

The AAAI 2008 Robotics and Creativity Workshop

*Youngmoo E. Kim, Paul Oh,
and Odest Chadwicke Jenkins*

- *The AAAI 2008 Robotics and Creativity Workshop was held in Chicago on July 14, 2008, and was immediately followed by the three-day Robotics Exhibition. In 2008, the AAAI Robotics organizers eschewed the previous format of a Robot Competition, choosing instead to focus on groundbreaking work representing two areas of robotics: creativity and mobility and manipulation (detailed in a separate article). Both workshops were held on July 14, and the Robotics Exhibition included participants from both categories. The Robotics and Creativity Workshop was made possible through the support of the National Science Foundation's CreativeIT program and Microsoft Research.*

Robotics and creativity may appear to some to be a contradiction in terms. Developments in mechanical control and complex motion planning have enabled robots to become almost commonplace in situations requiring precise but menial, tedious, and repetitive tasks. Recent robotics research has targeted the mechanical and computational challenges inherent in performing a much broader range of tasks autonomously. These problems are less well-defined, requiring greater intelligence, commonsense reasoning, and oftentimes novel solutions. By most definitions, creativity (the generation of novel and useful ideas) is necessary for intelligence; thus research efforts focusing on robotics and creativity are also efforts toward artificial intelligence. As robots and computer physical systems become more capable, they are increasingly useful in the study of creativity itself.

Furthermore, machines have the capacity to expand the human creative palette, and robots have been embraced by many in the arts community for the development and execution of new creative works. Robots have been incorporated into live performances, some with capabilities that exceed the limitations of most human performers (such as the speed of playing a musical instrument). Robots could potentially be creativity-enhancing tools for artists and performers, for example, serving as proxies for human performers in rehearsals to prototype and refine artistic ideas. Robotics could also be invaluable as a platform for studying human creativity through controlled, repeatable experiments. As a physical, numerically controlled platform, a robot can be asked to perform actions precisely and repeatedly, whereas a human performer can not. Furthermore, by recreating components of a human-generated performance exactly, we could examine aspects of creativity: When is an action perceived as being a mere



Figure 1. A Group of Students, Instructors, and Alumni from the Illinois Mathematics and Science Academy (IMSA) Visiting the Robotics Exhibition.

repetition versus something creative?

The AAAI 2008 Robotics and Creativity Workshop was organized to highlight work relevant to this multidisciplinary field, to bring together researchers focusing on this area, and to discuss challenges and opportunities for future work. The workshop sessions began with invited talks from several distinguished speakers noted for their recent work incorporating aspects of robotics and creativity. These were followed by spotlight presentations from the other invited workshop participants. The session concluded with a general group discussion of the challenges and opportunities linking research in robotics and creativity. The Robotics Exhibition was open over the next three days, and hundreds of visitors from the general AAAI conference were able to observe and interact with the robots and exhibits brought to the event (figure 1).

Workshop Invited Presentations

The workshop program began with 30-minute invited talks by distinguished speakers on topics holding particular relevance for research in robotics and creativity. The first presentation was given by Amy Baylor, program director at the National Science Foundation (NSF) in the Directorate of Computer

and Information Science and Engineering (CISE). This presentation focused on the NSF CreativeIT program, initiated in 2007 and continuing in 2008, which also supports the work of several workshop participants. Dr. Baylor outlined the research areas targeted by the program: understanding of creative cognition and computation, creativity to stimulate breakthroughs in science and engineering, educational approaches that encourage creativity, and support for creativity with information technology. She also reviewed a list of recent awardees, highlighting those with particular connections to robotics and AI research.

Ruzena Bajcsy, a professor of electrical engineering and computer science at the University of California, Berkeley, and former director of the Center for Information Technology Research in the Interest of Society (CITRIS), gave the second invited talk, along with her collaborator Lisa Wymore (assistant professor of dance at University of California, Berkeley). The presentation, titled “Digital Choreography—The Road to IT Creativity,” highlighted their recent work (in collaboration with Klara Nahrstedt and Renata Sheppard from the University of Illinois, Urbana-Champaign) investigating distance collaboration for dancers. This involves a full three-dimensional visual capture of the col-

laborators at each endpoint using a multiple-camera setup and volumetric reconstruction for remote display (also incorporating compression and appropriate network architectures for high-efficiency transmission). Bajcsy elaborated on her proposed model of creativity as well as the difficulties in integrating notation systems used by creators (such as Laban notation for choreography) with collected visual data, a theme that reappeared in the workshop discussions.

The third invited talk was given by Stellan Ohlsson, a professor of psychology and computer science at the University of Illinois at Chicago. In his presentation, Ohlsson laid out principles for a quantitative model of creative insight (the process through which a new idea or solution becomes evident). His work focuses on the collaboration of multiple agents enabling an information-processing system to produce novelty when single ones are unable to do so. In his presentation, Ohlsson argued that no unique or separate “creative process” switches in at the moment of insight, but instead the creative insight is a side effect of “regular” processing. Using a set of basic rules, he is able to model the emergence of a novel idea in consciousness as a straightforward threshold phenomenon.

Gil Weinberg, an assistant professor of music and director of music technology at Georgia Tech, gave the final invited presentation at the workshop detailing his widely reported work on a robotic musician, Haile, who plays the powwow drums (a native American instrument). Weinberg presented a wide range of video clips demonstrating Haile in practice sessions, collaborating with and learning patterns from a human musician, and also in performance, playing virtuoso rhythms in a percussion ensemble. He also presented preliminary work on a new musical robot that will be able to play a pitched percussion instrument, such as a marimba or xylophone. A video presentation of Haile was also on display during the robotics exhibition, and for his work Weinberg was awarded first prize by the AAAI Robotics awards committee (prizes were sponsored by Robotis Corporation).

Robotics and Creativity Exhibits

The workshop continued with spotlight presentations, in which each of the invited exhibitors was given a few minutes to briefly introduce the exhibits. The exhibits are described in greater detail later on in this article.

Marek Michalowski, a graduate student at Carnegie-Mellon University (CMU) supervised by Reid Simmons (CMU), presented Keepon (figure 2), a robotic character developed in collaboration with Hideki Kozima (Miyagi University). Already somewhat of an Internet celebrity (Keepon's videos on YouTube have become quite popular), Keepon was created for research on social development. In particular, the robot has been used to investigate the social interaction of children with robots, hence its appealing, cartoonlike design, and in research for treating autism (Keepon's movements motivate rhythmic play). Michalowski demonstrated a video game incorporating Keepon that was controlled using a Nintendo Wii Fit controller to virtually "bounce" falling objects off of Keepon's head as it moved from side to side.

Jeff Lieberman, a graduate student at the Massachusetts Institute of Technology Media Lab in Cynthia Breazeal's Personal Robots research group, is one of the designers of Absolut Quartet, a large robotic interactive music installation on display to the public in New York in the spring of 2008 (it will also be on display at the Ars Electronica Museum in Linz, Austria, starting in January 2009). Absolut Quartet allows local and remote audiences to participate in each performance: each visitor enters a 5-second theme, and the machine generates, in real-time, a unique musical piece based on the input melody provided. The piece is rendered by three robotic instruments: (1) a ballistic marimba, which launches rubber balls roughly 2 meters into the air, precisely aimed to bounce off of 42 chromatic wooden keys; (2) an array of 35 custom-tuned wine glasses, played by robotic fingers; and (3) an array of nine percussion instruments. At the Robotics Exhibition, Lieberman presented video from the

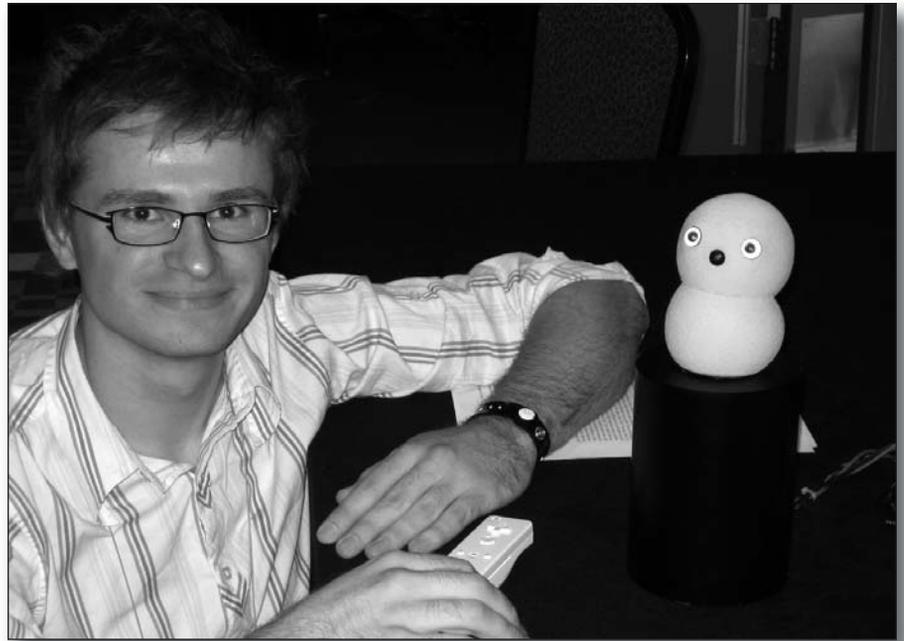


Figure 2. Marek Michalowski (Carnegie Mellon) and Keepon.

New York installation of Absolut Quartet.

The Great Wumpus Hunt was presented by Debra Burhans, an associate professor of computer science at Canisius College, along with Canisius student Camille Moreno (figure 3). The Wumpus World is a well-known virtual environment consisting of a grid whose cells might contain gold, pits, or a deadly wumpus, and a wumpus hunter is an intelligent agent who enters the grid, avoids pits, collects gold, and kills the wumpus. The exhibit included a wumpus hunter embodied in a physical robot (an Aibo), moving and sensing on a real-world grid with the cognitive ability to consciously represent and reason about itself, the environment, and its actions. Burhans also demonstrated the educational potential of linking the virtual Wumpus World with a physically embodied robotic agent for students in computer science and robotics.

Zachary Dodds, an associate professor of computer science at Harvey Mudd College, and students Peter Mawhorter, Elaine Shaver, and Zeke Koziol presented an exhibit titled Mapping for All (figure 4). This project implemented a vision-based mapping algorithm, FastSLAM, through the Python scripting language on multiple inexpensive robotic platforms (iRobot

Create, Parallax Scribbler, and CMU Querkbot). Their work is largely targeted at educational applications, allowing students at a wide range of curricular levels to explore the use of spatial reasoning algorithms in the real world at low cost.

Robots Learning about Objects from Human Teachers was presented by Andrea Thomaz, an assistant professor of interactive computing at Georgia Tech and graduate student Maya Cakmak. Using the Robotis Bioloid platform (in an upper-torso humanoid configura-



Figure 3. Debra Burhans (Canisius College) Demonstrating the Great Wumpus Hunt.



Figure 4. Zeke Koziol (Harvey Mudd College) Demonstrating Mapping for All.



Figure 5. Zeno (Hanson Robotics) Taking a Break.

lenging for robots, particularly humanoids, even with fewer degrees of freedom than a marionette. Murphey's project uses computational simulation tools towards the automatic generation of control inputs that imitate human motion using a marionette.

Hanson Robotics, represented by Richard Margolin, an undergraduate at the University of Texas at Arlington, presented Zeno RoboKind: An Instance of Cognitively Capable Characters (figure 5). Zeno is an ambitious prototype expressive character with conversational capabilities (incorporating speech recognition and synthesis) that makes eye contact with people and is able to form a wide range of facial expressions. To enhance social interaction with Zeno, particularly for children, the project team created a fictional backstory for the character, and the physical robot serves as a proxy for the storybook Zeno. The project was designed to be a platform for continued cognitive AI development and is able to interface with OpenCog and other robot development frameworks.

Enabling a humanoid robot to dance in response to live music was the objective of Blame It On the Robonova, an exhibit presented by Youngmoo Kim and Paul Oh of the Drexel University College of Engineering, along with students Robert Ellenberg and David Grunberg. This project (figure 6) implemented a perceptual model of hearing to accurately determine beat locations within music. This information was combined with a vocabulary of limb gestures allowing the robot, a Hitec Robonova-1, to move synchronously with the music in real time. The group also demonstrated a simplified graphical user interface, allowing a user to experiment with both choreographed movement sequences and simple generative behavior.

tion), a human instructor attempts to teach the robot the affordances of particular objects (how each can be manipulated; for example, a ball responds differently to a push than a block). This project aims to study social and nonsocial learning about objects and to understand how a human instructor may scaffold a robot's learning through positive examples.

Todd Murphey, an assistant professor of computer science at the University of Colorado, Boulder, and graduate student Elliot Johnson presented the Automated Marionette Project. Marionettes are highly complex mechanisms, but expert puppeteers are able to control and manipulate these systems to exhibit expressivity. Similarly complex motion planning remains chal-

Future Research Directions and Challenges

The workshop concluded with an hour-long discussion regarding long-term goals and a general roadmap for research in robotics and creativity. Although the discussion was wide-ranging, four general themes emerged. The

first was the inherent challenges of pursuing joint research involving creativity and technology. The second theme was the difficulties of mapping signals to symbols in computational systems, a requirement for dealing with the high-level descriptions used in many creative fields. Existing and potential methods for incorporating creative robotics in computer science and engineering education formed the third general topic. The final discussion point targeted proposed grand challenges for future work integrating robotics and creativity.

The initial discussion focused on the challenges involved in pursuing joint research in computation and creativity. One issue is the lack of a standard definition of creativity. Although a creative act is generally considered to be one that results in a new, unexpected, or interesting result, this does not provide a complete definition. Another issue raised is the importance of constraints: these often catalyze creativity (a specific problem inspires a novel solution) and, in fact, may be a necessary element of creativity (random motion is not creative, while constrained systems, such as dance and music, are considered creative fields). Significant challenges arise when combining robotics with the creative arts, particularly for a public performance or installation, and such projects are seldom executed without turbulence. In general, however, participants felt that such collaborations form a unique crucible for multidisciplinary work and can be very effective for learning new perspectives, vocabulary, and approaches of another field.

Many creative fields have developed notation systems (such as music notation, Laban notation for dance, and so on) that require a wide range of domain-specific knowledge for correct interpretation. In many cases, the mappings from sensor (audio, visual, movement, and so on) data to symbolic notation (and vice versa) are ambiguous. The ability to make these types of broad inferences (signal to symbol) appears to be another requirement for creativity and remains a significant research challenge. Additionally, the creative and performing arts often take advantage of character-

istics of human perception (for example, the limits of visual, aural, and tactile acuity), and robotic systems designed for creative applications may benefit from incorporating more of these characteristics.

The third major area of discussion focused on the educational implications and applications of creative robotics. Many institutions already incorporate robotics into the standard engineering and computer science curriculum. The multidisciplinary nature of the platform (integrating mechanics, sensing, movement, and programming) has broad appeal, and several participants commented on the ability of robots to inspire students to find unique and creative solutions to problems. Student robotics competitions elicited mixed opinions: while they can generate excitement among students, a strict competitive goal may also limit creativity. Likewise, emphasizing creativity by grading of robotics projects using a creativity-based metric (as opposed to quantitative objectives) had proponents and critics among the participants.

Robots are a relatively new form of artifact requiring new evaluation methods, and the final topic of the discussion was directed towards potential grand challenges for work in robotics and creativity. One proposal was for the formulation of robotic Turing tests, where success would consist of a robot convincing a human observer that they were observing or interacting with a human. This would bring the traditional conversational Turing test into new domains, such as movement and physical interaction, where the state of the art is still relatively far from mimicking natural human behavior. Another proposed challenge was to advance the development of robots as creativity-enhancing tools. While there are many domain-specific computational tools for creativity (such as music creation, image, and video manipulation), none is able to interact with the physical world, which creates new opportunities. As the session came to a close, there was broad consensus that robotics education represents another grand challenge and that designing curricula that inspire creativity within students



Figure 6. The Dancing Robonova-1 (Drexel University).

at all levels of education may have the greatest impact of all.

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Youngmoo E. Kim is an assistant professor of electrical and computing engineering at Drexel University. His research lab focuses on music, and entertainment technology (MET-lab) including audio signal processing, machine learning, music information retrieval, and human-computer interaction.

Paul Oh is an associate professor at Drexel University's Mechanical Engineering Department and director of the Drexel Autonomous Systems Laboratory (DASL).

Odest Chadwicke Jenkins is an assistant professor of computer science at Brown University. His research group, Robotics, Learning, and Autonomy at Brown (r-lab), explores topics related to human-robot interaction and robot learning with a specific focus on robot learning from human demonstration. His research strives towards realizing robots and autonomous systems as effective collaborators for humans to pursue their endeavors.