AstroSLAM - A Robust and Reliable Visual Localization and Pose Estimation Architecture for Space Robots in Orbit

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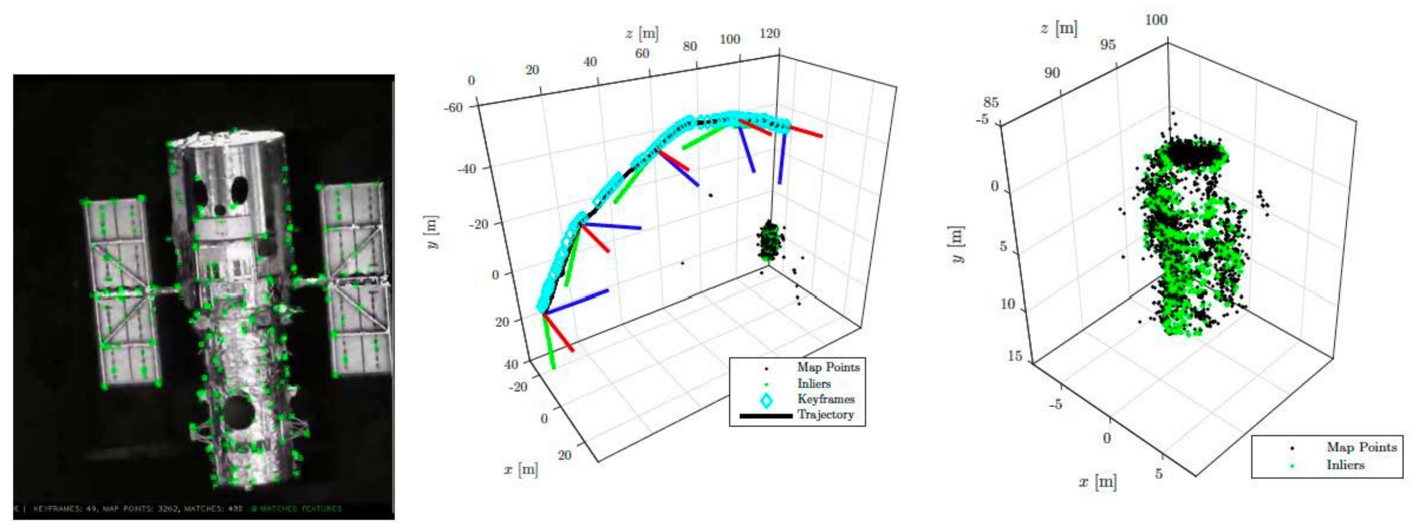
http://dcsl.gatech.edu/research/space-robotics-astroslam.html

Project Objectives and Goals

- Develop the next generation of **sensing and planning** technologies to enable **routine collaborative human-robot** on-orbit servicing

Main Challenges

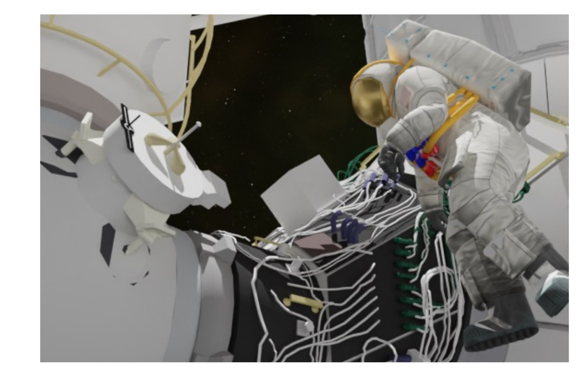
- Extreme environment, challenging lighting conditions, limited communication bandwidth, etc.
- Orbital motion, fuel constraints, limited computational resources
- Specular reflection, high contrast



(a) ORB features (b) Key frames (c) Point cloud of HST

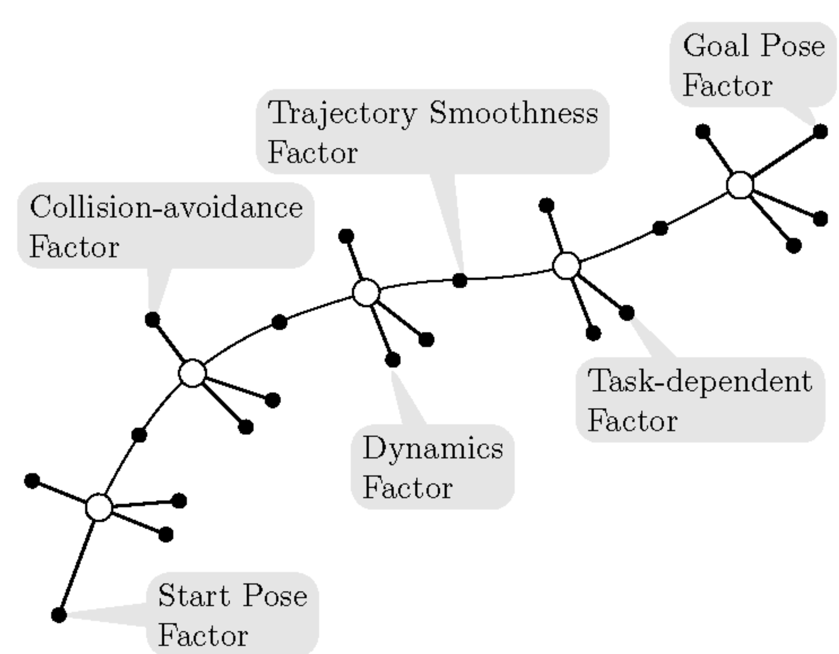
Scientific Impact

- Innovative collaborative and learning-based sensing architecture within the traditional Guidance, Navigation & Control (GNC) framework
- Advancements in Human-Robot Interaction (HRI) through the design of a safe collaborative scenario compensating for risks derived from in-space operations
- Advancements in multi-agent task-specific motion planning on a conceptual, technical, and implementation level
- Novel front-end, multi-model (VISIR) robust feature detection
- Collaborative multi-view perception and shape reconstruction



Proposed Technical Approach

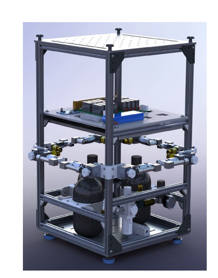
- Deep NN Architectures for Automated Feature Detection and Matching in Space
- Full 4D Situational Awareness (4DSA) for Robots and Humans in Space
- Multi-agent Kinodynamic Motion Planning for 4DSA
- Simultaneous Trajectory Estimation and Planning (STEAP) able to provide fuel-optimal, collision-free motion plans satisfying task-specific
- Efficient 3D shape reconstruction

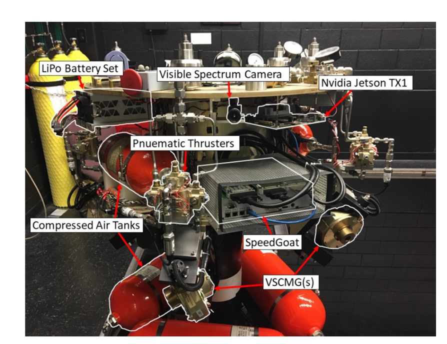


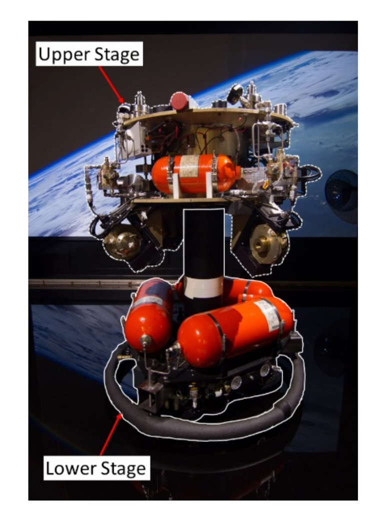
- Dynamic factor graphs
- Fusion of visible and IR imagery
- Relative Keplerian motion priors
- Co-visibility constraints
- DQ formalism for combined motion

Experimental Validation

- ASTROS (5dof)
- COSMOS (3dof)

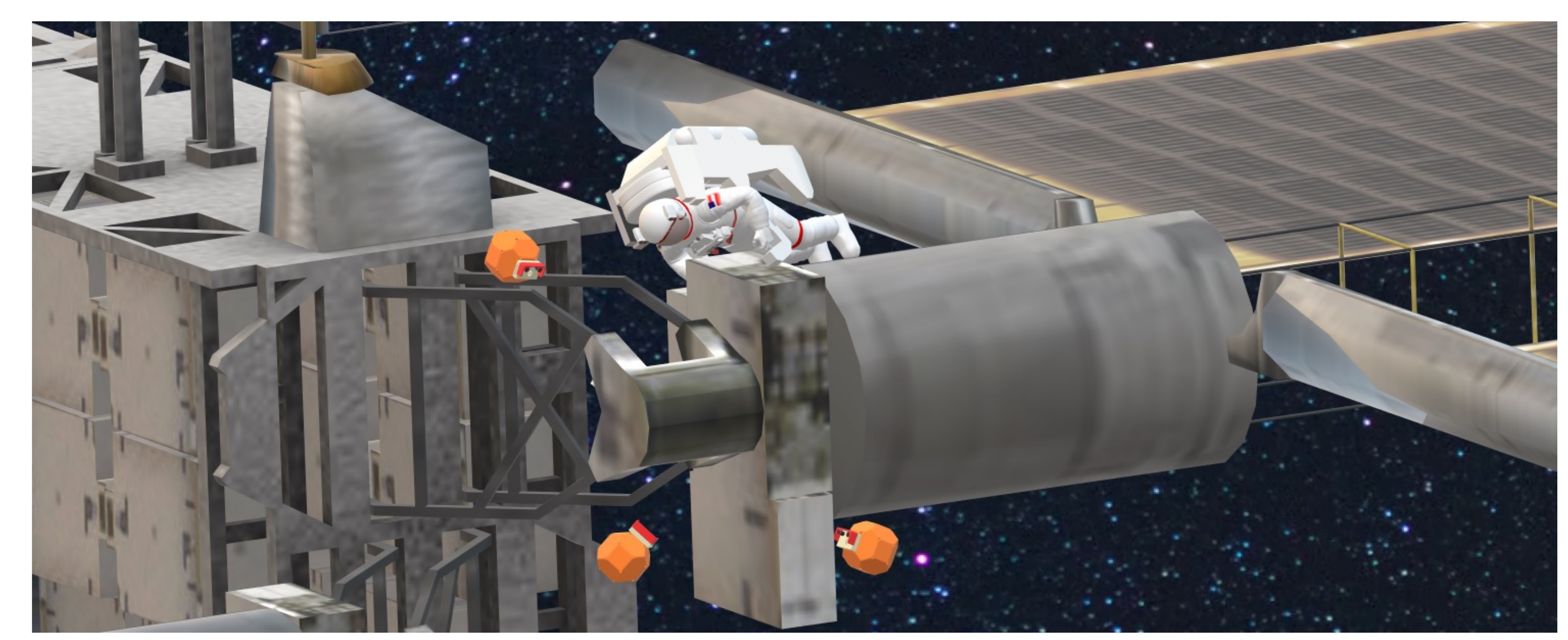






Broader Impacts

- Operation in dangerous and inaccessible environments
- Maintenance and enhancement of current space infrastructure
- Attract a young and diverse audience through presentations and research fellowships (PURA, REU)



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