Active Project (2015 - 2016)

Telerobotic Perception during Asteroid and Mars Regolith Operations Project

Center Innovation Fund: KSC CIF Program | Space Technology Mission Directorate (STMD)

ABSTRACT

Current space telerobotic systems are constrained to only operating in bright light and dust-free conditions. This project will study the effects of difficult lighting and dust conditions on telerobotic perception systems to better assess and refine regolith operations on other neighboring celestial bodies. In partnership with Embry-Riddle Aeronautical University and Caterpillar, Inc., optical, LiDAR and RADAR sensing equipment will be used in performing the study. This project will create a known dust environment in the Swamp Works Granular Mechanics & Regolith Operations (GMRO) Laboratory regolith test bin to characterize the behavior of the sensing equipment in various calibrated lighting and dust conditions. It will also identify potential methods for mitigating the impacts of these undesirable conditions on the performance of the sensing equipment.

Enhancing the capability of telerobotic perception systems will help improve life on earth for those working in dangerous, dusty mining conditions, as well as help advance the same technologies used for safer self-driving automobiles in various lighting and weather conditions. It will also prove to be a critical skill needed for advancing robotic and human exploration throughout our solar system, for activities such as mining on an asteroid or pioneering the first colony on Mars.

ANTICIPATED BENEFITS

To NASA funded missions:

Current space telerobotic systems are constrained to only operating in bright light and dust-free conditions. Enhancing the capability of telerobotic perception systems will prove to be a critical skill needed for advancing robotic and human exploration throughout our solar system, for activities such as mining on an asteroid or pioneering the first colony on Mars.

GMRO Lab Regolith Test Bin at KSC

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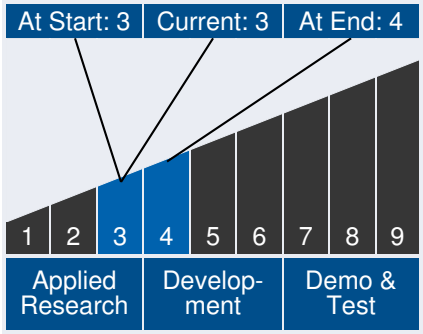
Technology Maturity



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To NASA unfunded & planned missions:

Current space telerobotic systems are constrained to only operating in bright light and dust-free conditions. Enhancing the capability of telerobotic perception systems will prove to be a critical skill needed for advancing robotic and human exploration throughout our solar system, for activities such as mining on an asteroid or pioneering the first colony on Mars.

To other government agencies:

Enhancing the capability of telerobotic perception systems will help improve life on earth for those working in dangerous, dusty mining conditions, as well as help advance the same technologies used for safer self-driving automobiles in various lighting and weather conditions.

To the commercial space industry:

Current space telerobotic systems are constrained to only operating in bright light and dust-free conditions. Enhancing the capability of telerobotic perception systems will prove to be a critical skill needed for advancing robotic and human exploration throughout our solar system, for activities such as mining on an asteroid or pioneering the first colony on Mars.

To the nation:

Enhancing the capability of telerobotic perception systems will help improve life on earth for those working in dangerous, dusty mining conditions, as well as help advance the same technologies used for safer self-driving automobiles in various lighting and weather conditions.

DETAILED DESCRIPTION

The goal of this project is to study the effect of difficult lighting and dust conditions on Telerobotic Perception Systems to better assess and refine regolith operations for asteroid, Mars and

Management Team

Program Director:
- Steven Gaddis

Project Manager:
- Nancy Zeitlin

Principal Investigator:
- Robert Mueller

Technology Areas

Primary Technology Area:
Robotics, Tele-Robotics & Autonomous Systems (TA 4)

Secondary Technology Area:
Modeling, Simulation, Information Technology & Processing (TA 11)

Other Technology Areas:
- Human Exploration Destination Systems (TA 7)

polar lunar missions. Low illumination and low angle of incidence lighting pose significant problems to computer vision and human perception. Levitated dust on Asteroids interferes with imaging and degrades depth perception. Dust storms on Mars pose a significant problem.

Due to these factors, the likely performance of telerobotics is poorly understood for future missions. Current space telerobotic systems are only operated in bright lighting and dust-free conditions. This technology development testing will identify:

1. the impact of degraded lighting and environmental dust on computer vision and operator perception
2. potential methods and procedures for mitigating these impacts
3. requirements for telerobotic perception systems for asteroid capture, Mars dust storms and lunar regolith ISRU missions.

Machine perception during navigation will be studied and improved using a variety of new optical sensing techniques. It is anticipated that sensing techniques will be highly dependent on ambient light and dust concentrations. Velodyne LiDAR systems used by Caterpillar in commercial applications will be tested. Lighting angle of incidence mounts to simulate various geometries will be manufactured. Collimation will be achieved by a combination of low viewing angle LEDs and commercially available optical components. Evaluation will coincide with Regolith Operations development testing opportunities and be available for further use and simulation to advance robotics and telepresence understanding.

Studies will involve a variety of optical, and other sensor tests, using preprogrammed asteroid tumbling models, varying both intensity and angle of incidence to determine susceptibility to bloom, glare, and contrast issues. Polarization, single and multi-wavelength band pass will be tested and improvements researched.

In telerobotic systems, sensors, **cameras and other optic elements suffer from pixel saturation and bloom with associated recovery times**. Coupled with a decreased perceived contrast and erratic daylight cycles, asteroid missions will have to overcome, or compensate for these effects. **This study will have a direct impact on both human habitation and the extraction of in-situ resources using autonomous systems**. The study will also highlight shortfalls prior to deployment for automated systems and identify physiological hazards**. Thus, the study has potential to significantly influence design of telerobotic perception systems and operations for future exploration missions.**

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Autonomous mining vehicles (as well as self-driving cars) are an emerging technology with large potential. Dust and lighting conditions may cause serious accidents if sensing systems are compromised. Research in this area could also impact the understanding of perception and cognition in older drivers and mitigate a leading cause of traffic accidents.

The knowledge gained by this project:

- Understanding of the operational challenges facing a telerobotic asteroid mission
- Development of full capability to simulate lighting conditions through user interface to 3 axis tumbling simulation code
- Insight into the effect on computer vision systems under these conditions as well as human perception
- Ability to test and evaluate new technologies in high fidelity conditions for use in future telerobotic missions

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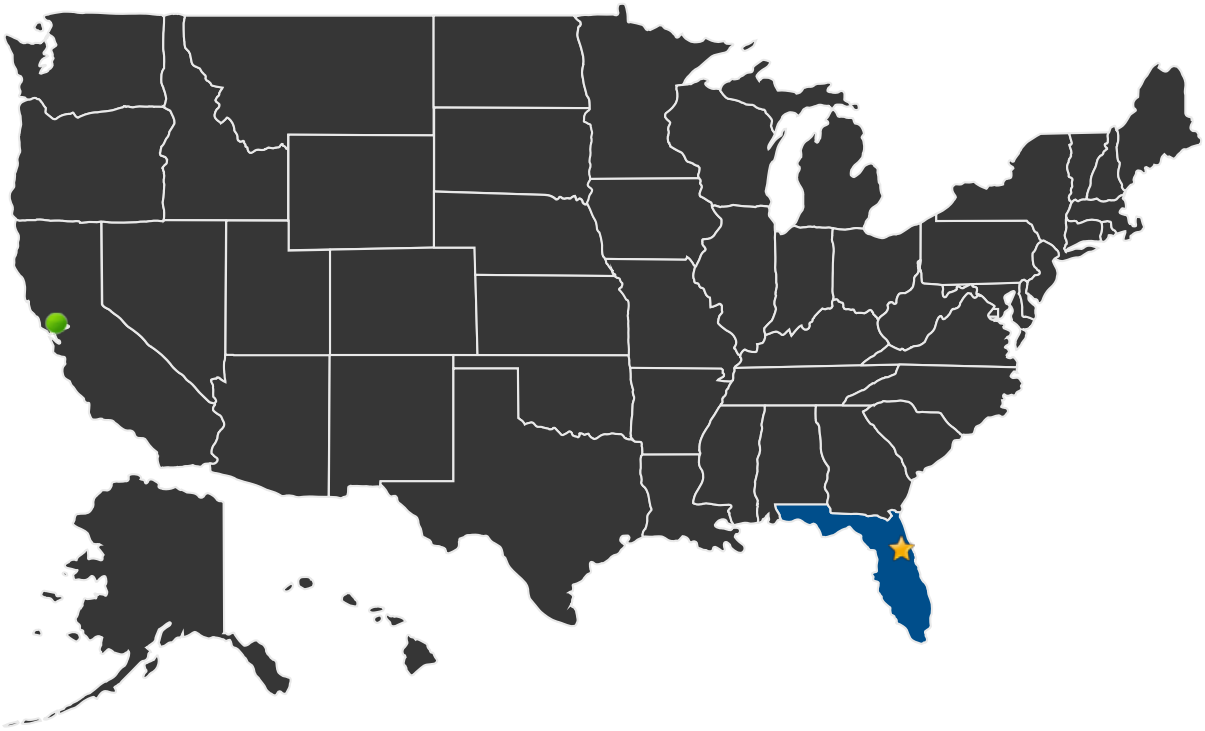
U.S. LOCATIONS WORKING ON THIS PROJECT



U.S. States With Work

Lead Center:
Kennedy Space Center

Supporting Centers:

- Ames Research Center

Other Organizations Performing Work:

- Caterpillar, Inc.

Contributing Partners:

- Embry-Riddle Aeronautical University

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IMAGE GALLERY

200 ton truck operating without a driver

Verlodyne LiDAR sensor equipment

DETAILS FOR TECHNOLOGY 1

Technology Title

Telerobotic Perception in Dusty Environments

Technology Description

This technology is categorized as a hardware subsystem for unmanned flight

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Capabilities Provided

The knowledge gained by this project:

- Understanding of the operational challenges facing a telerobotic asteroid mission

Continued on following page.

- Development of full capability to simulate lighting conditions through user interface to 3 axis tumbling simulation code
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Potential Applications

Space Missions to dusty Asteroids

Surface Operations on Mars during dust storms

Landing operations on Moon, Mars and Asteroids

Mining operations underground and in open pit mines

Autonomous and piloted helicopter landing and takeoff lofted dust "brown-out" mitigation

Autonomous cars driving off-road or in dusty low angle light conditions

Performance Metrics

Metric	Unit	Quantity
Target visible in a dusty environment	meters	5
Target visible in a low angle lighting environment	degrees	5