

Report on the 2004 AAAI Spring Symposia: Knowledge Representation and Ontologies for Autonomous Systems

Craig Schlenoff

This symposium was motivated by the desire to bring together experts in the autonomous systems, knowledge representation, ontology, and data fusion communities to explore leveraging existing knowledge technologies to benefit autonomous systems. The symposium was the first of its kind, and was attended by 36 participants, representing a cross section of the communities mentioned above.

Many researchers feel that an autonomous system must have an internal representation of entities, events, and situations that it perceived in the world in order for it to behave appropriately in uncertain environments. The term "autonomous systems" in this context refers to embodied intelligent systems that can operate for extended periods of time without human supervision. A major challenge for these systems is maintaining an accurate internal representation of pertinent information about the environment.

A large body of work exists in various knowledge representation, ontology, and data fusion areas, yet relatively little has been applied to real-time world modeling in autonomous systems. The primary goals of this symposium were threefold: 1) to educate the autonomous systems community as to the strengths and weaknesses of various knowledge representation approaches, 2) to educate the knowledge representation community as to the knowledge-related challenges being faced within the autonomous systems arena, 3) establish networks of teaming arrangements and possible collaborations to allow the communities to work closer together in the future. All three goals were accomplished to various level of success, with the second and the third goal resulting in a bit more success than the first.

The symposium started with an autonomous systems keynote presentation by Prof. Ernst Dickmanns (University of the Federal Armed Forces of Germany, Munich) who described the state of the art in autonomous vehicle research and development, focusing on efforts over the past 25 years at his university. This was followed by six paper presentations that were grouped into the tracks "Knowledge Representation Perspectives and Integration Issues" and "Knowledge Representation for Autonomous Mobility". Following the paper presentations was a poster session.

On the second day, Dr. Michael Genesereth (Stanford University) gave the knowledge representation keynote presentation entitled "World Models for Autonomous Systems" in which he described his thoughts on what types of knowledge representations appeared to provide the most value to autonomous systems. This was followed by four paper presentations in the track "Applying Ontologies to Autonomous Systems".

Some questions seemed to be common following many of the presentations. They were: "How does one know what knowledge should be embedded in an external knowledge base vs. in the code itself?", "How does one know which representations are good for what types of requirements?", and "What is an ontology how is it different than the knowledge representation techniques we have used in the past?". The answers to the first two questions varied from presenter to presenter, showing that there is no clear-cut answer and more research needs to be performed. To address the third question, Michael Uschold from Boeing gave a brief, impromptu presentation at the start of the day describing a common view of what an ontology is and how it is intended to be used.

After the presentations, the audience was split into three predefined, cross-disciplinary breakout groups, each tasked with addressing a challenge problem. Their job was to determine a "knowledge architecture" for a group of five trash removal robots that were responsible for cleaning an airport. The robots had to coordinate with each other, provide complete trash-removal coverage of the airport multiple times each day, monitor their health, travel within marked lanes whenever possible, recycle, identify suspicious packages, and stay a predefined distance from humans at all times. Within the "knowledge architecture," the groups had to define the types of knowledge necessary for the robots to perform their tasks, identify the types of representations that lent themselves best to representing that type of information, and develop the interfaces between the knowledge sources and the algorithms that were controlling the robots.

On the third day, the moderators of the breakout groups reported back on their groups' findings. Each group tackled a different aspect of the problem, often employing different approaches to do so, thus providing insight that there is no "magic bullet" in knowledge representations, and that different techniques offer different advantages and disadvantages. Allowing the participants to "get their hands dirty" by addressing the challenge problem also confirmed the belief that knowledge representation for autonomous systems is a tough problem, and should receive more attention from the community.

This was followed by a panel discussion made up of participants from industry and academia, and represented all of the communities present at the symposium. The panel was tasked with highlighting the main issues and challenges that came out of the symposium, as well as determining the best way for these communities to work together in the future. Issues that arose from the panel included the need for an upper ontology, the challenge of integrating disparate terminology and semantics from different disciplines, and the need for a knowledge representation formalism to capture the autonomous systems' competencies. There was also widespread agreement that the symposium was valuable and that similar ones should be held in the future.