National Aeronautics and Space Administration

FY24 Strategic University Research Partnership (SURP)

Multi-Phase Autonomous Vision-Based Navigation for Planetary and Small Body Exploration

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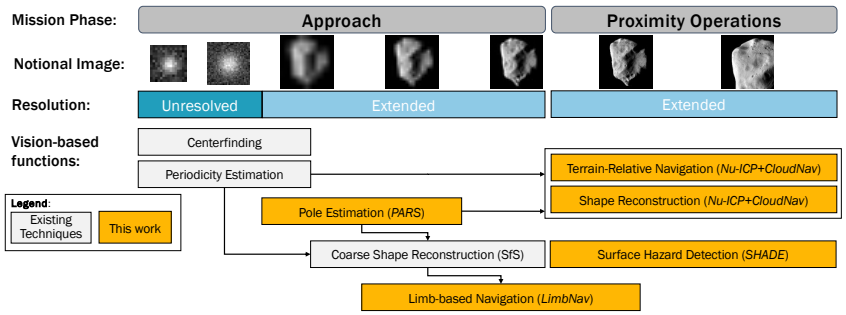
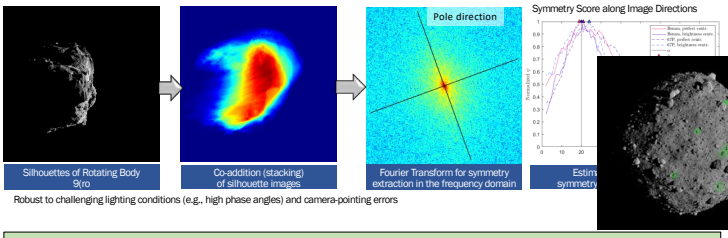
Objectives: Enable robust autonomous optical-based navigation from approach to landing on small bodies.

Significance/Benefits to JPL/NASA: Enables more affordable access to explore the large population of small bodies



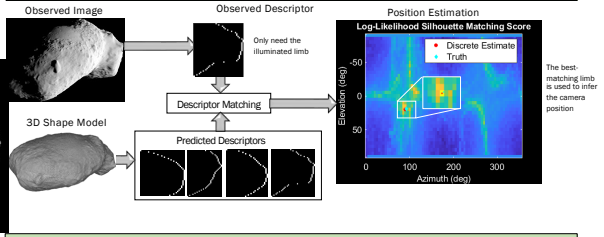
Approach and Results

Pole Estimation



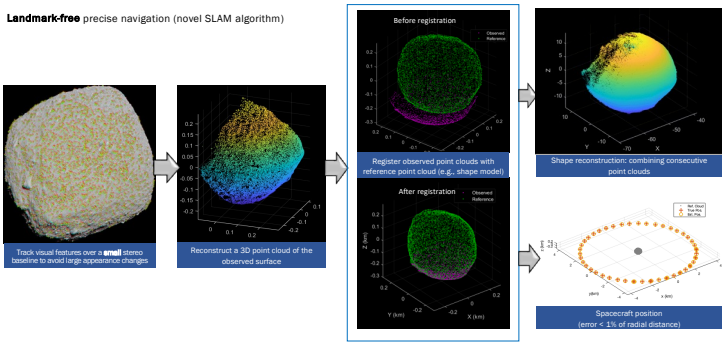
Robust to challenging lighting conditions (e.g., high phase angles) and camera-pointing errors

Limb-based Navigation (LimbNav)

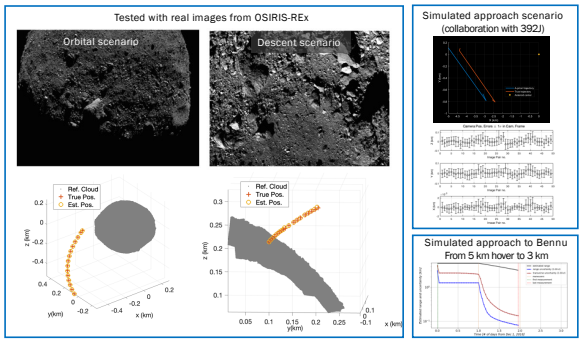


Point-Cloud-based Navigation (CloudNav)

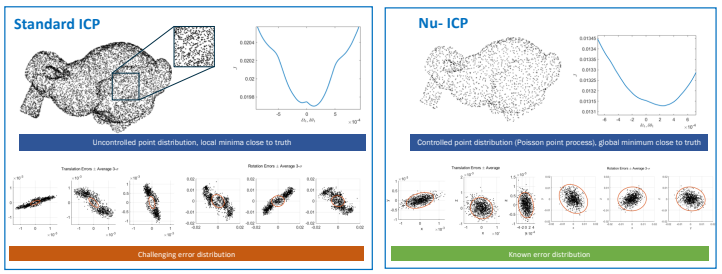
Landmark-free precise navigation (novel SLAM algorithm)



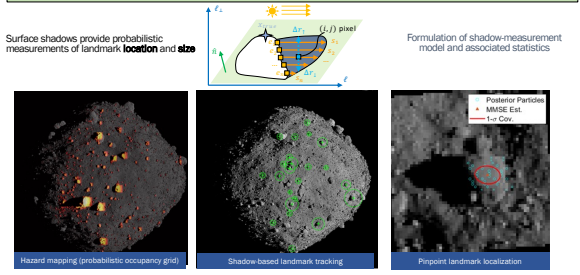
CloudNav Testing and Validation



Noise-Update Iterative Closest Point Algorithm (Nu-ICP)



Shadow-based HAzard DEtection and Tracking (SHADE)



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Publications:
- J. Villa, J. McMahon, and I. Nesnas, "Autonomous Navigation and Dense Shape Reconstruction using Stereophotogrammetry at Small Celestial Bodies", AAS Guidance, Navigation, and Control Conference, 2022
- J. Villa, J. McMahon, and I. Nesnas, "Robust Landmark and Hazard Detection on Small Body Surfaces Using Shadow Imagery", AAS Astrodynamics Specialist Conference, 2022
- J. Villa, J. McMahon, and I. Nesnas, "Point Cloud Visual SLAM for Autonomous Navigation and Mapping Around Small Celestial Bodies", 3rd Space Imaging Workshop, 2022
- J. Villa, J. McMahon, and I. Nesnas, "Image Rendering and Terrain Generation of Planetary Surfaces using Source-Available Tools", AAS Guidance, Navigation, and Control Conference, 2023
- (In preparation) J. Villa, J. McMahon, and I. Nesnas, "CloudNav: Landmark-Free Terrain Relative Navigation at Planetary Bodies Using Visual Point Clouds", Journal of Guidance, Control, and Dynamics
- (In preparation) J. Villa, J. McMahon, and I. Nesnas, "PARS: Robust Estimation of the Principal Axis of Rotation from Silhouette", Journal of Guidance, Control, and Dynamics
- M. Givens, J. Villa, J. McMahon, and I. Nesnas, "Visual Point Cloud SLAM for Spacecraft Rendezvous and Proximity Operations", AAS Astrodynamics Specialist Conference, 2023

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