◀**Future uses of robotics include demining and both military and civilian search and rescue. The machines require a great deal of human supervision, but developers hope that they will gain more autonomy.** (DARPA artist's conception)

User-Friendly Machines Help Boost Performance in Robots

by A. Duffy Baker

Technological advances in the field of human-computer interaction will pay off dividends for U.S. military programs focusing on battlefield robots and tactical data networks, experts said.

Jim Osborne, a robotics specialist with the Pittsburgh Robotics Initiative, believes that autonomous machines today have enough intelligence to govern their own actions.

But not everyone agrees. Some experts believe that autonomous capabilities are mature and advanced enough for full deployment in robotic platforms, while others advocate a more cautious approach.

Osborne predicts that U.S. military programs will support a "mixed mode of operations," including both fully autonomous robots and others that need more human control.

The "program to watch" for robotics technology development is the Army's Future Combat System, said Osborne. Under this project, the Army plans to develop a fleet of light combat vehicles, some of which may be remotely operated. "The success of this program will shape the future of military robotics," Osborne said. "We'll see how well the rubber meets the road."

Additionally, said Osborne, there are many other areas where the U.S. military services will benefit from robotics technology. These include de-mining, and search-and-rescue missions.

Some of the challenges in developing advanced robots can be attributed to the fact that "computers are hard to use," said Clinton Kelly, senior vice president of advanced technology programs at Science Applications International Corporation, in San Diego. "It is unarguable that computers have changed the way we do business, but it is debatable whether or not they have made it more productive," Kelly told a conference of the Government Electronics and Information Technology Association (GEIA).

Computers make demands on certain cognitive abilities such as logical reasoning and spatial memory, he explained. Users who score in the top 25 percent in logical and spatial ability do twice as well with a computer as the lowest 25 percent. "We concluded that one out of three college-educated people can't use computers very effectively," Kelly said.

More research work, therefore, is needed in human-computer interaction, he stressed. One of the most promising areas is speech recognition. Systems are available today for about $200. The software available has a large vocabulary, from 50,000 to 100,000 words in multiple languages. The training time has been reduced to about three to 10 minutes, with a 98 percent recognition accuracy, Kelly said. One growing application for voice recognition technology is to retrieve one's e-mail.

Interface devices will lead to what Kelly calls "the age of proxy devices" or "the post-PC era" in the next three years. He believes that general-purpose computers will be replaced with simpler devices, set up for specific tasks such as e-mail or Web-surfing.

While speech recognition—or converting audible signals to digital symbols is a tough problem—an even harder one is getting computers to understand natural language, the actual meaning of words. Kelly summed up the problem of semantic ambiguity. "You take a word like 'strike' and it has something like 20 to 40 definitions. The average common noun out of the top 200 in usage has about eight meanings and the average common verb about 12 meanings."

There are syntactical ambiguities as well. Any one sentence could potentially have at least half a dozen meanings, Kelly explained.

The way to deal with these problems is to develop computers that know and reason, according to Kelly. "Turns out we've been doing that in the machine intelligence community for a long time. We have created systems that are called knowledge-based systems or expert systems." Kelly said. He cited a project known as Cyc, short for encyclopedia, at Cycorp in Austin, Texas. "They have something like a billion actions in their database that reflects about 10 years of work. ... The kind of knowledge people need to do anything has to be understood by the machine in order for it to understand natural language."

By 2020, Kelly believes, "the age of thinking machines will be well underway."

Computers in Combat

As the military services try to take advantage of computer capabilities in combat applications, they should focus on interface devices, said Corinna E. Lathan, chief executive officer of AnthroTronix Inc., in College Park, Md.

The company is involved in two information technology and robotics programs currently funded by the U.S. Defense Advanced Research Projects Agency (DARPA).

One is the digital military police (MP) program, managed by the U.S. Army Soldier's System Center. Digital MP is a wearable communication and information management computer. The system was developed by ViA Inc., MicroOptical Corporation and Honeywell Inc. A pair of eyeglass frames contains a built-in miniature cam-

The equipment needed to control a tactical mobile robot is wearable and part of a soldier's combat uniform. When activated, the gloves control movement, and a display in the glasses is connected to a camera mounted on the robot. (Raytheon photos)

era—used for face recognition and image displays. A noise-canceling microphone and earphone are used for voice recognition.

The camera allows streaming video to be transmitted from one MP to another. Video generated at checkpoints can be matched against mug shots from the National Crime Interdiction Center database, for example. A military "e-Book" can be used to plot maps that can be shared between soldiers. The e-Book display gives off no light, and the display is readable in sunlight or starlight with night vision goggles. There is also an electronic glove, which works as a computer mouse for the e-Book. It can capture combat gestures and communicate the meaning to other troops in the area, even those not in the line of sight. For instance, a soldier can hold up a fist in a gesture that means halt. His wearable computer translates that into the verbal command and sends it to the earphones of other soldiers in the area. The gestures are preprogrammed into the various sensors contained in the glove.

AnthroTronix originally used this technology in systems developed for children with cerebral palsy, who do not have the fine motor skills to work with objects such as keyboards.

Lathan cited the example of one boy who loves sports. With a baseball glove—equipped with an accelerometer—his movements can be recorded. The computer can then be programmed to accept different gestures as commands. If he wants to swing a bat in an electronic baseball game, all he might have to do is raise his arm, instead of using a joystick or control pad. This can also help him increase his range of motion so that he possibly could feed himself, Lathan explained.

The digital MP also can be programmed to translate English to Spanish, Korean, Arabic, German, French, Italian, Portuguese, Dutch, Thai and Turkish, with only a five-second delay. There are plans to add a feature that allows military terms such as "clicks" to be translated into "kilometers."

Another project that is pushing the technology in computer interface is the tactical mobile robot (TMR). The program seeks to develop lightweight remote-controlled vehicles that can perform reconnaissance missions and other tasks in areas considered too dangerous for manned patrols.

In the early stages of the program, the robot was controlled with a laptop computer, which was not "very effective," according to Lathan.

The obstacles robots used in ground operations face are very complex, explained Army Lt. Col. John Blitch, the program manager for DARPA. They not only have to deal with obstacle detection and avoidance, but with negotiation as well. "These robots have to climb and maneuver on obstacles," Blitch said in a recent interview. "They might have to cut through a chain link fence." The NASA Jet Propulsion Laboratory has also created a robot that can climb stairs. This robot possibly could interact with hostile or non-hostile humans, according to Blitch. Even dogs or horses have been known to interfere with the robots.

While ideally Blitch would like to see the TMR gain full autonomy, dealing with these kinds of situations requires a strong human interface. "We're talking about a robot supervisor, not a driver," stated Blitch. "The robots are still pretty dumb. We need to take over sometimes, override internal commands every once in a while."

Everything used to control a TMR is wearable and part of a soldier's normal combat gear, explained Blitch. The primary interface is a pair of gloves that act as regular protection until a button is pressed. They then become gesture recognizers that control the robot. The thumb acts as a joystick. Touching the pads of various fingers together or rotating the user's wrist will send different commands to the robot. Sign language is also used instead of speech recognition, which can be misinterpreted by the robot or detected by enemy forces, Blitch added.

The robot is equipped with an Omni-Cam, a camera aimed at a hemispheric mirror allowing a 360 degree view. The image is sent to an overhead display set in a pair of glasses worn by the supervisor.

Auditory information is communicated through a bone phone, a tight connection to the skull. "Sound resonates through bone," explained Blitch. "The sound is sent through the skull to the inner ear to the brain."

The robots currently need a lot of supervision, conceded Blitch. This is why he advocates a new operational specialty for robot operations. Studies show that control of the robot can degrade a soldier's primary skills.

Gaurav Sukhatme, a professor of computer science at the University of Southern California (USC), described some of the work that the university is doing on the TMR project. "We have developed a touchscreen-based interface for commanding and controlling a group of TMRs in support of complex missions," he said. The user interface work began in-house at USC and has since been subcontracted to two companies: Rossum Technologies and Indelible Systems.

USC also is participating in the development of autonomous aerial vehicle control and cooperative indoor mapping by robot groups, explained Sukhatme. "In the aerial vehicle-control area, we have demonstrated how an onboard computer can be used to control a helicopter robot, so that a warfighter (who is not a helicopter pilot) could task the flying robot at a high level (point and click) to performs missions, such as surveillance or deploying other robots.

"In the cooperative mapping area, we have demonstrated how a group of small mobile robots can autonomously create a map of the inside of a building. These robots are not joysticked by a human. Instead, they search and map out the building on their own. A map of the inside is displayed to a human on a laptop." ***ND***