

@ Robotics researchers expect that personal robots will become common in the workplace, home and school within the next 20 years. These assistants may take away the boring parts of everyday life.

“Personal robots are becoming more popular as people want to do more and more with their lives. Technology is making it possible....”

Henrik Christensen,
director of the
Robotics and
Intelligent Machines
Center in the
Georgia Tech
College of
Computing

From Science Fiction to Reality

Personal robots emerge to improve quality of life at work, home and school.

BY JANE M. SANDERS

It's 6 a.m., and the Clarks awake to fresh coffee served to them by Millie, one of the family's personal robots. As they get ready for work, Millie makes the bed, and their robotic dog Mickey gently reminds Mr. Clark to take his medicine.

Once at work, Mrs. Clark, a hospital nurse, assigns a personal robot to deliver blood samples to the lab while she talks with a patient. Meanwhile, Mr. Clark catches the morning news while his autonomous car navigates the traffic into the city.

At day's end, the family returns to a spotlessly clean home courtesy of Millie's untiring work. The Clark children do math homework with tutoring from Margie, another robot. After a dinner the Clarks prepared based on a menu suggested by Millie, the family enjoys the rest of the evening free from chores. They sleep soundly knowing that Mickey is always alert to any trouble.

This scenario is not a page from a lost "Jetsons" script. It's likely to be a normal day in the life of a family in as few as 20 years from now, according to robotics experts at the Georgia Institute of Technology.

Already, the global market for personal robots is growing 400 percent a year, says Professor Henrik Christensen, director of the newly formed Robotics and Intelligent Machines Center in the Georgia Tech College of Computing.

"Personal robots are becoming more popular as people want to do more and more with their lives,"

Christensen says.

"Technology is making it possible.... We live stressful lives now, and we can use technology to take away the boring parts of everyday life."

Robots are



not novel technology in industry, the military and even space exploration. But a new generation of intelligent machines called personal robots — ones that work with and directly for humans, especially in the home, workplace and school — have begun to emerge only recently. A confluence of smart materials, low-cost, high-speed computing power, better batteries and knowledge of how humans interact with machines is creating an explosion in the market for personal robots, researchers say.

“To have a personal robot that does things you need, you have to have onboard processing, perception, motion and power,” says roboticist Tucker Balch, an associate professor in the College of Computing. “Until two or three years ago, you couldn't put all of that on one small, light platform. Motors and computers take a lot of energy, and the batteries we had couldn't do the job.

“Now, demand for better cell phone and laptop batteries is driving improvements,” Balch adds. “Until recently, you couldn't get enough processing power without drawing lots of electricity. Also, robots on the market now have addressed the high power requirements of motors.

LEFT: Materials used to build robots, such as this robotic arm, must not only protect components, but also protect the humans that interact with the machines. That requires the development of flexible materials, says Professor of Computing Henrik Christensen.



PHOTO BY GARY MEEK

PHOTO BY GARY MEEK



ABOVE: Professor of Computing Henrik Christensen and his students are designing a personal robot that makes and delivers coffee in the home. They are testing it in Georgia Tech's Broadband Institute Residential Laboratory. At right, the coffee robot is on the move.



PHOTO BY GARY MEEK

Finally, we have all the technologies that can support a consumer robot that is not too expensive."

Balch predicts that truly useful, multi-function personal robots will cost between \$1,000 and \$1,500. Single-purpose robots, such as the Roomba vacuum cleaner already on the market, cost between \$150 and \$300.

While some personal robots are already available, important research is under way to address the remaining technical and societal challenges. Georgia Tech researchers in computer science, engineering, psychology and the liberal arts are collaborating under the umbrella of the new

Robotics and Intelligent Machines Center that Christensen directs. That cooperation is vital to creating the best-designed personal robots.

"If you just have computer scientists designing robots, you're not going to build a robot that's as good as one that could be built by computer scientists and mechanical engineers working together," Christensen says. "We are leveraging Georgia Tech's world-class expertise in all of these domains and want to make something that no one else in the United States is doing today."

The center's research agenda draws upon Georgia Tech's long tradition of robotics study, as well as findings from an ongoing analysis of 40 Georgia companies. Christensen and Professor Steven Danyluk, who heads Georgia Tech's Manufacturing Research Center, are identifying the problems preventing companies from integrating robots into their operations.

Solving industry and workplace problems — such as robotic robustness and perception — will lead to better robots in the home and school, researchers say.

"In our lifetimes, we will have a Rosie (of 'Jetsons' fame), the ultimate home assistant," Christensen says.

Technical Challenges

Before personal robots become part of daily life, improvements are needed in personal robot software, robustness, materials, component integration, power and human-machine interaction, researchers say.

"Two key chunks of missing technology are perception and reliability, and research is focusing deeply on these issues," Balch says.

Perception involves the processing of information



PHOTO BY GARY MEEK



Henrik Christensen and the autonomous, robot-driven Porsche.

MY WAY OR THE HIGHWAY

“We're not going to change our houses to accommodate robots. That's not realistic. Robots must live by our rules. We want them to be able to understand natural language and gestures. It's an interesting and tough challenge for us as researchers.”

— Henrik Christensen,

professor of computing and director, Georgia Tech Robotics and Intelligent Machines Center

from a robot's sensors so the robot understands the outside world — at least enough to know what it should be doing.

“Robots need to be able to interpret their world,” Christensen explains. “If they go in a new environment, they need to be able to recognize, for example, a chair even though it's a different chair from one they've seen before.”

From a reliability standpoint, the robot needs to be able to realize when it's stuck and call for help. “Even better would be that it not get stuck or that it can get itself unstuck,” Balch says.

Personal robots must be robust, able to function 24 hours a day, 7 days a week in a variety of environments. Their industrial counterparts already are being asked to work in an array of environments, including temperature extremes ranging from freezing to 100 degrees or more. Emerging industrial application areas, including poultry processing, require units to work 16 hours a day and also endure a daily cleanup process that employs high-pressure water and caustic chemicals.

“Designing a robot to survive in this environment is difficult,” says Gary McMurray, a senior research engineer in the Georgia Tech Research Institute (GTRI). “You have to protect the electronics and sensors, so material selection is important. We'll have to move away from lubricant use for robot joints, and we'll need the right types of motors and drive systems.”

Materials used to build robots must not only protect components, but also protect the humans that interact with the machines. That requires the development of flexible materials, Christensen says.

For example, robotic arms need to be as flexible as the human arm, which won't break easily, yet as stiff as the human arm when it lifts and pushes, he explains. An example is a lightweight robot that naturally yields when pushed

PHOTO BY GARY MEEK



LEFT: In the food processing industry, new intelligent robotic systems under development at the Georgia Tech Research Institute will be able to operate in unstructured environments and respond to unforeseen circumstances. In a poultry plant, for example, robotic systems on a cutting line would be able to discriminate among a range of bird sizes.

upon; it is based upon Georgia Tech research and manufactured by the Atlanta company CAMotion Inc.

Another technical challenge is the integration of various products into one robotic system. Microsoft is attempting to address this problem with its new Robotics Studio operating system, though it will face competition from other companies vying to create the robotics operating system of choice, Christensen says.

Balch predicts that a standard operating system will accelerate robotics development like IBM's PC did in the early 1980s. “Microsoft is now helping define a standard that's not been there, and I think that companies waiting to enter the robotics marketplace now will enter it,” Balch says. “Combined with the hardware that's available, this will be the last domino to fall.”

If component integration is the final piece of the puzzle, issues of robot power and human interaction must be addressed first. Better batteries might allow robots to operate untethered for long periods of time, says robotics expert Wayne Book, a Georgia Tech professor of mechanical engineering. But current batteries are way below the necessary levels of operation. Alternatives are being studied in the Center for Compact and Efficient Fluid Power funded by the National Science Foundation. In building a robot called the

“Two key chunks of missing technology are perception and reliability, and research is focusing deeply on these issues.”

Tucker Balch, associate professor of computing and director, Georgia Tech Institute for Personal Robots in Education

ROBOTICS RIVALRY

This summer, Georgia Tech will host an annual international robotics competition in which teams of robots compete in soccer games and search-and-rescue missions. The mission of the RoboCup competition is to foster artificial intelligence and intelligent robotics research by providing a standard problem in which a wide range of technologies can be integrated and examined. The ultimate goal is to develop a team of fully autonomous, humanoid robots that can defeat the human world champion team in soccer by 2050. RoboCup 2007 is expected to draw more than 1,500 students and faculty from colleges and universities and about 500 middle and high school students from 20-plus countries. For more information, contact Georgia Tech Associate Professor Tucker Balch at tucker@cc.gatech.edu or see www.robocup-us.org.

PHOTO BY NICOLE CAPPELLO



RIGHT: Robotic vacuum cleaners, such as the Roomba, are providing an interesting case study in human-robot interaction for Beki Grinter, an associate professor in the College of Computing. People name them and dress them, as if they were pets.



PHOTO BY GARY MEEK

Compact Rescue Crawler, Book and his colleagues at Vanderbilt University are addressing the power issue by using energy generated by chemical fluids called monopropellants, such as hydrogen peroxide.

In human-robot interaction, hurdles remain in ease-of-use and communication. Balch likens the goal for personal robot ease-of-use to the simplicity of the TiVo digital video recorder interface. "It is a technology that you can give to a 70-year-old and not have to worry about helping her with it," Balch says.

For humans to effectively communicate with personal robots, the machines need to be able to understand spoken language and gestures, Christensen says. For now, those capabilities are limited.

"The big question is, 'How can people tell a robot what they want it to do?'" Balch says. "People need to be able to show their robot how to do something. Researchers have lots of ideas on how to do this, but the problem is not solved yet."

One researcher in GTRI is seeking insight by focusing on opportunistic human-robotic interactions that will enable people to work with robots, rather than commanding them. Researcher Lora Weiss is analyzing both social and mathe-

(continued on page 12)

The World with Robots

Researchers envision the roles for robots.

BY JANE M. SANDERS

Robots are already at work in the military, homeland security and space exploration arenas. But a new generation of personal robots is expected to enhance workplace production and safety, and make home management easier.

On the urban battlefield, the military loses soldiers to snipers and mines, explains Henrik Christensen, a professor in the Georgia Tech College of Computing. "But if soldiers could send in a robot first, it could give them a reasonable sense of the layout of an environment," he says.

In rescue operations, robots are already used, but they are frail, says robotics expert Wayne Book, a Georgia Tech professor of mechanical engineering. Funded by the National Science Foundation, he and colleagues at four other universities are designing the Compact Rescue Crawler, which will extend to robots the significant capabilities of fluid power — technology for the generation, control and transmission of pressurized fluids.

Book and his colleagues are also giving the Crawler six legs — creating a bug-like appearance — to increase its maneuverability. Book's research lab is contributing its expertise on haptics — the "feel" associated with operating a mechanical device — to build an interface that will aid the crawler's operators.

In space exploration, robots have made great strides. Roboticist Ayanna Howard, a Georgia Tech associate professor of electrical and computer engineering, developed intelligent terrain-assessment algorithms for NASA's autonomous rovers that will navigate Mars in the future. Now, Howard and her research team focus on increasing the perception and reasoning capabilities of science-driven robots for exploring both planetary surfaces and remote geological locations on Earth.

Robots in the Workplace

Robots also have been used in manufacturing and food processing. But industries have tradi-

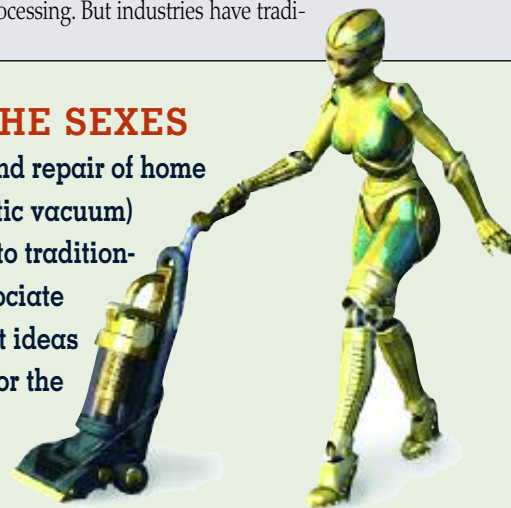


ILLUSTRATION BY LINDA BUCKLIN, COURTESY ISTOCKPHOTO.COM

DESIGNING TECHNOLOGY FOR THE SEXES

"There's a rise in digital housework, such as the maintenance and repair of home computers, printers and networking equipment. Roomba (a robotic vacuum) would be included in digital housework, even though it's closer to traditional notions of housework," says Beki Grinter, a Georgia Tech associate professor of computing. Studying this phenomenon may suggest ideas for design. For example, some technologies might be designed for the 49 percent of the population that is male. "We don't think about technology as having gender consequences," she adds. "But if it does, we must understand that as part of the design process."

tionally put up "fences" around robots to prevent injuries to workers and robot malfunctions caused by human error or interference. Now, robots and humans are interacting more, Christensen says.

In another effort, Book designed robots that yield when pushed upon to prevent injury to humans and damage to the machine.

"In a setting like this where humans are working in the vicinity of robots, if a massive robot collides with one of these people, the robot is not even aware it's pushing on somebody," Book says. "But with a lighter-weight robot, the potential for damage is reduced a lot."

In the food processing industry, new intelligent robotic systems under development at the Georgia Tech Research Institute (GTRI) will be able to operate in unstructured environments and respond to unforeseen circumstances, says senior research engineer Gary McMurray. In a poultry plant, for example, robotic systems on a cutting line would be able to discriminate among a range of bird sizes. "We'll only be able to do tasks like this with sensor guidance from a variety of sensing technologies — tactile, force, vision, even radar or ultrasonic," he explains.

From Work to Home

Following — if not, coinciding — with the assimilation of personal robots into the workplace will be their use in the home. Christensen predicts that the first robotic assistants in the home will help senior adults and people with disabilities.

"A 'smart' robotic wheelchair might

help someone get out of bed and go to the restroom," Christensen says. "If someone has to have assistance to go to the restroom, it's a deep violation of their personal sphere, and if help is delayed in coming, it may be too late."

Researchers are also examining the concept of robotic sentries that monitor senior adults. "If you have someone who wants to be in their home rather than the nursing home, one of the dangers is that they may fall or need some assistance when no one is there," Howard says. "So you may have a robot that just follows them around and checks on them every so often. And if something does happen, it actually will contact someone."

Once personal robots prove useful in these situations, they will become more commonplace in everyone's homes, Christensen says. Already available are robotic vacuum cleaners, such as the Roomba, and they are providing an interesting case study in human-robot interaction for Christensen and collaborator Beki Grinter, an associate professor in the College of Computing.

"The first time I turned my Roomba on, I found myself watching it clean the floor," Grinter says, "and I was a little surprised that I was watching it like it was some kind of spectator sport."

Grinter and her students found that her initial reaction is quite similar to that of other Roomba users. They also found that people are naming and buying cute costumes for their Roombas, as if they were pets.

"As a scholar, I'm fascinated by why people have such a personal response to their Roombas," Grinter explains. "Robots have occupied a science fiction place in our imaginations for so long. What are the implications of that response when everybody is able to have one of these robots in their home?"

Robots in the Classroom

Making better robots also will require a new generation of computer scientists and engineers. To spur interest in computer science, Georgia Tech and Bryn Mawr College are piloting a Microsoft-funded program using personal robots to teach introductory concepts.

"Robots spark interest in students because they can relate to it more easily and directly," says Balch, who directs Georgia Tech's new Institute for Personal Robots in Education. "Students can see how a program they've written is interacting with the world as the robot senses a light and moves a motor. They get that."

"Some other ways of teaching computer science are disembodied," he adds. "Students type in their name and print out a sentence with their name in it. Students don't get why that matters.... But robots help them see the possibilities in computer science. They can make things happen."

Writer Rick Robinson also contributed to this article.

ILLUSTRATION COURTESY OF WAYNE BOOK



ABOVE: The Compact Rescue Crawler robot will have six legs — creating a bug-like appearance — to increase its maneuverability.



PHOTO BY GARY MEEK

ABOVE: Professor Wayne Book and his robotics research team have developed a haptic backhoe system that gives the operator the sense of touching a wall when approaching a utility line.

TEACHING THE YOUNG

Ayanna Howard, a Georgia Tech associate professor of electrical and computer engineering, is developing curriculum to spark interest in fields such as computer engineering among those middle school students who don't traditionally pursue math and science careers. Funded by the National Science Foundation, Howard and Brian Blake, a collaborator from Georgetown University, will offer a one-day, proof-of-concept course this summer using a video game approach.

“Kids play lots of computer games, and they are so technologically savvy, yet they still don't see that there's a linkage with computer science and computer engineering,” Howard says. “So what we're trying to do is to couch learning techniques — for example, geometry and programming algorithms — in a computer game environment.”

PHOTO BY RICK ROBINSON



Associate Professor Ayanna Howard introduces young students to a robotic dog.



PHOTO BY GARY MEEK

ABOVE: Researchers believe that social acceptance of personal robots will be easier if the machines look like things that are familiar to people. For example, a personal robot that looks like a dog would likely prompt someone to gently teach the machine the tasks it must learn to do, says Associate Professor of Computing Tucker Balch.

RIGHT: Professor of Mechanical Engineering Wayne Book and colleagues at four other universities are designing the Compact Rescue Crawler robot. Book's lab is contributing its expertise on haptics — the “feel” associated with operating a mechanical device — to build an interface that will aid the crawler's operators.

mathematical networks to understand the dynamics of robot-to-robot and robot-to-human interactions. She is studying these relationships via software and assessing the larger network of dynamic interaction. Her goal is to mathematically capture how humans behave toward machines from a systems perspective.

“Within software, you can provide some intelligent automation to the bots, and then have a system of real people interacting with the machines,” Weiss says. “The software approach allows one to rapidly populate scenarios with disparate entities and evaluate the emerging and evolving behaviors of the larger system.”



PHOTO BY GARY MEEK

Social Acceptance

Robots running amok has often been a theme of science fiction. “One of our biggest enemies is Hollywood,” Christensen says. “The view of robots that Hollywood projects is almost always negative.”

Christensen believes the public's concern about robots running amok is unrealistic because technology developers place so much emphasis on safety.

“We have to overcome misconceptions about robots,” Christensen says. “We cannot afford one failure.... We need to make robots that are cute and fun and interact socially with people, but actually help them in their everyday lives.”

In the workplace, for example, Book says convincing people that a lightweight robot can work safely hand in hand with humans, while also being durable and effective, is a more significant challenge than the technical issues.

“Once we can overcome the perception that lightweight robots are flimsy, then every industry will be happy to save money by using these robots,” Book says. “.... When industry starts to accept that lightweight robots can do the job, the perception problem will become a non-issue.”

To build robots that people will accept and even like, researchers draw upon studies in psychology and human-computer interaction.

“There is a general hypothesis that robots similar in appearance to what is familiar to us will ease acceptance,” Balch notes. “.... If you see a robot that looks and acts like a puppy, you're going to treat it as somewhat of a subordinate, but gently. You will guide it.”

On the other end of the spectrum, there are human-looking robots. “You then expect it can do things like a person, and you're less patient with it,” Balch says.

That raises the question of whether robots should look like humans. “The more a robot looks like a person — it's called the uncanny valley theory — the creepier it seems to

“I GET MY KICKS ON ROUTE 66....”

Georgia Tech and Science Applications International Corp. (SAIC) have joined forces to compete in the DARPA Urban Challenge, which tests the ability of competing autonomous robots to drive 60 miles in an urban setting in six hours or less. The vehicles must obey the rules of the road and safely interact with other robot vehicles and other cars driven by people on the course. The driverless vehicles must have the ability to sense and react to the urban traffic environment, including lane markings, intersections, other vehicles and unexpected road blockages. The robot vehicles also must have the intelligence to select the best route and decide which vehicle has the right-of-way in normal traffic. For more information, contact Professor Henrik Christensen at hic@cc.gatech.edu or see www.sting-racing.org.



PHOTO BY GARY MEEK

The autonomous, robot-driven Porsche will rely on an array of sensors.

humans," Balch explains. "If you could design a robot that truly looks like a person, people might accept it, but if it's off target, it's creepy."

What the Future Holds

Challenges remain for researchers and society in assimilating personal robots into everyday life. Opportunities exist for business, industry, schools and our lives at home. Also, questions of ethics arise, and people are likely to wrestle with these issues (*See the Faculty Column by Professor Ronald Arkin on page 14*).

For business and industry, robots are another technology that helps countries compete in the global marketplace, says Craig Wyvill, chief of GTRI's Food Processing Technology Division. "While industrial robotic technology continues to evolve, it is already demonstrating it can increase product quality and help companies establish themselves as leaders in their fields," he explains. "In the process, the workforce must change to support the technology. These changes are essential to staying competitive."

In schools, personal robots are expected to capture the attention of a new generation of computer scientists and engineers by "embedding learning in an interesting physical thing that moves around," Balch says.

Home may become an easier and more pleasant place to live with personal robots that "take away the boring parts of life," Christensen says.

As robots become more commonplace in people's lives, society must address the ethical questions.

"Researchers must involve many others — such as philosophers and priests — to contribute to the understanding of the relationship between humans and machines," Christensen says. "If we just address these issues as computer scientists and engineers, we may come up with robots that look like what Hollywood creates." **rh**

ILLUSTRATION BY DAR YANG YAN, COURTESY OF ISTOCKPHOTO.COM



ABOVE: Robots running amok has often been a theme of science fiction. Professor of Computing Henrik Christensen says overcoming this misconception will require researchers to design personal robots that are cute and fun, but also helpful to people in their daily lives.

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TRANSFORMING TECHNOLOGY

“There is an argument that technology transforms the way we run our lives in subtle ways that we don't always realize. So far, most of this technology has been about information, not about changing our physical environment to help us. Robots are going to carry things the next few steps further.”

— **Tucker Balch**,

associate professor of computing and director, Georgia Tech Institute for Personal Robots in Education

Associate Professor Tucker Balch uses robots to teach introductory computer science concepts.



PHOTO BY GARY MEEK

FACULTY COLUMN

Robot Ethics

From the battlefield to the bedroom, robots of the future raise ethical concerns.

BY RONALD C. ARKIN
Regents Professor, Georgia Tech College of Computing

RIGHT: Robotist Ronald Arkin, a Regents Professor in the Georgia Tech College of Computing, is exploring the ethical implications of personal robots.

As robots edge ever closer to having fundamental impact in our daily lives, more and more concerns are being raised on just what this will really mean.

For example, Bill Joy, co-founder of Sun Microsystems, argues that robotics is sufficiently dangerous to call for complete cessation of all research on the subject. Others, such as Carnegie Mellon University robotics researcher Hans Moravec, forecast, somewhat gleefully, the day when robots will replace humanity and will serve as our natural successors. Indeed in his vision we, as humans, may become them.

Recently, I have engaged in considerable introspection, largely due to my long-term involvement in robotics research. As a scientist I have explored many different domains, all of which impinge on ethical concerns, and I will share a few here.

Robots in warfare are becoming the standard for the United States military of the future. A congressional mandate requires that by 2010, one-third of all operational deep-strike aircraft be unmanned and by 2015, one-third of all ground combat vehicles be unmanned.

While reducing the number of our soldiers on the battlefield seems at first an easy decision, there are many questions related to the viability of this approach. One concerns the issue of lethality, i.e., will intelligent robots be allowed to make decisions regarding the application of lethal force against humans in war without requiring direct



PHOTO BY GARY MEEK

human intervention (can a robot pull the trigger on its own)? Can robotic soldiers ultimately be more humane (humane-oids?) than actual warfighters by incorporating a means for ensuring that the laws of war are strictly followed? Our laboratory is currently exploring these questions for the Army, while concurrently designing complex, multi-robot mission software for the Navy.

On the entertainment front, I have been involved with the development of entertainment robots for almost a decade with Sony Corporation's AIBO (dog) and QRIO (humanoid) robots. The seemingly benign goal here is to create robots that bring joy and happiness into people's lives, especially among the elderly, and that can serve as life-long partners, not unlike pets or companions.

The real question from an ethical perspective involves the incorporation of human psychological models to tap



PHOTO BY GARY MEEK

PHOTO BY STEVEN THOMAS



CATCHING THE CULPRITS

When food products are recalled because of safety concerns, the recall is massive because the company doesn't know when the product in question came through the plant and the potential for cross contamination. The Georgia Tech Research Institute (GTRI), is developing fully automated robotic systems that eventually could — with future improvements in sensors, such as GTRI's biosensor — detect contamination in real time.

deeply into an emotional vein unbeknownst to the observer. This in many ways is in common with advertising, cinema, video gaming and other forms of entertainment. The physical embodiment of these robots, however, adds a special dimension that has caused concern among some ethicists and philosophers, particularly in terms of our society abrogating its responsibility for maintaining and enriching human-human contact with the aging. The use of such robots, according to this view, essentially provides an artifact displaying an illusion of life, thus encouraging a further loss of contact with reality by the elderly.

Related to this is the notion of human-robot intimacy and sexuality. The VCR and the Internet have been propelled by pornography to the ubiquity they possess today. It will not be a surprise to see the robotics field also move rapidly in this direction, which it already has in limited ways. We as a society might do well to consider where this might lead: the impact of sex industries built up around this new technology (not simply advanced sexual toys); the consequences of robotic sex therapy perhaps targeted for the rehabilitation or management of sex offenders; robot prostitution; and ultimately, the choices regarding human-robot intimacy on a more permanent basis. As I've said in the past, would you want your daughter to marry a robot?

A more traditional ethical question for robotics is its impact on unemployment. What would happen if instead of concentrating on the traditional robotic tasks of the "3 Ds" (dull, dirty and dangerous), we moved into more mundane environments, such as babysitting, housecleaning and other service industries? What are our responsibilities to displaced workers as a society? Are there lessons from the previous revolutions (industrial and computer) that we can apply here? In the extreme, what if the cost of labor drops to near zero? Will we have a utopian environment of leisure and wealth for all people? Or instead a dystopian future, including humanity's

return to a slavery mindset (albeit robotic), governmental instabilities due to the outsourcing of all work for our species, and a complete dependency on robotic technology where people can no longer function without these machines at all?

If you find some of these issues unsettling, you are not alone. Hence there is now a strong push within the roboethics community, which originated from a series of workshops involving scientists from the robotics community, as well as representatives from the Vatican, the Pugwash Institute and the Geneva Convention, among others, to engage in this debate.

Some evidence of progress is the release of the recent EURON Roboethics Roadmap (www.roboethics.org/). At the IEEE Conference on Robotics and Automation (www.roboethics.org/icra07), members of the roboethics community will attempt to further engage society in what many of us see as the need to manage critical choices in our field proactively as we move closer and closer to the upcoming robot revolution. **rh**

Additional Reading

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- *Mind Children: The Future of Robot and Human Intelligence* by Hans Moravec, Harvard University Press, 1990
- "The March of the Robot Dogs" by Robert Sparrow, *Ethics and Information Technology*, Vol. 4, No. 4, 2002, pp. 305-318
- *Love and Sex with Robots: The Evolution of Human-Robot Relationships* by David Levy, Harper Collins, 2007
- "The Birth of Roboethics" by Gianmarco Veruggio, Proc. ICRA 2005 *Workshop on Roboethics*, Barcelona, Spain, 2005

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PHOTO BY GARY MEEK



“A congressional mandate requires that by 2010, one-third of all operational deep-strike aircraft be unmanned and by 2015, one-third of all ground combat vehicles be unmanned.”

Ronald C. Arkin,
Regents Professor,
Georgia Tech
College of
Computing

PHOTO BY GARY MEEK



Georgia Tech and Bryn Mawr are able to give students their own robots by using an existing commercial robot called Scribbler™ which is sold to universities at a discount rate. To read more about the new Institute for Personal Robots in Education, based at Georgia Tech, see the article at: gtresearchnews.gatech.edu/reshor/rh-w07/ipre.html

INTRO TO THE FUTURE

College students hoping to pass a required introductory computer science course now have a chance for learning fundamental, often-abstract concepts in a hands-on way. They are learning programming by making small, two-wheeled personal robots move and interact with each other.



PHOTO BY GARY MEEK