A Proposed Approach to Semantic Integration between Robot and Agent Systems

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Abstract

We are exploring using techniques of semantic integration to enable the integration of teams of mobile robots into new domains.. This paper proposes an approach to semantic integration which relies on the persona structure first presented for allocating resources within distributed, heterogeneous teams of robots. The persona, a reflection of the internal state of the robot, can be mapped to different domains through the use of a domain adapter that performs a semantic mapping between the ontology of the robot and the ontology of the domain. In this context, the multi-robot system and each robot play some role in the external domain; identifying and mapping these roles will be a critical first step in solving the larger problem. This work will ultimately enable more rapid integration of teams of robots into varied domains.

We are investigating semantic integration and ontology mapping as applied to distributed robotics in new domains and systems. Multirobot systems are currently used in a wide variety of situations, from military applications to search and rescue to off-world exploration. Unfortunately, there is little semantic interoperability between domains – existing approaches to multirobot system design incorporate domain knowledge directly in the robot software and system designs (Marmelstein 2002; DiLeo, Jacobs, & DeLoach 2002). Adaptation to the information environment of a new domain will be important for the rapid deployment of robot systems, particularly for organizations such as CRASAR that respond to Urban Search and Rescue events with a variety of external organizations. For instance, this could allow robot systems designed for use with US search and rescue teams to be integrated into an agent-based multinational rescue operation of the sort described in (Tate *et al.* 2004; Pěchouček, Mařík, & Bárta 2002).

This paper proposes an approach to semantic integration which relies on the persona structure first presented for allocating resources within distributed, heterogeneous teams of robots in (Long 2004). A persona is the way to represent the roles, goals, capabilities and limitations of a robot or other situated agent to another agent, and is in essence an ontology representing the public information about the robot. The use of the persona provides several advantages for semantic integration. First, the persona is a known ontology and is most likely more limited in scope than the overall domain. Second, we are not looking for a total map, and can limit search to the structures known in the persona. And third, since current practice calls for a human operator at some level of interaction with a robot, we may allow human-assisted semantic mapping (Uschold & Gruninger 2004). The first two features may yield effective heuristics that will improve results for mapping to and from the persona, while last is particularly important as most approaches to semantic integration are at least partially manual (Kalfoglou & Schorlemmer 2003).

Previous work has introduced the persona within a single distributed system, but it is not enough to design a multirobot system in isolation; a complex robotic system will eventually play roles in the context of some external domain. Without some way to address semantic consistency between the robot and the domain, the utility of such systems are limited. We propose using domain adapters to address the translation; the adapter defines the mapping between ontology of the persona and the ontology of the domain. The persona contains all the public information about a robot, and any of this is available for mapping. However, not all domains will be interested in all information; in the context of the CoSAR-TS project (Tate *et al.* 2004), role and task information is key. Each task or role that a robot can perform in the system could be attached to a set of properties and behaviors that define how the role should be performed. Roles are often dynamic: a robot may assume multiple roles, may transition between roles, or may be restricted to certain roles as events dictate (Steimann 2000). But while roles and tasks are important for planning in the domain, other sensor data, such as readings from a laser rangefinder, would be irrelevant and thus may not need to be mapped. On the other hand, for a narrower domain such as USAR, a domain ontology such as that proposed in (Chatterjee & Matsuno 2004; Messina *et al.* 2005; Schlenoff 2005) may require mapping to the level of sensor data, particularly for a medical or environmental monitoring task.

The approach in this work is a specific instance of the field of semantic integration. Semantic integration is ultimately a search task, but implementation of ontology mappings can vary from completely manual, guided (as in PROMPT (Noy & Musen 2003)), heuristic or learning-based (such as GLUE (Doan *et al.* 2003)) or framework-based (Maedche *et al.* 2002). Discussion of these and other techniques can be found in (Kalfoglou & Schorlemmer 2003). We will inves-

tigate specific issues that are unique to this robotics and this concept of a persona: i) can we leverage the persona to improve semantic integration? ii) is there a common subset of the persona that is commonly mapped across domains? iii) is there a specific methodology or toolset that can enable rapid adaptation of a robot system to new domains? iv) can the concept of the persona and results of this work be extended from physically situated agents (such as robots) to situated agents (such as complex software agents or services)?

The proposed approach will be designed and tested with an implementation on a heterogeneous robot team using the DFRA as the underlying distributed architecture and KAoS for policy-based agent management, which can control various aspects of the agent system, from how agents can communicate to allowing, denying or obligating certain actions. The implementation will initially use an ontology developed for roles and tasks in a search and rescue scenario. Testing will initially use simulation to validate the concept, but will be grounded on a team of real robots (Gage 2004; Long 2004).

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