PC. The robot connects to the PC trough a ssh connection and displays the visualization on his monitor. As a laser scanner we chose the Hokuyo URG-04LX-UG01 who is a simplified and cheaper version of URG-04LX. He has similar technical parameters with the Microsoft Kinect but as described in [1]. The biggest disadvantage of the Kinect is its small monitoring angle, which is essential for map building and localization. Another advantage of the Hokuyo is the power source 5V supplied by USB. For the robot platform we chose the Lynxmotion A4WD1 v2 rover. Because this rover fulfills the design requirements for a mapping robot like:

- Carry multiple sensors and microcontrollers
- CPU and display
- Easy maneuver on flat ground
- Big diameter wheels
- Powerful enough to support the payload weight.

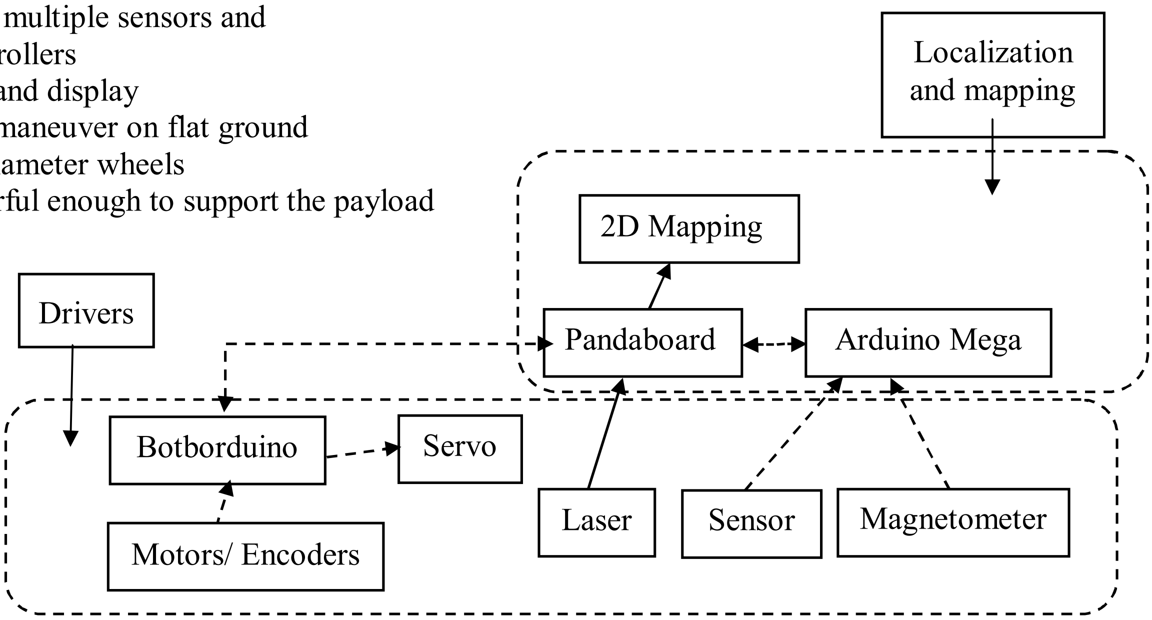

Fig. 1. *Components of driving localization and mapping system*

SOFTWARE DESIGN

For the robot middleware we use the Robot Operating System –ROS, which is widely used in robotic research and applications. The nodes connected with a line in Fig. 1 were used in this research. SLAM is a combination of object detection and recognition algorithms combined with the purpose to create a map and determine the position and orientation of the robot within the created map. Object recognition means the correlation between the new scans and the already created map. **E**xtended **K**alman **F**ilter (EKF) is one of the most used statistical methods for distinguishing between new objects and already mapped ones. Statistical methods are needed because when the robot moves the old object location will appear differently. Parallel to object recognition orientation estimation is performed. For that many SLAM methods use odometry and estimate how far the robot has moved since the last scan. The new location is then used as orientation of the robot and based upon it object recognition is performed. Afterwards if all present objects have moved in the same direction, the robot has moved in the opposite direction. New objects are distinguished from older ones and from error data by storing them temporarily between scans and checking if they exist in future scans.

If the object is repeatedly in one position then it is added to the map. The SLAM method is designed to detect unmovable objects. If people or other robots are still for a moment they will be added to the map, because they will be detected as obstacles, but after they move there will be a wrong reference point in the map. The same problem is also a rapid direction turn which will confuse the orientation estimation of the robot.

For our mapping task we used Hector (**He**terogeneous **C**ooperating **T**eam **o**f **R**obots) SLAM [3], which contains Hector mapping, hector map server, hector trajectory server and hector geotiff. Because simple odometry is unreliable, cause of possible wheel scrolling, the system uses only fast LIDAR (**L**ight **I**dentification **D**etection **A**nd **R**anging) [] data scan matching. Hector SLAM is discussed in detail in [2,4]

EXPERIMENTS AND RESULTS

We tested the system in a corridor within the Technical University Sofia facilities. Fig. 2 shows a visualization of the generated map. The mesh size is 1 meter. In our future work we will use the opportunity to tune fine the mesh grid in order to identify small objects/ points of interest. ROS visualization application uses OpenGL but ARM based boards have minimum or no OpenGL support so that's why the visualization is calculated on a separate pc and then trough a wlan ssh connection shown on the robot display. To be able to do that the Pandaboard roscore is configured as master. Thus nodes running on different pc can subscribe to topics and acquire or publish data.

Fig. 4 shows a generated map from our Lab. This map has multiple errors in it. The latter occur because the room has multiple chairs, i. e. multiple same looking objects. Plus, the chair legs are chrome-plated. This material as examined in [1,8] is almost invisible or creates a lot of error data. A detailed examination of obstacles in surfaces is allocated in [5,6]. Another explanation are external disturbances – the Hokuyo laser scanner is only for indoor applications.

The tested map is with south view and has large windows along the walls on two sides. We tested this at night and the resulted were better but again with errors.

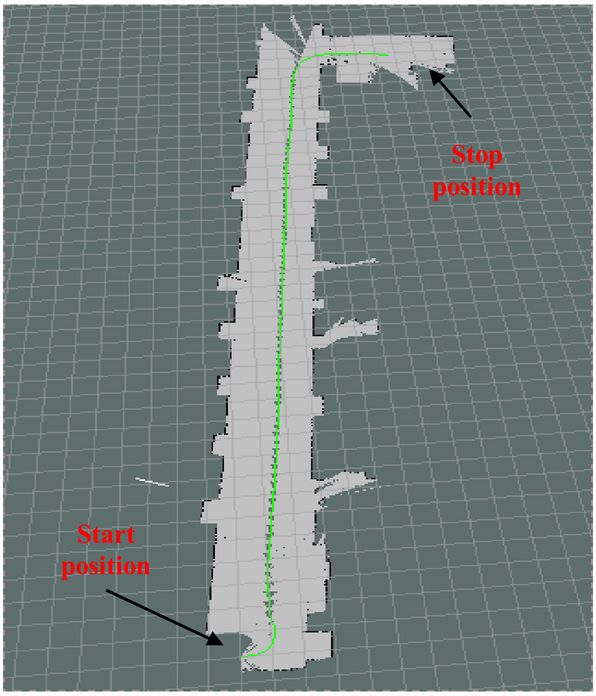

Fig. 2. *The generated corridor map. A green line shows the path passed by the robot*

Fig. 3. *Shows the mapped corridor. Only half of it was mapped in Fig. 2*

CONCLUSION

A method based on open source modules has been presented for providing in future research navigation in indoor environments.

Fig. 4.*The map generated in our Lab at the Technical University Sofia*

Fig. 5. *A photo from our Lab*

The main contribution of this paper can be divided in three parts:

- First, we present the possibility to combine the robot platform Lynxmotion A4WD1 v2 with the Hokuyo URG-04LX-UG01 laser scanner.

-Researched are opportunities for combining with magnitometers - 3D map.

-The third contribution addresses the future applying of the created map for the main task of the mobile platform – localization based upon magnetometer anomalies, points of interest and navigation. In our future work we intend to combine the achieved contributions and to provide possibilities for some significant implementation of the mobile systems.

REFERENCES

[1] Zug, S.; Penzlin, F.; Dietrich, A.; Tran Tuan Nguyen; Albert, S., "Are laser scanners replaceable by Kinect sensors in robotic applications?," *Robotic and Sensors Environments (ROSE), 2012 IEEE International Symposium on* , vol., no., pp.144,149, 16-18 Nov. 2012

[2] Kohlbrecher, S.; Petersen, K.; Steinbauer, G.; Maurer, J.; Lepej, P.; Uran, S.; Ventura, R.; Dornhege, C.; Hertle, A.; Sheh, R.; Pellenz, J., "Community-driven development of standard software modules for search and rescue robots," *Safety, Security, and Rescue Robotics (SSRR), 2012 IEEE International Symposium on* , vol., no., pp.1,2, 5-8 Nov. 2012 doi: 10.1109/SSRR.2012.6523917

[3] S. Kohlbrecher and J. Meyer and T. Graber and K. Petersen and O. von Stryk and U. Klingauf “Hector open source modules for autonomous mapping and navigation with rescue robots” *Proc. RoboCup Symposium 2013*

[4] Wirth, S. and Pellenz, J. “Exploration transform: A stable exploring algorithm for robots in rescue environments” *Safety, Security and Rescue Robotics, 2007. SSRR 2007. IEEE International Workshop*

[5] W. Boehler, M. Bordas Vicent, and A. Marbs, “Investigating laser scanner accuracy,” The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. 34, no. Part 5, pp. 696–701, 2003.

[6] T. Voegtle, I. Schwab, and T. Landes, “Influences of different materials on the measurements of a terrestrial laser scanner (tls),” in Proc. of the XXI Congress, The International Society for Photogrammetry and Remote Sensing, ISPRS2008, vol. 37, 2008, pp. 1061–1066.

[7] http://www.arm.com/products/multimedia/ mali-graphics-hardware/ index.php 15.10.2014.

[8] W.-C. Chiu, U. Blanke, and M. Fritz, “Improving the Kinect by cross-modal stereo,” in Proceedings of the British Machine Vision Conference, BMVA Press, 2011, pp. 116.1–116.10

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