Research group: Autonomous Mobile Robotics Group, University of Zagreb, Croatia
Head of group: Prof. Dr. Ivan Petrović

Contact Information

Postal address: University of Zagreb
Faculty of Electrical Engineering and Computing
Department of Control and Computer Engineering
Autonomous Mobile Robotics Group - AMOR Group
Croatia
Street address: Unska 3
10000 Zagreb

Tel.: +385 1 6129-844
Fax.: +385 1 6129-809

Email: ivan.petrovic@fer.hr
URL: http://act.rasip.fer.hr/groups_amor.php

Abstract:

AMOR Group research is focused on the development of a control system for mobile robots, which enables them to: (i) autonomously navigate in unknown and dynamic environments, (ii) interact with human beings providing them various services, and (iii) interact with distributed intelligent networked devices in the environment in order to extend the scope and reliability of provided services. In order to achieve appropriate level of robot competences in each of these areas, AMOR Group applies various methods from control theory and estimation, sensor fusion and artificial intelligence.

Detailed research information:

About the AMOR Group − AMOR Group is one of the leading robotic groups in Croatia. It currently consists of one Postdoc and five PhD students directed by prof. Ivan Petrović. AMOR Group possesses four fully equipped indoor mobile platforms Pioneer 3DX and an outdoor mobile platform Pioneer 3AT, a dozen of mobile mini robots, cameras, indoor and outdoor laser-range finders, etc. (see Figure 1).

Figure 1: AMOR Group - people and robots

The group coordinates the major national robotic research program "Intelligent robotic systems and autonomous vehicles" (2007-2011), which involves 5 major robotic research groups in Croatia. The main research objective of the group is development of a control system for mobile robots (Figure 2), which enables them to: (i) autonomously navigate in unknown and dynamic large-scale (indoor) environments, (ii) intuitively and effectively interact with human beings providing them various services, and (iii) interact with distributed intelligent networked devices in the environment (iSpace) in order to extend the scope and reliability of provided services. In order to achieve appropriate level of robot competences in each of these three areas, we have been applying various methods from control theory and estimation, sensor fusion and artificial intelligence. The major research achievements are briefly presented hereafter.

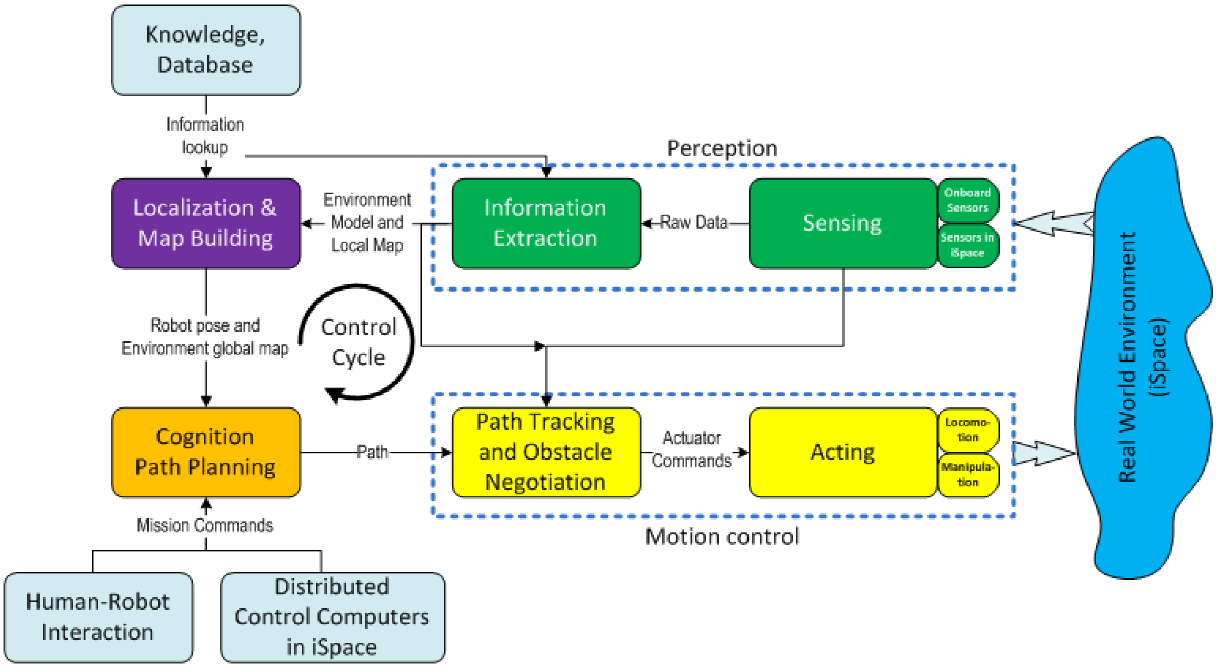

Figure 2 Mobile robot control system being developed by the AMOR Group

Autonomous Navigation in Unknown Environments − We have developed a complete solution for exploration and mapping of unknown arbitrary polygonal environments, which assumes a range sensor of finite angular resolution and thus provides sampled version of the visibility polygon instead of imposing further restrictions on the environment. The exploration strategy is proved to completely explore a finite unknown environment in finite time. We have been developing a Simultaneous Localization And Mapping (SLAM) solution based on a view-based representation of the environment and the current and key past robot poses estimation by using the Extended Information Filter (EIF). This ensures that SLAM information matrix has exactly sparse structure. The benefit of exact sparseness of the delayed-state framework is that the computation can be done in constant time without having to make any approximation. A new robust data association solution has also been developed.

Autonomous Navigation in Partially Known Dynamic Environments − In order to fully autonomously execute its mission the robot localization system must track its pose with respect to the environment map in real time, and motion controller must plan robot motion to the goal position. We have developed a multicriteria localization algorithm based on particle filter, which integrates particle filter sample set size adaptation mechanism and detection of the kidnapped robot situations. Such approach provides an effective way to detect kidnapped robot situations while sample set size is relatively small. We have also developed an automatic procedure for hierarchical decomposition of the environment map based on hierarchical graphs (H-Graphs), which reduces exponential complexity of path planning problems to linear ones. An example of modelling a building as an H-Graph of floor levels is shown in Figure 3. The path produced by the path-planning algorithm is a straight-line path with sharp turns and it is therefore hard to follow due to robot's kinematic and dynamic constraints. Our solution is to integrate path planning and dynamic window algorithm, which includes only those velocities that can be achieved in the next sampling time according to the dynamic constraints of the robot. Velocity vector is chosen from the allowed velocity space by maximizing a proposed objective measure. In order to ensure safe and smooth mobile robot motion in presence of moving obstacles we have developed a probabilistic algorithm for multiple moving objects tracking.

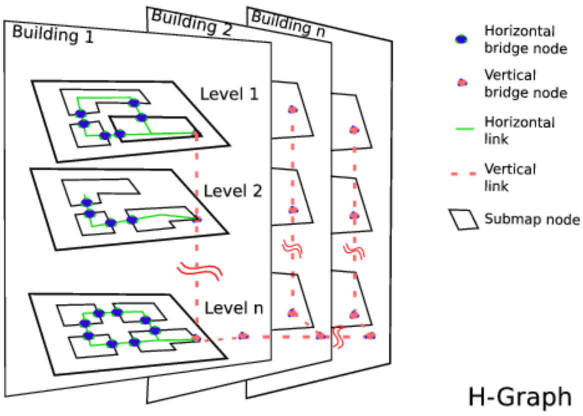

Figure 3 An example of hierarchical H-Graph model

Human-Robot Interaction − Our research efforts are oriented to the interaction of people with robots via a teleoperation system and via a multi-modal interaction system. The investigation of teleoperation control of mobile robots is oriented to realizing the visual feedback and the force feedback, so that the operator has the maximum feeling of presence in the remote location. In order to guarantee safe robot teleoperation in a dynamic environment we have developed a new obstacle avoidance algorithm based on the dynamic window approach. Multi-modal interaction system enables a mobile robot to determine which of the persons in its vicinity wants to interact with it in environments where many people are moving around. We have been working on the auditory system for mobile robots, which detects and tracks the sound source, but also can recognize who is speaking and establish a dialog with him/her. The sound source tracker is fused with the laser range tracker and with visual face and torso colour tracker.

Mobile Robot in Intelligent Space −Intelligent Space (iSpace) is an environment with distributed sensors (e.g. cameras, microphones, beacons, sonars) and actuators (e.g. mobile robots, manipulators), with the purpose of providing various advanced services to the space users (Figure 4). The sensors are used for the detection and tracking of objects and persons in the space and for receiving orders from space users, and the actuators are used for delivering of physical services to the users. We have developed a global vision system for real-time tracking of multiple mobile robots, which reliably tracks large (theoretically unlimited) number of robots under light intensity changes. We have also developed a pose-tracking algorithm that ensures accurate mobile robot localization based on active radiofrequency and ultrasound beacons and passive listeners, in order to support pervasive indoor location determination.

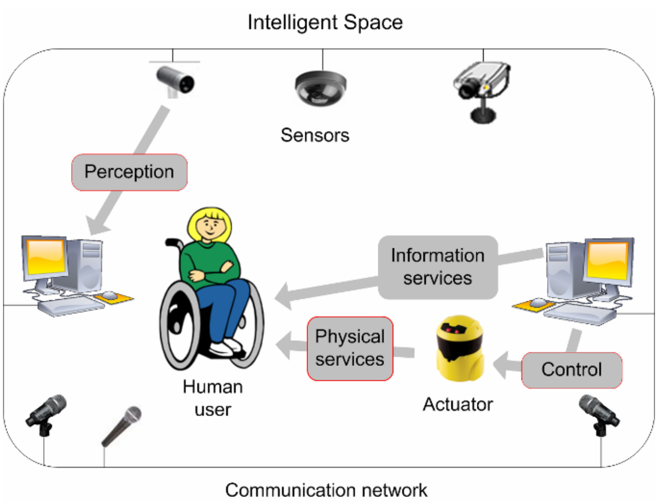

Figure 4 iSpace concept