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**Research Applies AI to Computer Animation**

# A New Generation of Military Robots

**Danna Voth**

US military branches are undergoing a shift in their structure and missions that's designed to help them become lighter and more agile, able to move easily and quickly to hot spots. Randall Steeb, senior scientist at Rand Corporation, says this transformation is occurring because the military services "see that we aren't going to have another Desert Storm—the enemy isn't going to present itself out in the open as easy targets where precision weapons go in there, take everything out, and we all go home."

Long-range planning to prepare for modern warfare includes developing robotics for military use. For instance, the Army's Future Combat Systems program plans to make a third of its ground forces robotic within about 15 years. Steeb says the Army's 20-year plan envisions 10 steps of robotic development, starting with completely human-controlled systems and ending with autonomous, armed, cooperative robots.

## Robot scouts

Chuck Thorpe, director of the Robotics Institute at Carnegie Mellon University, says robots are good for doing "dangerous, dull, and dirty" things such as scouting. The Robotics Institute has developed a small, unmanned ground vehicle called a "throwbot" that can be tossed into buildings to gather and relay information back to soldiers before they enter the building. The institute is also developing larger robotic vehicles that can do reconnaissance and breaching missions, including a robotic helicopter that can generate 3D models from the air.

The Marine Corps is deploying nine teleoperated throwbot prototypes in Iraq this summer. Dubbed the Dragon Runner, the lightweight robot designed for urban reconnaissance is managed by the Marine Corps Warfighting Lab (see Figure 1a). The robots are being produced by Automatika, which licensed the technology from CMU.

Automatika's cofounder Hagen Schempf says the robot has night capability and can be used as both a listening device and an observation device, using motion detection and sound alerts. Weighing 15 pounds, the Dragon Runner is designed to be light enough to toss through windows or up or down stairs to quickly survey an environment. The robot incorporates a pitching zoom video camera that automatically orients its image no matter which way the robot lands. The Dragon Runner can move at up to 20 miles per hour. Major Scott Gondek says the system is very intuitive. "The handheld controller is based on the latest gaming technology, so it is going to be fairly familiar to most of our young Marines."

## Detecting bombs, destroying mines

By far the most predominant use of robots is mine detection and destruction, says Arnis Mangolds of Foster-Miller, the company that produces the teleoperated Talon robot (see Figure 1b). Developed from earlier, more autonomous surf-zone mine hunter-killer robots, the Talon is an unmanned, waterproof vehicle that's primarily used for bomb disposal in land operations. The robot weighs 60 pounds stripped and can go as fast as 5.2 miles per hour. Designed as a modular system that can carry 200-pound payloads, the Talon uses a removable, double-jointed, 64-inch pincer arm when disposing of explosives. Mangolds says it has the size and mass capable of carrying significant payloads, with enough stability to plow through dry grass and similar environments.

Currently certified by the US Defense Department for remotely controlled live firing of lethal weapons, the Talon has been adapted to carry such payloads as an antitank launcher, a 40-mm grenade launcher, and remotely controlled M240, M249, M16, and M82A1 weapons. The Talon was used in search and recovery missions at the World Trade Center after the September 11 attack and was also deployed during the war in Afghanistan. Twenty Talon robots were deployed in Iraq in the beginning of 2003 and have accomplished over 10,000 missions. Mangolds says all the US military branches presently use the Talon.

A smaller robot used for explosive-ordnance disposal and search and reconnaissance is iRobot's teleoperated PackBot. Weighing about 40 pounds, the PackBot



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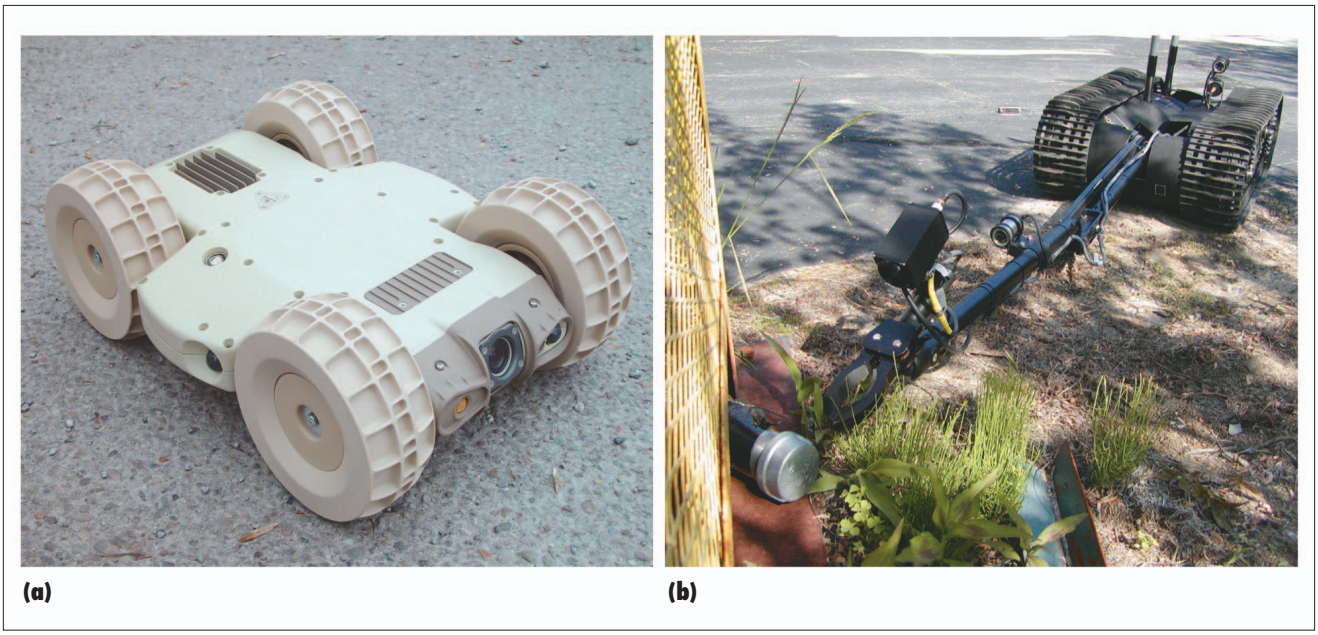


**Figure 1. Two military robots: (a) The 15-pound Dragon Runner is light enough to toss through a window for reconnaissance. (b) The 60-pound Talon is a modular system that can carry 200-pound payloads.**

garnered praise when one was recently lost on an "improvised explosive device" mission in Iraq. Tom Ryden, iRobot's director of sales and marketing for its government and industrial division, says, "We're happy that the robot could be in a situation so that a soldier didn't have to be—one robot lost means one soldier was not."

The PackBot was originally developed through a DARPA contract and first deployed in Afghanistan in the summer of 2002 for search and reconnaissance missions in caves and buildings. Then iRobot developed an arm payload that could reach up six feet from the platform with a gripper that can pick up things. Able to fire disrupters, it was deployed in Iraq, where roadside bombs are a big issue. Ryden says about 50 systems are deployed in Afghanistan and Iraq. Able to withstand 500 Gs, the PackBot is ruggedly built and can be thrown around, dropped, and stomped on. The vehicle has an all-digital architecture and eight payload ports, can carry up to 40 pounds, and moves at about 4.9 miles per hour. According to Ryden, iRobot is experimenting with chemical-biological payloads and working on building more autonomy into the robot. Another goal is to pare it down and make it more durable. "Every soldier has indicated that, boy, it would be nice if it were lighter," Ryden says.

Looking toward the future, iRobot is also developing a larger robot—what Ryden calls "a PackBot on steroids"—through funding provided by a DoD group called the TSWG (Technical Support Working Group). The new robot will be based on the same idea as the PackBot—with a dual-track system and flippers that let it move over a wide range of obstacles—but it will be able to carry a larger payload.

## Medical aides

Robots may also be able to help recover wounded soldiers in the field. Applied Perception Inc. is developing paired marsupial robots that could lead or follow medics around the battlefield and find and remove wounded soldiers. The project is funded by the US Army Tank Automotive Command, the Office of the Secretary of Defense Joint Robotics Program, the Army Medical Research and Materiel Command Telemedicine, and the Advanced Research Center. A small robot equipped with sensors goes out to search and reports discoveries to the larger robot, which then comes to carry the soldiers off the battlefield.

API's president, Todd Jochem, explains how the robots would work with medical personnel. "The medic has a PDA with GPS in it which he uses to interact with all the robots. The medic can simply walk where he wants to go, then hit a button, and the robot will automatically follow him."

The robot can also search first and relay information to the medic or other robots about the environment. Or, the robot can use environmental information to quickly retrace its steps. Jochem says that in terms of a 10-year goal, he's looking at putting more advanced diagnosis and intervention devices on the robots so that they can provide medicine and do procedures to help keep soldiers alive.

## The drawbacks

Robot use is growing as they become more capable and reliable, but not everyone thinks they will be as common or as autonomous as the military hopes. Steeb notes that while robots are less vulnerable than humans in many ways, such as to chemical and biological weapons or to pressure bombs, a small robot is easily disabled. "You can throw a coat over it," he says.

Studies by Rand also found that the robots' slow speeds makes them easy targets. Mangolds notes a final problem robots have: "They harm by telegraphing what you are doing. In fighting, the vast majority of successes really come from surprise and fast action."

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# Research Applies AI to Computer Animation

**Benjamin Alfonsi**

A recent report out of Brigham Young University details new methods for endowing computer-generated characters with artificial intelligence. Research findings, published in the *Journal of Computer Animation and Virtual Worlds* earlier this year, outline innovations in the interplay between animation and AI while raising questions about the future of computer animation technology.

"We thought we'd take these fields and try to find some kind of common ground between the two," says Parris Egbert, a computer science professor at BYU and coauthor of the report.

Jonathan Dinerstein, a PhD candidate at BYU whose doctoral research served as the impetus for the study's findings, would call it a marriage between animation and machine learning, specifically.

"Up until now, the ways in which machine learning has been applied to computer animation have been extremely limited," he says. "Programming by demonstration, such as in robotics, is the most exciting thing happening today with respect to animated characters."

## Speeding up the work

The study presents a model that lets computer animators create autonomous animated agents while drastically reducing the time traditionally required to bring them to life.

"It can often be difficult and time consuming to explicitly define all aspects of the behavior and animation of a complex virtual character," the report states. And in a world where time is money, faster equals cheaper equals better.

"Many improvements are being made to speed up the animation process and make it cheaper," says Chris Bregler, associate professor of computer science at New York University's Courant Institute and Media Research Lab. "AI-based techniques have already been used in crowd simulations, where hand-animations would have been way too labor intensive."

"We think that it will be very cost effective," Egbert says. "The storage requirements of this technique are very reasonable, and the computation time involved is also minimal."

## Guidelines rather than rules

Researchers behind the report used neural networks and what they call offline learning, a type of reinforcement learning, as the basis for their study. "We give the characters guidelines, then they decide what they want to do in the given situations," Egbert says.

"The system uses an artificial neural network to approximate a cognitive model. The computer figure uses the results of the neural network to determine appropriate actions based on its current state and the state of the environment," he explains. "Reinforcement learning is also employed so that the computer model can automatically learn an unknown behavior without an explicit model."

Among the benefits the technology offers are animated figures that are more life-like, especially human figures.

"The human figure is problematic to the animator," says John Canemaker, director of the Animation Studies Program at New York University's Tisch School for the Arts. "It's a calculated decision to have fish and robots be the 'stars' of animated movies."

Hugo de Garis, associate professor of computer science at Utah State University and coauthor of the report, agrees. "The aim is to make [animated characters] more life-like, to give them personalities in their motions," he says. "It's a real challenge, but 'brain building' is increasingly meeting it."

Other benefits include the ability to bring large numbers of animated models to

life at once, and to do so in real time. According to the report, several thousand intelligent characters can be animated in real time on a PC.

The latter point, according to Egbert, is key. "What's novel about this is that complex characters can adapt online and in real time," he says. "So if you played a game, a character could play one way. In another game, that same character could play another way."

## Will they work in films?

The utility of autonomous computer-generated models in gaming seems obvious. But to what extent would the same innovations impact filmmaking?

Although this software solution hasn't been tested in the movie market, researchers believe that large animated sequences—such as the battle scenes in the most recent *Lord of the Rings* installment—could be created more quickly, not to mention more realistically, using this technology.

Some experts in the animation field remain skeptical. "I can see how it has a lot of potential for the game market, but not so much for films," Canemaker says. "As an animator and filmmaker, you relish control; it's God-like, it's like Frankenstein."

Still, researchers believe that their animation innovations will entice game and movie companies alike that want to cut costs while creating more life-like computer-generated characters.

"We feel that the technique we have developed is useful for several applications," Egbert says. "How quickly that happens will depend upon how quickly people learn about the work and begin incorporating it into their applications."

How long will it take for this technology to become widely used? "Maybe in the next five years," de Garis says. "Brain building is still in its infancy."

## AI's emotional IQ

As for the future of AI and animation, will computer-generated characters one day be able to mimic human behavior as well as activity? Will they be able to mimic moral choices and emotional responses?

"Right now the most exciting area in AI is machine learning," Bregler says. "With machine learning techniques, it should be possible to simulate important emotions."

De Garis is also positive. "I think this kind of thing is coming," he says. "Modern electronics allows billions of artificial neurons to be made into A-brains today, so this kind of thing is definitely only a few years away."

Animation purists will believe it when they see it. "Human behavior is unpredictable," Canemaker says. "Are these characters going to be humanly unpredictable—for instance, laughing at funerals or crying with joy?"

The research outlined in the report is evolving, now concentrating on the issue of behavior. "Originally, we wanted autonomous agents to be able to make smart choices quickly," Dinerstein says. "Now we're moving on to more sophisticated concepts, such as the animator actually being able to teach a character what it should do, or even how it should feel." ⬒