

Robotics for Human Exploration

Future human missions to the Moon, Mars, and other destinations offer many new opportunities for exploration. But, astronaut time will always be limited and some work will not be feasible for humans to do manually. Robots, however, can complement human explorers, performing work autonomously and under remote supervision from Earth.

Robots can do a variety of work to increase the productivity of human explorers. Robots can perform tasks (systematic survey, inspection, etc.) that are tedious, highly-repetitive or long-duration. Robots can perform tasks, such as advance scouting, that help prepare for future crew activity. Robots can also perform "follow-up" work, completing tasks designated or started by humans.

Since 2004, the Intelligent Robotics Group has been working to make human-robot interaction efficient and effective for space exploration. A central focus of our research has been to develop and field test robots that benefit human exploration. Our approach is inspired by lessons learned from the Mars Exploration Rovers, as well as human spaceflight programs, including Apollo, the Space Shuttle, and the International Space Station.



Planetary Rovers



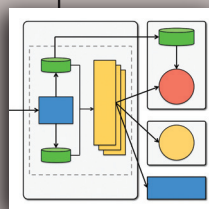
IRG develops planetary rovers to advance the robotics technologies needed for future exploration missions. K9 is a planetary rover used for studying autonomous instrument placement. K10 is a versatile robot designed to perform field work, including site surveys, scouting, and inspection. K10mini is a prototype lunar microrover, which is 1/4 the size of K10 but is fully software-compatible.

Research Facilities



IRG's research and development facilities include an electronics lab, two collaboration workspaces, and the Marscape outdoor test area. The Marscape is a 40m x 80m Mars surface analog site, which includes terrain representative of the geologic features of greatest scientific interest. IRG also makes extensive use of the supercomputing and cloud computing facilities at NASA Ames, in addition to its own large cluster of workstations.

Open Source Software



IRG is committed to developing and releasing open-source software. Open-source increases software quality, accelerates software development, and improves technology transfer to/from NASA. IRG's open-source software includes: the Ames Stereo Pipeline, GeoCam, NASA Vision Workbench, the Neo-Geography Toolkit, the Robot Application Programming Interface Delegate (RAPID), RoverSW, and VERVE. Visit irg.arc.nasa.gov.

The NASA Ames Intelligent Robotics Group (IRG) enables humans and robots to explore and learn about extreme environments, remote locations, and uncharted worlds. IRG conducts applied research in a wide range of areas including computer vision, geospatial data systems, human-robot interaction, interactive 3D visualization, and robot software architecture.

We firmly believe that collaboration is essential to high-quality research. Thus, we actively encourage joint projects with academia, government, and industry. If you are interested in collaborating, or have an application that can benefit from our technology, please contact us today.

For more information about the Intelligent Robotics Group:

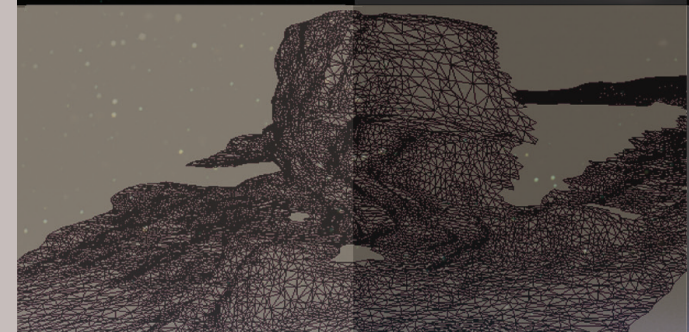
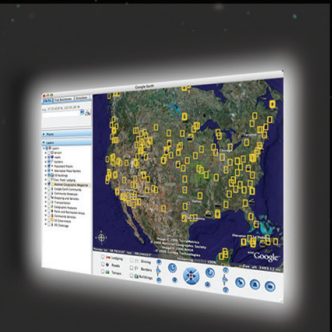
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Intelligent Robotics Group



Intelligent Systems Division
NASA Ames Research Center

Intelligent Robotics

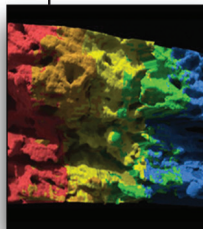
Perception, Interaction, and Architecture for Planetary Exploration

GigaPan Voyage



GigaPan makes creating billion-pixel panoramic images easy. These panoramas can be interactively explored for science, engineering, education and entertainment. Several GigaPan camera systems are available, including commercial robotic mounts and an all-in-one capture/process/display system called "GigaPan Voyage". GigaPan is a partnership between NASA, Carnegie Mellon University, and Google. Visit gigapan.org.

NASA Vision Workbench



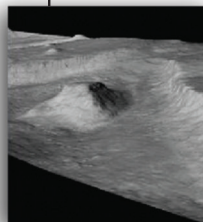
The NASA Vision Workbench (VW) is an open-source C++ framework for efficient computer vision. Vision Workbench has been used to create gigapixel panoramas, 3D terrain models from satellite images, and high-dynamic range images for visual inspection. Vision Workbench supports rapid development on multiple platforms. Visit ti.arc.nasa.gov/visionworkbench.

Planetary Lake Lander



We are developing intelligent sensors to study life and its response to rapidly changing conditions in high-altitude lakes in the Andes. Machine learning software helps guide year-round measurements (with robot floaters and shore stations) and detect unusual events. The techniques developed by this project may eventually be applied to future planetary missions: detecting life in the seas of Europa and understanding the methane lakes of Titan.

Digital Terrain Models



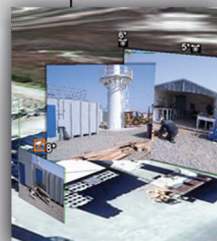
Digital terrain models are essential for cartography, science analysis, mission planning and operations. We have developed software to automatically generate high-quality topographic and albedo models from stereo images, lidar scans, etc. taken by satellites and planetary rovers. Our software uses multi-view geometry and photoclinometric techniques to produce models with very high accuracy and resolution. Visit ti.arc.nasa.gov/stereopipeline.

Human Exploration Telerobotics (HET)



The HET project is studying how advanced, remotely operated robots can improve future human exploration missions by off-loading work from crew, enhancing human abilities, and improving situational awareness for ground controllers. HET is testing how ground controllers on Earth can operate robots on the International Space Station (ISS) and how ISS crew can control robots on both ISS and on Earth.

GeoCam



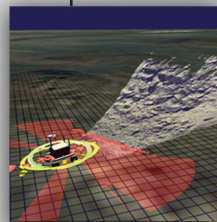
The GeoCam project improves disaster response by creating open-source software for sharing information via mobile devices. This software includes "Lens" (sharing geotagged photos and video), "Track" (tracking team member positions), "Talk" (geotagged text and voice messaging), and "Cover" (search and rescue management). GeoCam has helped responders following the Haiti earthquake and at major wildfires in California.

xGDS: Ground Data System



xGDS is a software system for managing science and operations data for human and robotic missions. xGDS includes tools for mission planning, data management, visualization and analysis. The system is highly modular, makes extensive use of open-source and open standards, and can be rapidly adapted to different missions. xGDS has supported a wide range of field studies and simulated exploration missions.

Verve



VERVE (Visual Environment for Remote & Virtual Exploration) is a high-performance, 3D, user interface for visualizing robot data in real-time. VERVE uses a component-based software architecture to flexibly support different applications and users. VERVE has been used to remotely operate many NASA mobile robots in a wide variety of planetary analog field tests.

Planetary Content



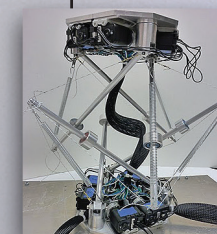
The Planetary Content project makes NASA's vast stores of planetary data more accessible and useful through Web-enabled tools. In collaboration with Google, Planetary Content has produced "Mars in Google Earth" and "Moon in Google Earth". Planetary Content develops everything from educational content for the general public to high-performance interfaces for scientists.

Human-Robotic Systems



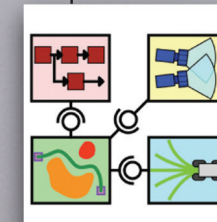
We are developing and field testing robots to understand how they can be used between manned exploration missions to improve crew productivity and science return. When humans return to the Moon, crews will initially be on the surface less than 10% of the time. Robots can perform work even when humans are not present, including reconnaissance, survey, and inspection.

Tensegrity Robots



Robots based on tensegrity structures have significant potential to reduce the size, mass, and energy required for manipulation and mobility in space. Tensegrity structures are extremely lightweight, can be compactly stored for launch, are inherently compliant, and are highly robust. Our work focuses on controlling these highly non-linear structures using distributed, force-based control methods.

Rover Software



IRG's rover software system is a service-oriented architecture. With this approach, robotic applications can be built as a collection of on-demand services. This enables complex, extensible and scalable development to be performed in a highly efficient manner. Rover software services include terrain mapping, hazard detection, infrastructure-free localization, rough terrain trajectory planning, and instrument control.