Robotic Technology Development at Ames
The Intelligent Robotics Group and Surface Telerobotics

Maria Bualat
Intelligent Robotics Group
NASA Ames Research Center
Maria.Bualat@nasa.gov
Intelligent Robotics Group (IRG)

Overview
• 31 researchers (14 Ph.D.’s)
• 20+ summer interns yearly
• 75% NASA work (ARMD, HEOMD, STMD, SMD)
• 25% reimbursable (Google, etc.)
• SBIR / STTR (10 current proj.)

Research themes
• Automated planetary mapping
  − Base maps & terrain models
  − Geospatial data systems
• Robots for human explorers
  − Improve efficiency & productivity
  − Pre-cursor & “follow-up” work
• Public service
  − Disaster response & outreach

irg.arc.nasa.gov

IRG Collaborations (2010 – 2012)

Academic

Commercial

Government
Robotics for Human Exploration

Purpose

• Increase human productivity
• Improve mission planning & execution
• Transfer some tasks to robots (tedious, repetitive, long-duration)

Before Crew

• Recon (scouting) & prospecting
• Site prep, deploy equipment, etc.

Supporting Crew

• Inspection, mobile camera, etc.
• Heavy transport & mobility

After Crew

• Follow-up & close-out work
• Site survey, supplementary tasks, etc.

IRG’s Current Robots

K10 mini
TenseBot
K10
Smart SPHERES
KREX
Modular Arm
Lake Lander
GigaPan
K10 Robot at Haughton Crater, Canada

Sensing

- Gas & vapor
- Force, torque, & tactile
- Position & orientation
- Vision & distance
Perception

High Dynamic Range inspection (2006)

Dark Navigation (2007)

Robotic Site Survey (2008)

GigaPan Voyage (2009 - 2011)

Rover driving, Basalt Hills, California (2012)
Smart SPHERES robot, ISS (2012)

User Interfaces

VERVE (2007 - 2013)
K10 Data Browser (2010 - 2011)
Google Earth Ops (2008 - 2011)
Interactive Ground Control (2008 - 2010)
System Software

Mars in Google Earth

Explore Mars in 3D
- Released Feb. 2, 2009
- Co-developed with Google
- NASA Ames created content & processing scripts

Content
- Global maps: topography, infrared, historical, etc.
- Imager footprints & overlay (HiRISE, CTX, MOC, ...)
- Mars rover tracks & color panoramas
- Tours (Bill Nye & Ira Flatow)
- Live from Mars: THEMIS
- And much more ...
Moon in Google Earth

Explore the Moon in 3D
•" Released July 20, 2009
•" Co-developed with Google
•" NASA Ames created content & processing scripts
Content
•" Global maps: topography, geologic, historical, etc.
•" Spacecraft imagery: Apollo, Lunar Orbiter, etc.
•" 3D models of spacecraft, landers, and crew rovers.
•" Tours (Andy Chaikin, Buzz Aldrin & Jack Schmidt)
•" And much more …

WorldWide Telescope | Mars

Complete HiRISE Mosaic
•" Mars Reconnaissance Orbiter HiRISE imager
•" 74,000 images
•" Each image: 20K x 50K pixels (> 1 GB / image)
Mosaic stats

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IRG Open Source Software

- Vision Workbench
- GeoCam
- RoverSW
- Vehicle Detection
- Neo Geography Toolkit
- RAPID

SURFACE TELEROBOTICS
Human Exploration Telerobotics (HET)

Key points
- Remotely operated robots (ground control & crew centric ops)
- Multiple robots, demos & missions
- Support future human exploration

HET Telerobotic Systems

- Robonaut 2
  - Humanoid robot (42 DOF, human-scale/safe)
  - Perform dexterous IVA/EVA manipulation tasks
  - Share astronaut tools and workspaces

- Smart SPHERES
  - Free-flying robot (6 axis, cold-gas propulsion)
  - Perform IVA/EVA remote mobile sensor tasks
  - Improve ground control situation awareness

- Surface Telerobotics
  - Mobile robot on surface (Moon, asteroid, Mars)
  - Perform surface activities before/support/after crew
  - Crew centric operations from inside flight vehicle
Surface Telerobotics

Surface Telerobotics is an engineering test of a human-robot “opscon” for future deep-space human exploration missions

Candidate Missions

• "L2 Lunar Farside. Orion crew module test flight (~2020) to Earth-Moon L2 point
• "Near-Earth Asteroid. NEA dynamics and distance make it impossible to manually control robot from Earth
• "Mars Orbit. Crew must operate surface robot from orbit when circumstances (contingency, etc.) preclude Earth control

What will the test achieve?

• "Obtain baseline engineering data
• "Validate & correlate prior ground simulations
• "Reduce the risk that mission planning is based on inaccurate assumptions

L2 Lunar Farside (Waypoint) Mission Concept

Orion at Earth-Moon L2 Lagrange point

• "60,000 km beyond lunar farside
• "Allows station keeping with minimal fuel
• "Crew remotely operates robot on lunar farside
• "Less expensive than human surface mission
• "Does not require human-rated lander

Primary objective: lunar telescope

• "Use telerobot to setup radio telescope
• "Requires surface survey, antenna/receiver deployment, and inspection/documentation
• "Lunar farside provides radio quiet zone for low-freq measurements cosmic dawn

Secondary objective: sample collection

• "Use telerobot to perform field geology
• "Requires scouting, sampling (possibly subsurface), and sample caching/return
• "South Pole Aitken (SPA) basin sampling is the highest priority lunar science objective
Waypoint Mission Simulation (2013)

Spring 2013

June 17

July 26

August 20

Crew Interface (Task Sequence Mode)
Crew Interface (Teleop Mode)

3D View controls
3D View controls

Rover path
Rover path

Motion controls
Motion controls

Camera controls
Camera controls

Terrain hazards
Terrain hazards

Rover camera display
Rover camera display

Data Communications (Upside-down Payload)

Crew Interface on SSC

384 kbits/sec (min), 5 sec delay (max)
384 kbits/sec (min), Out-of-Band

Rover/Science Data (e.g. imagery)

Interface Instrumentation & Evaluation Data

Rover Task Sequence (text file)

“Live” Rover Sensor and Instrument Data (telemetry)

Uplink, data transfer

Uplink

Downlink

Post-test File Transfer

Note: Normal uplink ~1Mbps, spike after LOS is ~2Mbps for 2 sec
K10 rover before dawn in the ARC “Roverscape”

K10 Planetary Rover @ NASA Ames

K10 Specifications
• 4-wheel drive, 4-wheel steer
• Split rocker chassis
• Size: 1.3 x 0.9 x 1.0 m (HxWxL)
• Speed: 0.9 m/s (on 10 deg slope)
• Power: 1900 W (Li-ion batteries)
• Weight: 100 kg (with 25 kg payload)
Telerobotic Lunar Telescope Deployment

K10 deploying simulated polyimide antenna.

K10 Deploys Kapton Film in Marscape
Chris Cassidy uses the “Surface Telerobotics Workbench”

Astronaut remotely operates K10 from the ISS (2013-06-17)

Astronauts Parmitano & Nyberg Operate K10 from ISS
ISS Mission Control (MCC-H) during Surface Telerobotics test (2013-08-20)

View of robot interface (top left) and K10 at ARC (top right)

“PLUTO” Multi-Purpose Support Room at JSC

Provides data comm & crew laptop support
Multi-Mission Operations Center (MMOC) at ARC

Manages Surface Telerobotics test sessions

K10 support team at ARC

Provides rover engineering & test logistics
Questions?

Intelligent Robotics Group
Intelligent Systems Division
NASA Ames Research Center

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