

The 2000 AAAI Mobile Robot Competition and Exhibition

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■ The events of the Ninth AAAI Robot Competition and Exhibition, held 30 July to 3 August 2000, included the popular Hors d'Oeuvres Anyone? and Challenge events as well as a new event, Urban Search and Rescue. Here, I describe these events as well as the exhibition and the concluding workshop.

A popular attraction at the 2000 AAAI National Conference on Artificial Intelligence was the Ninth AAAI Robot Competition and Exhibition, held 30 July to 3 August 2000 in Austin, Texas. This year's event brought six contest teams and nine exhibition teams from the United States and Canada.

The Robot Contest and Exhibition brings together teams from universities and other laboratories to compete and demonstrate state-of-the-art research in robotics and AI (figure 1).

The contest and exhibit have several goals: (1) encourage students to enter robotics and AI fields at both the undergraduate and graduate levels, (2) increase awareness of the field, and (3) foster the sharing of research ideas and technology.

The competition and exhibition is actually made up of multiple events: several contests, a challenge event, an exhibit, and a final workshop for all participants. Descriptions of previous years events can be found in Dean and Bonasso (1993); Konolige (1994); Simmons (1995); Hinkle, Kortenkamp and Miller (1996); Kortenkamp, Nourbakhsh, and Hinkle (1997); Arkin (1998); and Meeden et al. (2000).

The Competition: Something Old, Something New

The competition this year consisted of two events: Hors d'Oeuvres, Anyone? and a new event, Urban Search and Rescue.

Hors d'Oeuvres, Anyone?

The objective of the Hors d'Oeuvres, Anyone? contest is to create service robots that can offer hors d'oeuvres to attendees at the reception. The event stresses human-robot interaction, as well as mobility, and each contestant is required to explicitly and unambiguously demonstrate interaction with the spectators.

The fourth year for this popular event, the robots are judged while they serve finger foods to attendees at the AI Festival. Unlike other contests over the years, there were no artificial walls or constraints in this event—the robots had to interact with regular conference participants, and no attempt was made to limit the number of people interacting with each robot. Robots were judged on the quality of their interactions, coverage, and ability to refill their trays (such as detecting when they needed a refill and navigating to a refill station).

First place in this event went to Swarthmore College, which received an AMIGOBOT from ActivMedia. An article by the winning team, which better describes their approach and robot, can be found in this issue of *AI Magazine*. Second place was awarded to the University of Arkansas, which received a MAGELLAN robot from Real World Interface (RWI).

Urban Search and Rescue

In January 2000, a suggestion was made to introduce a new contest, Urban Search and Rescue (USAR). There has been a growing interest in this humanitarian task, a task whose complexities require much greater integration of AI techniques, such as mobility in three dimensions, the ability for the robot platform to change shape, adjustable autonomy, robot-human interaction, sensor fusion, and accu-



Figure 1. Participants at the Award Ceremony (courtesy of William Adams).

rate map building and localization (Blitch, Sidki, and Durkin 2000; Blitch 1996).

Being late in the year, I was uncertain how many teams might be attracted to the contest, but I felt that even with a small turnout, this event could be used to introduce the task to the AI community. Although a few teams came with very different approaches, the event drew attention and brought forward many teams that say they will compete in 2001.

The USAR arena (figure 2) consisted of three sections, which differed in physical complexity from the easiest section, with a flat-world assumption, to the hardest area, which included small spaces, nonflat and unstable surfaces, and debris. Figures 3 to 5 show robots from the University of South Florida (USF) in the two more difficult sections of the arena.

One of the most difficult aspects of this event was to generate metrics to be used in judging the event. As in recent years, judging was based on combining internal, quantitative metrics with more qualitative Olympic-style scoring. Judges were given specific metrics to use in determining a score from 1 to 10 for each team.

First place and a MAGELLAN robot from RWI were awarded to Swarthmore College. The University of Arkansas received second place and an AMIGOBOT from ActivMedia.

The Challenge: Can My Robot Attend the Conference?

The Challenge event requires robots to be dropped off at the conference, find their way to the registration desk, register for the conference, attend a session, and present a paper—that is, to be a AAAI conference attendee! As in previous years, teams were allowed to demonstrate only parts or abstractions of the overall task.

Awards

This year, two teams participated in the Mobile Robot Challenge: (1) LABORUS, developed by Francois Michaud, Dominic Litourneau, and Jonathan Audet at the Universite de Sherbrooke, Canada; and (2) CEREBUS, developed by Ian Horswill at Northwestern University. The developers of LABORUS focused on enabling their robot to understand and follow “human-readable” visual cues, but CEREBUS was programmed to understand and respond appropriately to natural language input.

As a multiyear challenge, we expect teams to build on previous success and make incremental additions to the completion of this task.

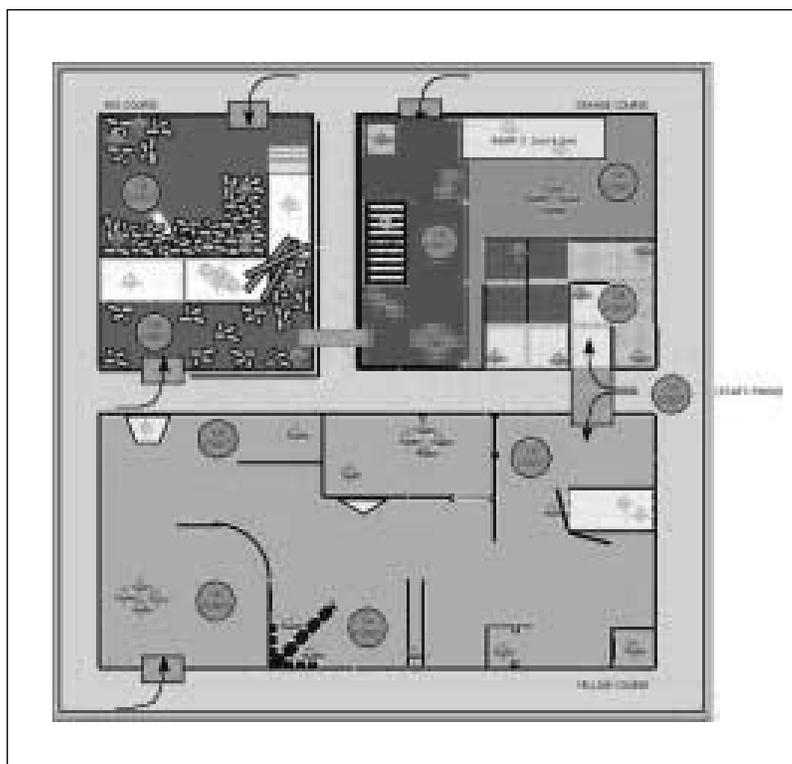


Figure 2. Diagram of Urban-Search-and-Rescue Arena.

Therefore, this event does not judge for place awards, only for technical achievement and integration awards.

The Exhibit

The exhibition included groups that wanted to demonstrate work outside the robot competitions. Participants of the exhibition included University of Oklahoma, University of Minnesota, Georgia Institute of Technology, Utah State University, University of South Florida, ActivMedia, and K-Team. This year's exhibition entries represented research in vision and machine learning as well as mobility for autonomous agents.

A USAR demonstration by USF was a highlight of this year's exhibition. Using two very different robots in the USAR arena's more difficult sections, USF demonstrated sensor fusion in a mixed-initiative system. The robot autonomously fused sensor readings to alert operators of potential victims, while human operators handled the vehicle mobility.

Certificates, as well as small research robots, were awarded for the first- and second-place teams in the two contest events, as mentioned earlier.

In addition, two awards (which included



Figure 3. University of South Florida Robot Descending Steps in the Medium-Difficulty Section of the Urban-Search-and-Rescue Arena (courtesy of William Adams).

research robots and certificates) were given for outstanding efforts to integrate AI technology. The Nils Nilsson Award for Integration of AI Technologies was awarded to USF; this award included an AMIGOBOT robot from ActivMedia. Swarthmore College received the Ben Wegbrait Award for Integration of AI Technologies, which included a MAGELLAN robot from RWI.

When a team demonstrates a particularly good approach or technique, judges may, at their discretion, present a team with a technical innovation award. This year, USF was awarded a Technical Innovation Award for its use of emotional states in action planning.

The Robot Workshop

Traditionally, the workshop for the robot competition is held the last day of the conference, after the robot competition events and exhibitions have concluded. Thus, participants can

discuss their actual entries in the robot events and talk about the results and lessons learned.

Students and faculty from almost all the teams presented research related to contest and exhibition events. Topics included architectural issues such as integration of high-level cognition and low-level behaviors, implementation of arbitrators for subsumption-like architectures, innovative vision approaches for face tracking and recognition, and human detection using fused sensor data. Human-robot interaction issues and interface implementations were discussed as well.

Even though participants focused on the research and work done prior to the competition and exhibition, they also discussed the performance of the systems during the contest—instances of both failure and success were heard. The future direction of each team's research was briefly mentioned as well. At the conclusion of the workshop, participants discussed various future improvements to the



Figure 4. University of South Florida Robot in the Most Difficult Section of the Urban-Search-and-Rescue Arena (courtesy of William Adams).



Figure 5. ATRV Robot in Difficult Section of the Urban-Search-and-Rescue Arena (courtesy of William Adams).

Mobile Robot Competition and Exhibition. This workshop gave the participants an opportunity to share their research with fellow researchers and get valuable feedback for future work. Each of the participants was invited to submit a paper to be published in fall 2000 in the workshop proceedings.

Acknowledgments

The AAI Robot Competition would not be possible without generous support from the Defense Advanced Research Projects Agency, the American Association for Artificial Intelligence (AAAI), and the Naval Research Laboratory. The USAR arena was constructed by the National Institute of Standards and Technology. I would also like to express appreciation for personal contributions from Nils Nilsson and Ben Wegbreit. In addition, several robot companies contributed robots that were used as awards. Thanks to ActivMedia, Real World Interface, and K-Team for their contributions.

The judges for these events were Harold Forbes, Ken Forbes, Sven Koenig, David Kortenkamp, Ben Kuipers, Dennis Perzanowski, Paul Rybski, Reid Simmons, and Ben Wegbreit, who took time from attending technical sessions to volunteer their time.

Most importantly, we want to thank the teams that participated in these events: University of Arkansas, Kansas State University, Northwestern University, Universite de Sherbrooke, USF, and Swarthmore College. Without them, these events would not exist!

Putting together these events is a lot of work, and I would like to personally thank the organizers—Lisa Meeden, Tucker Balch, Marc Bohlen, and Vandi Verma—for their time and effort. Thank you also to the various volunteers provided by AAAI.

Finally, I would like to thank Lt. Col. John Blicht for suggesting USAR as an important task area for AI.

References

- Arkin, R. 1998. The 1997 AAAI Mobile Robot Competition and Exhibition. *AI Magazine* 19(3):13–17.
- Blicht, J. G. 1996. Artificial Intelligence Technologies for Robot-Assisted Urban Search and Rescue. *Expert Systems with Applications* 11(2): 109–124.
- Blicht, J. G.; Sidki, N.; and Durkin, T. 2000. Tactical Mobile Robots for Urban Search and Rescue. In Proceedings of the Unmanned Ground Vehicle Technology II, 201–211. Bellingham, Wash.: SPIE.
- Dean, T., and Bonasso, R. P. 1993. 1992 AAAI Robot Exhibition and Competition. *AI Magazine* 14(1): 49–57.
- Hinkle, D.; Kortenkamp, D.; and Miller, D. 1996. The 1995 Robot Competition and Exhibition. *AI Magazine* 17(1): 31–45.

Konolige, K. 1994. Designing the 1993 Robot Competition. *AI Magazine* 15(1): 57–62.

Kortenkamp, D.; Nourbakhsh, I.; and Hinkle, D. 1997. The 1996 AAAI Mobile Robot Competition and Exhibition. *AI Magazine* 18(1): 25–31.

Meeden, L.; Schultz, A. C.; Balch, T.; Bhargava, R.; Haigh, K.; Bohlen, M.; Stein, C.; and Miller, D. 2000. The AAAI 1999 Mobile Robot Competitions and Exhibitions. *AI Magazine* 21(3): 69–78.

Simmons, R. 1995. The 1994 AAAI Robot Competition and Exhibition. *AI Magazine* 16(2): 19–30.



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