FEATURE

Beyond Science Fiction -- NASA Tests Human-Robot Cooperation in Utah Desert

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Designing, then teaching robots to converse and to work in teams with human beings seems like the stuff of science fiction. Yet, NASA already has been taking steps in a Utah desert that may lead the space agency even beyond the creative imagination of science fiction writers.

"One of our biggest problems is to break out of preconceived notions rooted in science fiction or existing robotic technology," said Bill Clancey, principal investigator for the mobile agent software project at NASA Ames Research Center, located in California's Silicon Valley. "By building prototypes and testing them, we can discover what's the appropriate design concept."

For the last three years, near Hanksville, Utah, located in the Southeast Desert, NASA scientists and robots have boldly moved out onto the barren landscape with the goal of advancing robotics, so human-robot teams one day can explore the moon and Mars more effectively. For more than a week in early spring, a group of NASA scientists, engineers and robots have entered the desert to simulate geology explorations of other planets.

Image right: Geologist Abby Semple prepares for EVA (ExtraVehicular Activity, a "space walk" or lunar/planetary surface activity, usually involving astronauts wearing space suits). More efficient ventilation system requiring only one fan is being tested. Image courtesy: NASA.

Ambitious goals were set for this year's Utah field expedition, April 3 to April 16, 2005. One objective was to encourage robots to work together to help 'astronauts' maintain a connection to a wireless computer network, according to Clancey. "The robot is a tool to help people make scientific discoveries," Clancey said, explaining that the robot is another device being added to NASA's scientific tool kit.

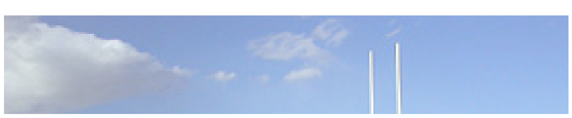
"As you look at NASA's exploration vision to return to the moon and go on to Mars, human-robotic cooperation will be vital to achieve that vision," said Eugene Tu, deputy director for the Exploration Technology Directorate at NASA Ames.

"In order for human beings to work effectively in extreme environments, such as the moon and Mars for long durations, astronauts will require the assistance of robotic systems for such tasks as making science discoveries, constructing human habitats, maintaining habitat environments and performing other scientific studies," Tu explained.

"Human-robotic interactions can best be improved through in-situ experiments, during which people and robots do authentic work," said Clancey. This year's project took place at the Mars Society's Mars Desert Research Station (MDRS), a 20-minute drive from Hanksville, Utah, or four hours from Salt Lake City.

"April is the most variable month in the desert. At that time, it's a transition from temperatures in the 50's (degrees Fahrenheit) (10 degrees Celsius), which occur in March, and the 80's (degrees Fahrenheit) (27 degrees Celsius), which happen May," Clancey noted. "It's a high desert - about 4,000 feet (1,219 meters) in elevation. I've been there three times before, and during that time, we've had dust storms, mud, severe lightning and snow flurries. It can be wonderful, and it can be very uncomfortable. We tell people to bring winter clothes with them - a hat and gloves - because you can always shed layers."

Two robot prototypes participated in the 2005 Utah field operation as part of the Extra-Vehicular Activity Robotic Assistant (ERA) project, which is based at NASA Johnson Space Center, Houston. Each four-wheeled ERA robot, with antennas and other instruments sprouting up from its main body, stands about as tall as a human being. Some 20 scientists and engineers from NASA Ames and NASA Johnson Space Center participated in the tests.



"In this third year, we are attempting to show interactions between the ERA and two geologists," Clancey said prior to the field test. "The ERA will attempt to keep the

geologists on the wireless (computer) network," Clancey added.

Image left: Geologist Brent Garry works on a hill, with the relay in the foreground. Within line of sight of the hab, no relay was actually required at this location. Image courtesy: NASA.

Developed at NASA Johnson Space Center, the robotic assistant responds to voice commands. Engineers designed the robots to be test-beds for research that would lead to the development of specifications and eventually, successful cooperation among suited astronauts and autonomous robots.

The ERA robot includes sensors, similar to the human five senses, but more powerful in some cases. A global positioning system pinpoints each robot's place on the planet, and laser rangefinders help the robots avoid obstacles and plan routes. In addition, each ERA has either a six-axis accelerometer, or a roll-pitch sensor to help the robots navigate and judge the slant of the terrain to avoid tumbles.

The robot's appendages include a manipulator 'hand' that can move in seven degrees of motion, and several pan-tilt camera platforms. The ERA can also pull a trailer to carry tools, samples and equipment.

The ERA robots take part in periodic field exercises at NASA Johnson Space Center and at remote test locations such as Utah. During these exercises, the ERA robots cooperate with space-suited scientists and engineers during a variety of space-relevant scenarios. Engineers use the results of the field tests to improve not only the robot, but also the design of spacesuits, empowering the team to carry out ever more complex jobs.

The robotic assistants also will enable engineers to advance the development of new autonomous robots capable of working in near zero gravity while 'floating' in space.

During the Utah field tests, scientists examined the interacting constraints of landscape, distance, work coordination and other factors to determine what new tools and new methods should be developed and to refine existing technology. This process brought together the remote science team, mission support, the habitat and its crew, robots, computer networks and astronauts to simulate future planetary surface exploration.

Image right: Boudreaux tries to tackle a hill during an independent test of its obstacle avoidance system, which was redesigned this year to use the laser sensor (to provide better data about hills and overhangs). Image courtesy: NASA.

The team set up equipment in and around the Mars Desert Research Station. Team members used prototype tools, including a wireless computer network, voice-commanded robots and voice-commanded mission control communication services that partly automated the role of the kind of communications used during the Apollo missions to the moon in the late 1960s and early 1970s.

Researchers conducted a series of ever-more demanding, human-robot simulated geology missions to scout new terrain during multiple days. These simulations also involved the remote science team. Scientists made audio and video recordings of the activities. Researchers later will evaluate the recordings to learn about human-robot interactions including voice commands and work preferences. From analysis of the recordings and other data, scientists can assess equipment, software and procedures. Scientists can then write new requirements and specifications to improve human-robot interactions and cooperation.

On space missions, astronaut time is valuable. Any help that autonomous robots can lend to astronauts to accomplish routine, repetitive tasks will free human space travelers to focus on research that requires their expertise. Among jobs robots may undertake are simple inspections, maintenance, scouting terrain, making maps and gathering field samples.

Scientists believe that robots also can be helpful to human beings exploring space because of the physical demands that spacesuits and other equipment present to astronauts. Though spacesuits enable people to live and work in the extremely hazardous space environment, these protective garments do hinder astronauts' mobility, dexterity, communications, visibility and strength. In all these areas, robots can augment astronauts' capabilities, and the human-robot team can do what neither people nor machines could do by themselves, according to scientists.

"Last year, our main objective was to test the mobile agent system while people and a robotic assistant explored the desert," Clancey said, discussing the 2004 spring desert tests. "During Apollo missions to the moon, astronauts continuously talked with mission control in Houston. But during our test, each person carried a laptop computer in a backpack. These computers included 'personal agent' software that could literally speak with the human explorers," Clancey added.

The 'mobile agent' software someday may help astronaut-robot teams on Mars talk with teams on Earth, according to Clancey. Scientists believe that the software will improve communications between human planetary explorers, robots and mission support on Earth. 'Mobile agent' software has several parts, including 'personal agent' software -- software to which people can speak -- and 'com' software that links software and hardware devices.

Image left: EVA configuration with Tropos relay to hab (on trailer) and John Ossenfort, from NASA Ames, operating the ATV that simulates Thibodeaux (display mounted up front indicates commands received by Thibodeaux from the agent system). Geologist Abby Semple told Thibodeaux to follow her; Ossenfort carries out necessary movements indicated by the display. Image courtesy: NASA.

During the 2004 field trip, 'astronaut explorers' used the mobile agent system to simulate conducting real science. "They looked for geological evidence of past water in the desert. In the area, there also are many fossils from the Jurassic Period," Clancey noted.

"The key thing is that future explorers will talk with the computer mobile agent software about science observations being made," Clancey said. "There are three specifics that the explorer relays to the agent - the name of the location, which sample bag the explorer is using to collect samples, and a narration of contents of the bag and the geologic context."

The astronaut speaks through a microphone to his or her personal agent software, which relays commands to the robot's personal agent software. This software activates computer programs that direct the robot to follow astronauts, take photographs, keep a video camera focused on a particular astronaut or carry samples.

"In 2004, we also tested planning and communications software, as well as procedures, by having the 'astronauts' communicate with science teams located at several universities," Clancey said. "By sharing data as soon as possible, and sending a video of the crew's planning session for the next day's work, we gained experience on how the Mars crew and scientists on Earth can best work together."

During future planetary exploration, data will be relayed by personal agent software to others on the science team, both on the planet's surface and back on Earth, according to Clancey. Information will be stored in a database in a Mars or planetary human habitat. The personal agent software will send this data via e-mail to the Earth-bound science team. The software also automatically will transmit images taken by the astronauts to their planetary habitat and to Earth.

For more information about the April 3 - 15, 2005, field experiments and images, please visit:

http://www.marssociety.org/MDRS/fs04/

http://ic.arc.nasa.gov/story.php?id=171&sec=3

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