# Towards a Higher Level of Human-Robot Interaction and Integration

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**Abstract**

Spartacus, our 2005 AAAI Mobile Robot Challenge entry, integrated planning and scheduling, sound source localization, tracking and separation, message reading, speech recognition and generation, and autonomous navigation capabilities onboard a custom-made interactive robot. Integration of such a high number of capabilities revealed interesting new issues such as coordinating audio/visual/graphical capabilities, monitoring the impacts of the capabilities in usage by the robot, and inferring the robot's intentions and goals. Our 2006 entry will be used to address these issues, add new capabilities to the robot and improving our software and computational architectures, with the objective of increasing the level, evaluating and improving our understanding of human-robot interaction and integration with an autonomous mobile platform.

## Challenges

Designing a mobile robot that must operate in public settings probably addresses the most complete set of issues related to autonomous and interactive mobile robots, with system integration playing a fundamental role at all levels. Reported issues are 1) the robust integration of different software packages and intelligent decision-making capabilities; 2) natural interaction modalities in open settings; 3) adaptation to environmental changes for localization; and 4) monitoring/reporting decisions made by the robot (Gockley *et al*. 2004; Smart *et al*. 2003; Maxwell *et al*. 2004; Simmons *et al*. 2003).

## Integration of Software and Hardware Components

Spartacus is the robotic platform we have designed for high-level interaction with people in real life settings (Michaud *et al*. 2005). This custom built robot is equipped with a SICK LMS200 laser range finder, a Sony SNC-RZ30N 25X pan-tilt-zoom color camera, a Crossbow IMU400CC inertial measurement unit, an array of eight microphones placed in the robot's body, a touch screen interface, an audio system, one on-board computer and two laptop computers. The robot is also equipped with a business card dispenser, which is part of the robot's interaction strategy.

We address the first issue with MARIE, our a middleware framework oriented towards developing and integrating new and existing software for robotic systems (Cote *et al*. 2006), and MBA, our motivated behavioral architecture using distributed modules for goal management (Michaud *et al*. 2005). The focus of our 2005 work on Spartacus was on these elements. Work on these software and computational architectures are on-going and continue to our foundation for designing Spartacus' intelligent capabilities. We have developed a new vision capability (recognition of electric outlets for recharging) integrated with CARMEN map localization package (Montemerlo, Roy, & Thrun 2003). We are also developing an interface to a dialogue manager using the CLSU toolkit[1].

## Human-Robot Interaction of an Autonomous Robot in Open Settings

Our 2006 objectives are to simultaneously address issues 2, 3 and 4 by doing the following:

- Spartacus will be designed to be a robot servant, with only one intrinsic goal of wanting to recharge when its energy is getting low (by either going to an outlet identified on the map or by searching for one, and then ask to be plugged in). All of its other goals are going to be provided by requests made by people, and Spartacus' duty will be to address these requests to the best of its capabilities and what is 'robotically' possible. Such requests may be to deliver a written or a vocal message to a specific location or to a specific person, to meet at a specific time and place, to schmooze, etc. The robot may receive multiple requests at different periods, and will have to manage on



[1] http://cslu.cse.ogi.edu/toolkit/

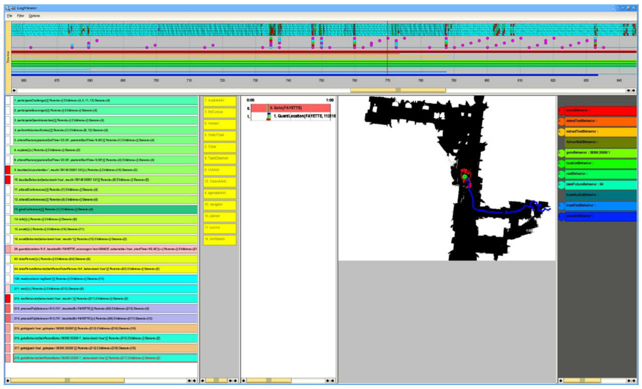

Figure 1: LogViewer: entire view.

its own what, when and how it will satisfy them, demonstrating the capabilities of our planning and scheduling motivational source. This plan will have to adapt to what the robot will experienced. Our solution consists of using a reactive Hierarchical Task Network planner (Beaudry *et al*. 2005) as one motivational module. Special features were added to the HTN-based planner to deal with specific constraints of having an autonomous robots operate in real life settings (e.g., on-line planning under flexible temporal constraints, tasks with priorities), and is combined with the path planning component to handle navigation tasks. These features mainly deal with plan generation, monitoring and execution in dynamic conditions, features that, when taken collectively, provides an original solution to mobile robot planning capabilities.

- We hope to demonstrate a fully integrated and working SLAM on Spartacus. With no other requests to fulfill, Spartacus will explore its environment.
- When the robot will be in operation, it will illustrate its decision-making processes involved. Our idea is to extend the capabilities of the LogViewer application (shown in Fig. 1 developed in 2005 to monitor off-line the complete set of states of the robot through log files created by the different software components. Our objective is to include an on-line version of the LogViewer to provide a dynamic and real-time view of what the robot is actually doing and planning to do. The idea is to have Spartacus display, on its graphical interface, contextual information according to its current plan (e.g., behavioral configuration, map, active task, processing load).

With these capabilities, we aim at facilitating understanding of the robot's state, characterize the effect of combining the use of multiple components (both from a system and from a human-robot interaction perspectives). It will allow us to supply different mission scenarios (such as the challenge or other usages of the robot), providing a flexible way to adapt to demonstration and experimental needs. Spartacus' vision, audition, localization and interaction capabilities will be better coordinated and it will use different means to communicate its intentions to people, helping it to be more effective in its tasks. Finally, data will be available on-line and off-line for analysis and evaluation of the robot's decisional capabilities.


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