Extravehicular Activity Robotic Assistant

Kimberly Tyree, Johnson Space Center
Jeffrey Graham, S&K Technologies
Robert Hirsh, Johnson Space Center

The Extravehicular Activity (EVA) Robotic Assistant (ERA) Project at Johnson Space Center (JSC) is a testbed for studying human-robot interaction, particularly in planetary surface environments. The project currently has two four-wheeled robots, and has performed many local and remote field tests over the past five years in collaboration with multiple groups from JSC, Ames Research Center, Glenn Research Center, and various universities. Research, software, and hardware from this project are also being ported to other human-robotic interaction projects at JSC.

Local field tests have taken place in the Rock Yard at JSC, in cooperation with the JSC Advanced Suit Laboratory. Remote field tests have taken place in multiple locations in Arizona, including Meteor Crater and Cinder Lake, and near Hanksville, Utah, at the Mars Desert Research Station. Local and remote field tests involve many types of human-robot interaction. Human subjects—in shirtsleeves or in pressurized spacesuits—perform traverses, investigate areas of scientific interest, or deploy sensors. The ERA assists in these tasks by:

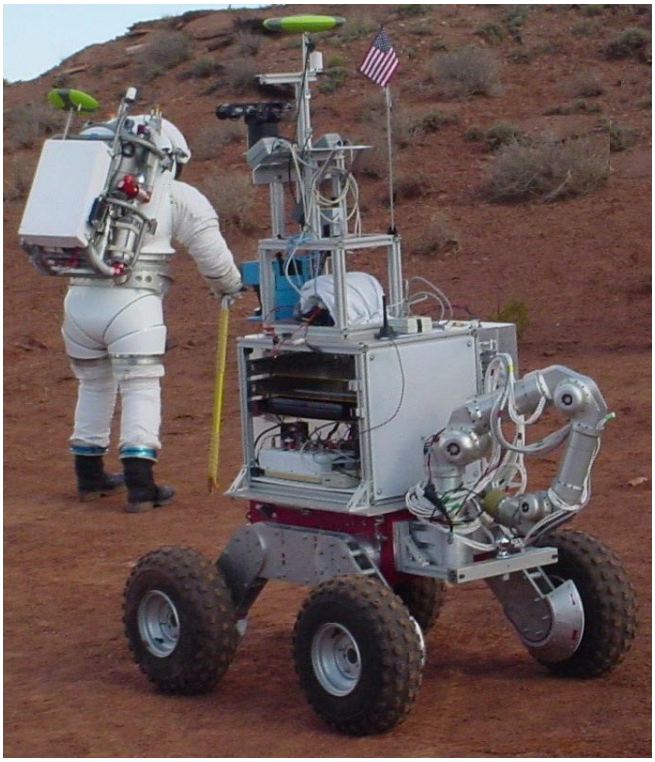
- Tracking and following the human
- Assisting in cable, solar panel, or sensor deployments
- Performing autonomous sensor deployments
- Mapping or scouting a given region autonomously
- Providing advance imagery for a region via teleoperation
- Planning paths for itself or other agents
- Carrying tools, equipment, geological samples, etc.
- Pulling a science trailer
- Monitoring astronaut activities and vital statistics
- Providing EVA imagery, data, and status to a remote base station

Tracking is performed either by having the human wear a global positioning system (GPS)-equipped backpack or by having the robot's laser range finder or stereo-vision cameras locate the human. Each method for acquiring the target has different strengths and weaknesses, and part of the research involves evaluating when to use different methods for the best human-robot interaction. The ERA can maintain a requested distance from the target at all times, whether day or night. Interaction between the human and the robot is through voice recognition and synthesis, gestures, and/or computer control.

One ERA robot has a four-wheeled, skid-steered, rigid suspension base. The second ERA robot has a four-wheel independent drive base with suspension. Both have a modular suite of processors and sensors that can be selected from for different missions. Both bases can be powered with batteries, but the second base was originally designed to accommodate an experimental fuel cell for extended operational time. A seven-

degree-of-freedom arm can also be mounted on either base, and is able to reach storage locations on the robot and ground locations to obtain samples or deploy instruments. A three-fingered hand is attached to the end of the arm.

Computers include as many as three laptops onboard each robot. The software architecture uses multiple CORBA [Common Object Request Broker Architecture] servers, written in C++. Each software server is dedicated to either a particular piece of hardware or a specific functionality, such as base drive,



arm and hand control, GPS, heading, laser targeting, obstacle avoidance, path planning, voice recognition, speech synthesis, stereo vision, object pose recording, tracking, and logging. The servers are modular and can run on any computer connected to the appropriate hardware. Servers on different computers communicate via an Ethernet switch and can be monitored remotely via wireless Ethernet.

The available sensors include a laser range finder, a three-dimensional ladar, multiple vision systems, an attitude and heading sensor, a pan/tilt sensor, and a differential GPS system providing 2-cm position accuracy and 5-deg heading accuracy. One stereo pair of cameras, which is mounted on a pan/tilt platform, is used for autonomously tracking space-suited subjects. Additional cameras can be used for obstacle detection, autonomous crew monitoring, manipulator arm monitoring, and remote viewing by distant crewmembers.

The ultimate purpose of the ERA Project is to develop robotic assistants that will provide useful and robust support to astronauts exploring and living on other planets. Such assistants will increase the efficiency and safety of planetary exploration in support of human exploration of space.