Robo Rescue Cup 2006 - Robot League Team ResKo Team (Germany)

Johannes Pellenz

Arbeitsgruppe Aktives Sehen
Universität Koblenz-Landau
Universitätsstr. 1
56070 Koblenz, Germany
pellenz@uni-koblenz.de
http://www.uni-koblenz.de/agas

Abstract. This paper describes our approach for the RoboCup 2006 Rescue League. The mobile system we use is based on an ActivMedia Pineer 3 AT. It is equipped with a four wheel drive and sonar sensors in the front and in the back. On this platform, an alumnium rack is installed where the other devices are attached to: A self made stereo camera system (consisting of two high resolution Sony FireWire cameras), an electronic compass and a HOKUYU laser range finder (LRF). In addition, a third FireWire camera is attached to the back of the robot to give a rear view. The robot is manually controlled from a client computer, which is operated by one team member. The map building is done by the computer automatically by merging the collected LRF data with the depth information aquired by the stereo system. The operator can adjust the map proposed by the computer by correcting wrong matches. The victim detection has to be done by human observations using the visual cameras.
The system was develpoped by students of the University of Koblenz-Landau in Germany during the last 12 months.

Introduction

The *ResKo Team* is a team of students from the University of Koblenz-Landau, Germany. The mobile system called "Robbie" was developed during the last year. Two practical courses were held in which the robot was built and its software developed. The students of the first course constructed the robot hardware, which by then was able to drive to a point, to identify a red container with its stereo camera system and to pick it up with a gripper. The students of the current course form the ResKo Team. Currently the robot is able to drive through the yellow and orange arena. The robot is navigated by an operator using a second PC, which is connected to the robot's PC via wireless LAN.

Fig. 1. Our Pioneer 3 AT robot

1 Team Members and Their Contributions

- Judith Haas: quality management representative, GUI, programming
- Peter Decker: stereo image system, programming
- Christian Latsch: public relations, sensor data visualization, programming
- Marco Mengelkoch: infrastructure, wireless communication protocol, remote control, programming
- Johannes Pellenz: scientific advisor, project manager, coach
- Martina Schmidt: project manager, programming
- Peter Schneider: mobile system, wireless communication protocol, programming
- Sarah Steinmetz: 3D reconstruction, programming
- Sebastian Vetter: technical design, programming
- Stephan Wirth: hardware, localization, mapping, programming

2 Operator Station Set-up and Break-Down (10 minutes)

Our equipment includes a robot, a laptop, a printer and a gamepad. The robot is transported on a rolling cart and the rest of the hardware is stowed away in a backpack. Within the 10 minutes timelimit the robot and the operator station are booted, the wireless communication module is connected and the functionality of all sensors is tested. The break-down takes the same time.

3 Communications

We use a wireless LAN connection with 802.11g. We could change the channels and the power, if necessary. Right now, we use channel 11 with 22 mW. The other 2.4 GHz device is a Logitech Game Controler. It is not connected to the robot platform but to the operator station, so we could switch to a cable device, if necessary.

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frequency	Channel/Band	Power (mW)
2.4 GHz - WLAN 802.11b/g	11 (selectable)	22 mW (selectable)
2.4 GHz - Logitech Device	(unknown)	(low)

4 Control Method and Human-Robot Interface

Our robot will be navigated through the arenas controlled remotely from the operator station, either via keyboard or via gamepad. The human-robot interface is a Qt4-GUI running on the operators laptop. In this interface the operator sees all the sensor measurements, the relevant section of the map and the images from the cameras. He can also choose to see the full map. The operator can mark the position of victims in the electronic version of the map. We use OpenGL widgets for visualizing easy to understand 3D plots of the data. An example of the visualization of a laser scan is given in figure 2.

5 Map generation/printing

The map we are going to present will mainly be generated by the program, based on the laser scans and the dense depth images. Anyway, the operator can adjust wrong matches by hand to make the map more accurate. We bring our own printer for printing out the generated map.

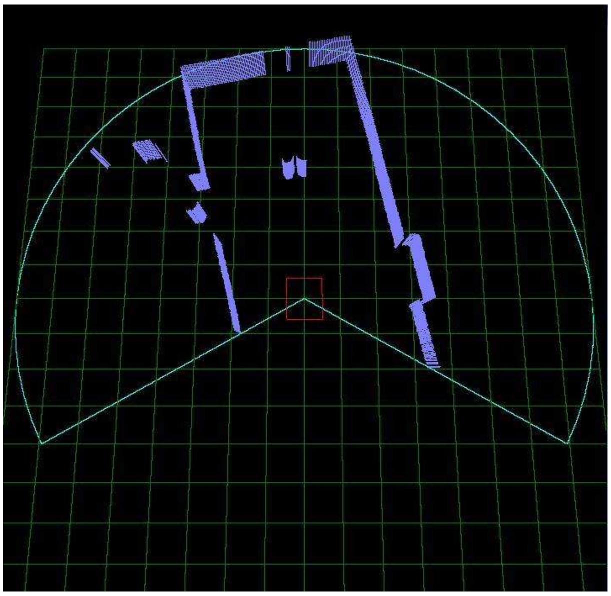

Fig. 2. Part of the map, generated from the laser scanner data.

6 Sensors for Navigation and Localization

6.1 Odometry data

The Pioneer robot has a built in system to report odometry data from the wheels. Anyway, our experiments have shown that the data is very unreliable. Therefore, we do not use it for navigation purposes. Also, the newspaper that might lie on the floor makes the odometry data even worse.

6.2 Electronic compass

The electronic compass is connected to the notebook on the robot via USB. The compass yields the direction the robot points to. The compass is embedded in a black plastic box as depicted in figure 5.

6.3 Sonar sensors

Our Pioneer 3 AT robot platform has two sonar rings (one scanning the front and one scanning the back) with eight sonar sensors each. Totally they cover 360 degrees, but with large gaps inbetween the sensors. We use the sonar sensors to avoid collisions with objects that the operator did not see and the laser scanner did not detect. The sonar sensors are used for collision avoidance only, but neither for mapping nor for localization.

6.4 Laser scanner

The Hokuyo URG-LX laser scanner is used for 240 degree scans that measure the distance (up to 4 meters) of the closest objects near the robot. The resolution of the laser scanner is 0.36 degrees. The operator interface shows these scans with respect to the robots position. With this information the operator is able to estimate distances to obstacles better than with video images only. We got our laser scanner only a few weeks ago, and are very pleased with the accuracy of the scanning data. The scanner is attached to the front of the robot as shown in figure 3.

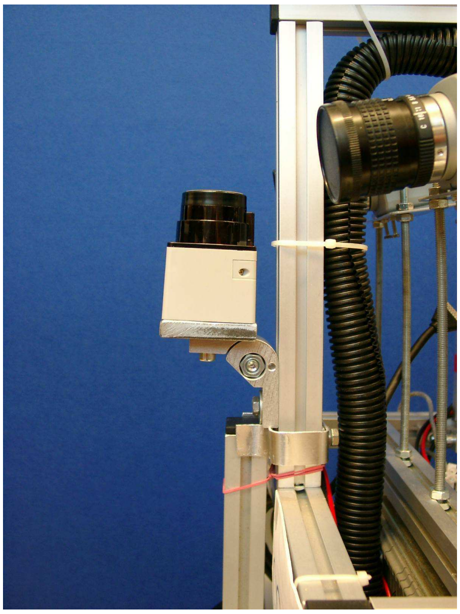

Fig. 3. The Hokuyo URG-LX laser scanner

6.5 Videostream

With a continuous videostream the operator is able to navigate the robot in a natural visual manner. The video data is transported to the operator station via WLAN.

7 Sensors for Victim Identification

7.1 Stereo Vision System

We have a stereo vision system mounted at the robot's front, as illustrated in figure 5. The two Sony cameras (one DFW-X700 and one DFW-X710) are looking into the direction the robot is moving. We use them to detect motion, e. g. caused by waving arms of a victim. The distance to the victim is then calculated using the stereo images as depicted in figure 4. Found victims will be indicated to the operator who notes the victims location manually into the electronic map.

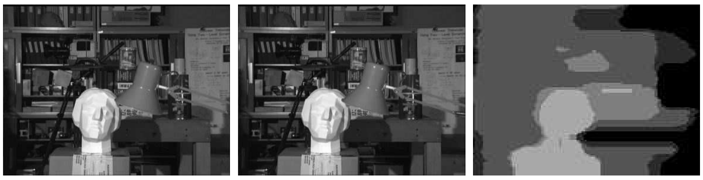

Fig. 4. Stereo image pair, and the calculated depth image. (Stereo images are the property of the University of Tsukuba.)

Fig. 5. The stereo vision system with the two Sony FireWire cameras. The compass is installed in the black box at the top.

8 Robot Locomotion

8.1 Wheeled Locomotion

The Pioneer 3 AT is a robot equipped with four air-filled tires. They are turned by an electrical 4-wheel drive. We control them by using the programming library (called ARIA) provided by the manufacturer. We implemented gamepad and keyboard control.

9 Other Mechanisms

9.1 High resolution Stereo Vision

We have two high resolution (1024×768 pixels) FireWire cameras which can determine the distance to a specific object. In an earlier project, the system was used to localize red containers and to estimate the distance between the robot and these objects [1].

9.2 Depth Images

The result of the processing of the stereo images is a dense depth image. Although the quality of the depth image is not satisfying so far, it yields additional information about obstacles that cannot be detected neither by the laser range finder nor by the sonar sensors (e. g. black nets or cloths, as seen at the competition last year in Japan). We believe that this is an important addition for accurate navigation decisions.

10 Team Training for Operation (Human Factors)

We set up an USARSim training platform (provided in the web) combined with a modified version of the Pioneer robot for training without using our real robot. We also use it to test and enhance our map building algorithm. The training that is required to use our system consists of knowing how to turn on the robot (and its devices) and how to start the application. Only a minimum amount of training is needed for using the GUI due to the intuitive representation of the data.

11 Possibility for Practical Application to Real Disaster Site

We yet have no practical experience with real disaster sites, but the robot can be taken apart (robot body and the rack) so it would fit in one or two backpacks. The operation station consists of a standard laptop with a wireless LAN access point, which would also fit in a backpack.

Our Pioneer 3 AT robot is incapable to drive through difficult terrain covered with larg pieces of debris. Anyway, because of the 4-wheel drive it is able to drive on slippery ground as long as the ground is planar. Our robot might be usefull for disaster sites such as buildings that are biologically or chemically contaminated, or for disaster sites where the floor is not blocked to heavily.

So far we did not focus on mobility, but on a suitable presentation (using OpenGL) of the data for the operator, map generation, exploitation of the high resolution stereo system and the great precision of the attached laser range finder.

12 System Cost

Article	Type	Price
Notebook	JVC MP-XP731	1402 EUR
Robot	Pioneer 3 AT	6050 EUR
Electronic compass	CMPS03	40 EUR
I^2C to USB Adapter	unknown	65 EUR
FireWire Camera	Sony DFW–X710	1392 EUR
Lens	Cosmicar	222 EUR
FireWire Camera	Sony DFW–X700	2038 EUR
Lens	Cosmicar	222 EUR
FireWire Camera	Unibrain Fire-i	80 EUR
Laser range finder	Hukoyu URG04-LX	1555 EUR
USB Hub	4 port USB Hub	30 EUR
WLAN Hub and stick	Linksys	100 EUR
Alumnium rack	Machinenbau Kitz	400 EUR
Misc. electronic parts	–	200 EUR
Total		13796 EUR

13 Lessons Learned

(To be written after the competition.)

References

1. Johannes Pellenz, Sabine Bauer, Tobias Hebel, Sebastian Spiekermann, Gerd Tillmann, and Dietrich Paulus. Verbesserte GPS-Positionsschätzung mit IP-transportierten Korrekturdaten für Autonome Systeme im Outdoor-Bereich. In *Autonome Mobile Systeme 2005*.