The AAAI-2002 Mobile Robot Competition and Exhibition

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■ The Eleventh Annual AAAI Robot Competition and Exhibition was held at the National Conference on Artificial Intelligence in Edmonton, Alberta, Canada, in August 2002. This article describes each of the events that were held: Robot Challenge, Robot Exhibition, Robot Host, and Robot Rescue.

It is not unusual for the registration area at an academic conference to include several desks. Usually those attendees with names beginning A–L are encouraged to line up behind one desk, and M–Z line up behind another. However, the 2002 National Conference on Artificial Intelligence included another desk: Robots! Some robots at the 2002 American Association for Artificial Intelligence (AAAI) Mobile Robot Competition and Exhibition actually registered for the conference on their own.

The AAAI Mobile Robot Competition and Exhibition is held each year in conjunction with the National Conference on Artificial Intelligence. This summer marked the eleventh annual competition and exhibition, making it the oldest AI-centric mobile robot competition. The event included three competitions and a mobile robot exhibition. The competitive events included the Robot Challenge, in which robots are to emulate a human attending the conference; Robot Rescue, in which robots find simulated disaster victims in a damaged building; and Robot Host, in which robots serve food to human guests and act as mobile information kiosks.

Over the last decade, the competitions and exhibitions have witnessed numerous AI robotics firsts, including the first demonstration of robotic soccer (Sahota 1994), the first multirobot competition teams (Balch et al. 1995), and early practical demonstrations of important vision and localization algorithms (Buhmann et al. 1995; Dudek 1998). This year marked another group of firsts: For the first time robots attempted the entire "Grand Challenge," where a robot emulates a person attending and speaking at the National Conference on Artificial Intelligence.[1] This year was also the first time a team scored well enough to place in the rigorously judged Robot Rescue event as well as the first time a team from outside North America took first place in any of the events (YSC, an Iranian team, took top honors in the Rescue event). The results of the competitions are given in figure 1, and group photographs of all the robots at the event are shown in figures 2 and 3.

In 2002, the event was organized by Holly Yanco of the University of Massachusetts at Lowell and Tucker Balch of the Georgia Institute of Technology. The Robot Challenge was organized by Ben Kuipers of the University of Texas at Austin and Ashley Stroupe of Carnegie Mellon University (CMU). The Robot Exhibition was run by Ian Horswill and Christopher Dac Le, both of Northwestern University. Robot Host was cochaired by David Gustafson of Kansas State University and Francois Michaud of Universite de Sherbrooke. Robot Rescue was run by Jenn Casper, Mark Micire, and Robin Murphy, all of the University of South Florida.

Robot Rescue

In its third year at the AAAI Robot Competition, Robot Rescue saw the number of competitors double over last year, with participants coming from three countries and from universities, government laboratories, and even a high school. The event simulates a search and rescue situation, using rules developed by a joint committee from the AAAI and RoboCup communities. An arena designed by

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Robot Challenge

- *Judge's Award for Autonomous Localization and Mapping:* Massachusetts Institute of Technology
- *Judge's Award for Human-Computer Interaction:* GRACE
- *Judge's Award for Mixed Local Autonomy and Supervisory Control:* iROBOT
- *Judge's Award for Robustness in Recovery from Action and Localization Errors:* GRACE

Robot Host

- *First Place:* University of Rochester
- *Second Place:* Kansas State University
- *Third Place:* Swarthmore College

Robot Rescue

- *First Place:* YSC, Iran
- *Second Place:* Swarthmore College
- *Third Place:* Georgia Institute of Technology
- *Technical Award for Interface Design:* Idaho National Engineering and Environmental Laboratory
- *Technical Award for Mapping:* Georgia Institute of Technology
- *Technical Award for Platform Design:* YSC, Iran

Ben Wegbreit Award for Integration of AI Technologies

- GRACE: Carnegie Mellon University, Metrica, Naval Research Laboratory, Northwestern University, and Swarthmore College

Figure 1. Awards Given in the 2002 AAAI Robot Competition.

the National Institute for Standards and Technology (NIST) is used as the playing field (Jacoff et al. 2001).

The scoring of the competition is designed to encourage competitors to run more than one robot to cover more area and find more victims. For one operator to be able to control multiple robots simultaneously, the robot systems must have some level of autonomy because it is not possible to teleoperate multiple robots at the same time. Although several teams incorporated a significant amount of AI, we still saw a team of two teleoperated robots take the top award in the competition. Their win came in part because of their ability to find victims in the most difficult portions of the arena, resulting in greater scores for these victims. They received the scoring award for having multiple robots, although the robots were controlled serially, because the current scoring system does not differentiate between multiple robots run serially or concurrently.

Because the event is happening at the National Conference on Artificial Intelligence, how can we encourage all participants to incorporate AI into their entries? The rules committee is discussing ways to change the event so that some level of autonomy will result in better scores. One possibility is to enforce some period of radio silence, where fully teleoperated robots will just die in place until communication is resumed.

A formal study of the human-robot interaction between the operator and the robots was undertaken by researchers at NIST, the MITRE Corporation, and the University of Massachusetts at Lowell. The study was designed to determine how operators responded to critical events (for example, hitting a wall or running over a victim's hand), if at all. In addition to studying the interactions of the competitors, a fire chief also tested some of the systems. As would be expected, the operator's performance depends on his/her awareness of the robot's situation. However, the study found that awareness is not always increased with the use of additional sensors. If the sensor information is not fused to provide decision support for the operator, the operator must perform sensor fusion in his/her head, which requires more time. For complete results of the study, see Yanco, Drury, and Scholtz (2002).

Results of the competition are given in figure 1. For more on the Robot Rescue event, see "AAAI-2002 Robot Rescue" by Jennifer L. Casper and Mark J. Micire elsewhere in this issue of *AI Magazine*.

Robot Host

The Robot Host event, in its sixth year, saw changes to its design. Although serving food to reception attendees was still part of the competition, a new task was added: The robots were to act as mobile information kiosks for conference attendees, operating in front of the large lecture hall during two of the scheduled breaks. Both events were held in an unmodified, conference hall environment, unlike the penned robots of the early years of the competition.

This event continues to stress human-robot interaction and often shows how unpre-

Figure 2. The Robots of the 2002 AAAI Robot Competition and Exhibition.

dictable this interaction can be in the real world. Most human-robot interaction in applications such as space exploration and hazardous material cleanup only takes place after a great deal of training of the operators. However, robots deployed in a host capacity cannot require users to be trained on the systems, requiring an intuitive and adaptable interface. All competitors in the event designed systems that used natural language as the interface.

Results of the competition are shown in figure 1. For more on the Robot Host event, see David Gustafson's and François Michaud's article "The Host Robot Competition at the AAAI-2002 Mobile Robot Competition" elsewhere in this issue of *AI Magazine*.

Robot Challenge

The Robot Challenge was established in 2000 to "set the bar" for robotics research at a challenging and inspiring level. The task for robots entering the challenge is to attend the National Conference on Artificial Intelligence and give a presentation about themselves. Unlike the other competition events, entrants are not scored or ranked in the Robot Challenge. Instead, the robots are evaluated, and special awards are given to those researchers who demonstrate especially innovative research on their robots.

This year, the task for the robots was to find their way from the entrance of the conference center to the registration desk, register, navigate to a special location set up for them, and give a talk about themselves. The robots encountered several significant obstacles along the way, including an elevator from the entrance level and a line of people at the registration desk (as well as numerous members of the media and conference attendees blocking the way).

It was expected at the time the event was designed that it would take many years, perhaps a decade, before robots would be able to complete a significant portion of the challenge. In past years, researchers attempted subcompo-

Figure 3. The Robots of the 2002 AAAI Robot Competition and Exhibition.

nents of the overall task. However, this year, two rather ambitious entries attempted the entire challenge: CoWorker from iRobot and GRACE (graduate robot attending conference), developed by a consortium of universities and research institutions. The event also hosted ERIK, a robot from the Massachusetts Institute of Technology (MIT), which focused on the mapping and navigation challenges of the event.

iRobot's CoWorker robot is designed to provide robust performance by integrating autonomous capabilities with the facility to consult a human operator in the event of a problem. iRobot describes the CoWorker robot as an internet-controlled, wireless, mobile, remote telepresence platform. CoWorker can be accessed from any web browser with a high-speed connection. The user-friendly interface provides control over where CoWorker goes, what it sees, and what it hears and provides an interface for speaking. There is even a laser pointer so that the user can highlight what he/she is referring to at the robot's location. The platform was designed with many available ports (for example, power, serial, PCMCIA) for incorporation of additional hardware, including sensors and additional cameras. iRobot programmed CoWorker with several autonomous capabilities, including autonomous navigation, for the Robot Challenge. CoWorker breezed through the challenge without encountering any significant problems. CoWorker did not attempt to give a presentation about itself, however. Its handler, Jim Allard, presented details about CoWorker's integrated autonomous and human control technology.

GRACE is a multiinstitutional, cooperative effort including researchers from CMU, Metrica, the Naval Research Laboratory (NRL), Northwestern University, and Swarthmore College.

The GRACE team's goal this year was to integrate software from the various institutions onto a common hardware platform and attempt to do the complete AAAI Robot Challenge task autonomously, from beginning to end. They focused on multimodal human-robot interaction (speech and gesture), human-robot social interaction, task-level control in the face of a dynamic and uncertain environment, map-based navigation, and vision-based interaction. Considering their ambitious goal, the GRACE team was rather successful.

GRACE navigated autonomously all the way from the conference hall's entry, down the elevator, to the registration desk. Along the way, GRACE rather politely solicited advice and directions from other conference attendees. It successfully entered the registration line but cut into the middle of the line and pushed a judge (standing in line) out of the way. GRACE hit another snag when it reached the front of the line. The worker at the desk provided it with a badge and registration materials in one of the ubiquitous AAAI handbags. However, GRACE was not content; it repeatedly insisted on being provided a AAAI handbag even though it already had one. It seemed, perhaps, that a loop was somehow created in its knowledge base. Fortunately, the difficulty was overcome with some assistance from its handlers. GRACE proceeded to the presentation area and gave an informative talk about its constituant technologies.

According to MIT, ERIK the robot is focused on the problem of concurrent mapping and localization (CML) for autonomous mobile robots. The problem of CML is stated as follows: Starting from an initial position, a mobile robot travels through a sequence of positions and obtains a set of sensor measurements at each position. The goal is for the mobile robot to process the sensor data to produce an estimate of its position while it builds a map of the environment. ERIK did not attempt the entire Challenge task but did demonstrate autonomous mapping and navigation.

Benjamin Kuipers's and Ashley Stoupe's "The AAAI-2002 Robot Challenge" article (elsewhere in this issue of *AI Magazine)* provides more information about the Robot Challenge.

Robot Exhibition

The Robot Exhibition provides researchers with a forum to present current research that does not fit within any of the competition tasks. This year's exhibition had a dozen robot demonstrations, ranging from reconfigurable robots to a play performed by robots. The exhibition features live demonstrations, both scheduled and ongoing. For descriptions of all the exhibitors, see Ian Horswill's article "The AAAI-2002 Robot Challenge" elsewhere in this issue of *AI Magazine*.

Conclusions

This year, as in past years, the AAAI Mobile Robot Competition and Exhibition played an important role in providing a venue for promoting AI robotics research. The event and the competitors were afforded coverage in national and international news media, including NPR, the CBC, and the *New York Times*.

In spite of having hit a few snags, the GRACE team was considered by most as having significantly advanced a critically important, but neglected, research agenda: integrating robotics technologies. It is remarkable that such a large group from so many institutions was able to integrate their technologies in so short a time. The team was awarded the Ben Wegbreit Award for Integration of AI Technologies.

Next year, the Mobile Robot Competition and Exhibition will be held in Acapulco, Mexico! We invite all interested robotics researchers to register and attend. We also wish next year's chairs, Bruce Maxwell of Swarthmore College and Bill Smart of Washington University, the best.

Acknowledgments

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Note

1. In previous years, some robots attempted some components of the Challenge, but this was the first time that robots attempted the entire challenge at once.

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Tucker Balch is an assistant professor of computing at the Georgia Institute of Technology and an adjunct research scientist at Carnegie Mellon University's Robotics Institute. Balch has participated in the AAAI Mobile Robot Competition and Exhibition since 1993. His robots took first place in 1994 and 1997, he organized the robot exhibition in 1998, and he cochaired the overall competition in 2001 and 2002. Balch has published over 60 journal and conference papers in AI and robotics. His book, *Robot Teams* (A. K. Peters) (edited with Lynne Parker), appeared in 2002. His e-mail address is tucker@cc.gatech.edu.