

A Mobile Robot Platform for Assistance and Entertainment

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ABSTRACT

A new generation of mobile robots has recently been designed based on the successful hardware and software architecture of Care-O-bot™ [2]. The robots have been created to communicate with and to entertain visitors in a museum. Their tasks include welcoming visitors, leading a guided tour in the museum, or playing with a ball.

Keywords: Mobile Robot, Museum Robots, Self Localization, Obstacle Avoidance, Communication

the laser scanner. Activating one of the safety sensors as well as pressing either of the emergency stop buttons results in an immediate stop. Besides software restricting the allowed operation area, a magnetic sensor facing towards the ground is used as a secondary system to prevent the robots from leaving their assigned area. This area is bounded by a magnetic band lowered in the ground.

Being equipped with several long lasting batteries the robots are able to move independently for up to ten hours without interruption.

HARDWARE PLATFORM



Fig. 1 Basic platform and "fully dressed" museum robot (© Museumsstiftung Post und Kommunikation)

Each vehicle is equipped with two driven wheels (differential drive) including shaft encoders for motion tracking. The robots are able to move at a speed of up to 1.2 m/s. Four castor wheels are further used for keeping the robots upright. A gyroscope is integrated in the robot platforms to track their current orientations. A 2D laser scanner is attached to the front of each robot. It is used for self localization, navigation, and obstacle detection.

Additional safety sensors are a bumper at the bottom of the robots and several infrared sensors which are integrated in the bumper facing upwards. These sensors are used to detect obstacles above the scanning level of

NAVIGATION SKILLS

The following navigation skills have been implemented and tested on the mobile robot platforms:

Self Localization

Self localization is based on data gained from the wheel encoders (position in x and y) and the gyroscope (robot orientation). However, small errors using these functions are unavoidable (e.g. 6 degrees of drift per hour for the gyroscope). Therefore the robot's surroundings are modeled in a map. By comparing segments found in the natural environment of the robot (e.g. walls, doors), laser scanner data can be matched to the given map and the robot can correct its position. Information acquired by this method is merged with odometric data using a Kalman filter.

Robot Motion

Two different types of robot motion planning can be distinguished:

Program controlled navigation: In order to easily specify motion plans for a mobile robot, the "Mobile Vehicle Command Language" (MVCL) has been developed. It allows to write operation programs as simple ASCII files. Operation programs provide the possibility to easily synchronize motion, multimedia and upper axis control commands.

Reactive navigation: In this mode, the current target position for a robot is constantly recalculated in reaction its environment. Selected objects of a given shape can be detected by the laser scanner. The robot then drives to a computed intercepting position.

Obstacle Avoidance

Two methods have been implemented in order to prevent the robots from running into obstacles. Both use the 2D laser scanner for detecting the distance to obstacles around a robot.

Collision detection: This safety function is used to avoid hitting persons or objects in the path of the robot. It directly influences the driving speed of the vehicle.

Getting closer to an obstacle the robot gradually reduces its speed until it comes to a complete stop.

Obstacle surrounding: This module uses scanner data not only in the path of the robot but at the maximum surroundings of 180 degrees around the vehicle. After having detected an obstacle on the way to its next target the robot tries to find an intermediate target position along a calculated safety circle around the obstacle [1].

CONTROL AND COMMUNICATION

Control software for the mobile robots is based on an object oriented Realtime Framework [4]. As part of this framework, multiple robots can be connected to a control computer by radio ethernet. This enables the robots to communicate data – like their current position – to all other robots using a CORBA interface. It is further possible to remote control the robots – also from far away using an ISDN line.

MUSEUM APPLICATION

In order to entertain visitors in the recently reopened “Museum für Kommunikation” in Berlin with a new technical attraction, throughout the last year, three mobile robots have been built and programmed at Fraunhofer IPA.



Fig. 2 Entertainment robots in the “Museum für Kommunikation”, Berlin
(© Museumsstiftung Post und Kommunikation)

Each robot has a specific character, expressed through its looks and appearance (driving speed, voice etc.). The robots also differ in what information they give to the museum visitors:

“The Inciting” acts as an entertainer. It approaches the visitors and welcomes them to the museum. Speech output is further underlined by movement of the robot’s head. “The Instructive” gives guided tours in the museum. Moving its head up and down symbolizes the robot looking at the object it is currently talking about. Explanations are further underlined by pictures or video sequences shown on the screen of the robot. “The Twiddling” is the child in our “robot family”. It is unable to speak properly and runs around the museum playing with a ball.

Apart from performing their standard tasks, the robots are capable to interact with each other as well as with the museum visitors. So if, for example, a robot gets close to one of the others, it will turn towards it to say hello. If “The Instructive” detects that its way is obstructed by visitors it will ask them to step aside.

The following required constraints could be guaranteed by our implementation:

- Elimination of any possible danger for the visitors
- Obstacle detection and avoidance
- Restriction to a given operation area
- Robust design for long operation
- Easy handling for inexperienced personnel

CONCLUSION AND OUTLOOK

Care-O-bot™ has been designed as a mobile home care system. Based on this platform a group of mobile entertainment robots has been created. However, the underlying technological concept is not limited to the given applications. Further functions could be:

- “Personal robot” in private homes (“robotic butler”), robot valet
- Mobil information desk in public areas (shopping malls etc.)
- Safety guard, night watchman
- Robot receptionist in office buildings

A new Care-O-bot™ platform will soon be build, including a manipulator arm to perform handling tasks.

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