Robots and Education

Robin R. Murphy, University of South Florida

ARTIFICIAL INTELLIGENCE FOR ROBOTICS IS A HOT TOPIC FOR UNDERgraduate students, along with Java programming, data mining and e-commerce, or anything else perceived as relevant for the exotic high-tech job market. The current Christmas retail season shows numerous intelligent robotic toys, ranging from Hasbro's My Real Baby to several species of robot puppies.

The challenge of teaching robotics

Unfortunately, instructors often perceive AI for robotics as being harder to teach than, say, Java. The student "audience" for robotics is often varied, ranging from engineering students more interested in hardware than software to computer science students interested primarily in programming. Such an audience introduces the issues of what topics to cover, the course's depth, and the type and amount of meaningful laboratories or assignments. Regardless of the audience's emphasis, robotics requires a set of resources different from just a compiler that can run on the student's home machine: simulators, hardware, robots, interface cables, laboratory space, and so on. These resources might cost more, and those costs might be more visible (and less justifiable) to budget-conscious academic administrators.

The pedagogical support for teaching Java is much greater, with textbooks and publications canonizing what should be covered, methods, and appropriate laboratories. Indeed, an instructor sufficiently schooled in languages can pick up Java well enough to teach it, but that same instructor might be put off by teaching robotics unless he or she had direct experience with robotics in grad school.

Overall, robotics pedagogy is lagging behind the demand. For example, only three textbooks in robotics software exist—Ron Arkin's *Behavior-Based Robotics* (AAAI Press, 1998), Greg Dudek and Michael Jenkins' *Computational Principles of Mobile Robots* (Cambridge Univ. Press, 2000), and my *An Introduction to AI Robotics* (MIT Press, 2000). Only the last is aimed specifically at upper-level undergraduates or graduate students without a survey course in AI. And even so, textbooks, despite accompanying instructor's manuals, do not offer a comprehensive look at how to teach robotics on a daily basis.

Filling the gap

This issue of *IEEE Intelligent Systems* is intended to fill some of these gaps in teaching intelligent robotics to undergraduates. Four articles describe the experiences and practical lessons learned from five institutions, creating a broad canvas of approaches, syllabi, and laboratory assignments.

In "Undergraduate Robotics on a Shoestring," Karen Sutherland summarizes her experiences with teaching robotics to undergraduates at a small liberal arts school with significant budget

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and resource restrictions. Her efforts show that any institution can offer a meaningful robotics course without the instructors' being totally frustrated.

In "Designing and Implementing Hands-On Robotics Labs," Michael Rosenblatt and Howie Choset describe a laboratory course at Carnegie Mellon University that falls at the opposite end of the resource spectrum. Many aspects of their course will be prohibitively expensive to directly implement at a state university. However, their article provides adaptable solutions such as using volunteers from previous semesters to serve as the eight teaching assistants needed to direct the laboratories. Indeed, Rosenblatt himself is one of those undergraduate teaching assistants.

In "A Laboratory Course in Behavior-Based Robotics," Ian Horswill at Northwestern University describes how he integrates laboratories with traditional class material using a few research robots. The result is an insightful look at the balance between theory, practice, and the number of hours in a day for both students and instructors.

In "Integrating Robotics Research with Undergraduate Education," Bruce Maxwell and Lisa Meeden describe a multiclass sequence initiated at the University of North Dakota and refined at Swarthmore College. The sequence uses the AAAI Mobile Robot Competition as the motivating project. Swarthmore has fielded prize-winning teams since 1998 using this competition-oriented approach, as has the Colorado School of Mines in earlier years.[1]

In addition to the articles, two leaders in graduate robotics education, Ron Arkin and Illah Nourbakhsh, offer their insights into teaching (see the sidebars "Autonomous robotics education at Georgia Tech" and "When students meet robots" in this article).

YOU MIGHT BE QUICK TO NOTE that the authors in this issue are all robotics researchers. But this does not mean the articles speak only to robotics researchers. Instead, they clearly show how an instructor without an active research program in robotics, but with experience in intelligent systems, might orchestrate a true robotics class. Even if you are not interested in teaching a robotics course in the near future, you might find the articles motivating and thought-provoking. They capture the enthusiasm and excitement that stems from teaching a course that involves hands-on learning of challenging, cutting-edge topics.

Reference

1. R.R. Murphy, "Using Robot Competitions to Promote Intellectual Development," *AI Magazine*, vol. 21, no. 1, Spring 2000, pp. 77–90.

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Autonomous robotics education at Georgia Tech

Ronald C. Arkin, Georgia Institute of Technology

After teaching an autonomous robotics course at Georgia Tech for many years, I became quite aware in the mid 1990s that working solely from original technical papers (conferences and journal articles) was inadequate to provide a solid introduction to the field. At that time, I decided to write a textbook for the course, *Behavior-Based Robotics* (AAAI Press, 1998), that provides introductory material to the field far more coherently. In addition to this text, we still use articles in the course, including edited collections such as David Kortenkamp, R. Peter Bonasso, and Robin Murphy's *Artificial Intelligence and Mobile Robotics* (AAAI Press, 1998). Typically, students present the papers and critique them in light of what they have learned.

A bigger challenge remaining is solidifying the course's laboratory portion, which traditionally has been independent-project oriented. I am encouraged by Ian Horswill's approach (see "A Laboratory Course in Behavior-Based Robotics" in this issue). I hope that his course materials (and those of others teaching in the field) will be made generally available. At Georgia Tech, we have provided our MissionLab software system freely for use in both education and research (see www.cc.gatech.edu/ai/robot-lab) and have successfully used Tucker Balch's Teambots (previously known as Javabots) system (www.teambots.org), initially developed here. We look forward to the upcoming development of an integrated laboratory component for course delivery to facilitate teaching intelligent mobile robotic systems to graduate and undergraduate students.

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When students meet robots

Illah Reza Nourbakhsh, The Robotics Institute, Carnegie Mellon University

The undergraduate student team has spent days following their gopher robot around Wean Hall. They have designed OfficeBoy 2000 to do errands by convincing complete strangers to lend a helping hand (the robot has no arms). Late one night, the students decide it is time to turn OfficeBoy 2000 loose. They type "Get me a Coke" into the robot's interactive screen, hit OK, and hold their breath. OfficeBoy 2000 considers its options for a few seconds, formulates a plan, and takes off down the hall, turning the corner and disappearing from view. The students use heroic levels of self-control to keep from following OfficeBoy. Five minutes later the robot returns, with a Coke in its tray! OfficeBoy has succeeded. The students cheer loudly, then sprint off toward the vending machine to meet OfficeBoy 2000's first human volunteer.

This story is particularly exciting because robotics is a surprisingly young field. In 1980, researchers believed R2D2 was several decades away from being tenable. Today, R2D2 is still several decades away. This might be bad news for researchers, because robotics has turned out more difficult than anticipated. But it is good news for students. In a semester and a half, a robotics student can graduate from novice to pioneer. Few fields can boast such a speedy trip to the frontier of knowledge, where a truly creative undergraduate can do something with a robot that nobody else has done.

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