

Autonomous Approach to Small Unknown Bodies

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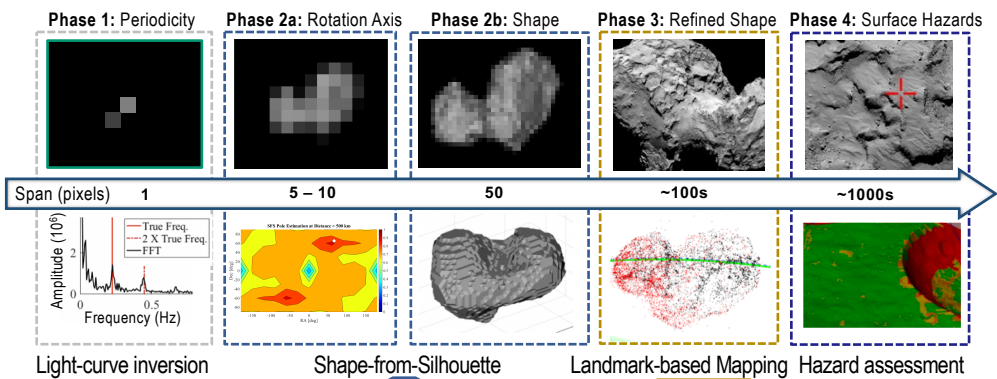
Program: Topical RTD

Project Objective:

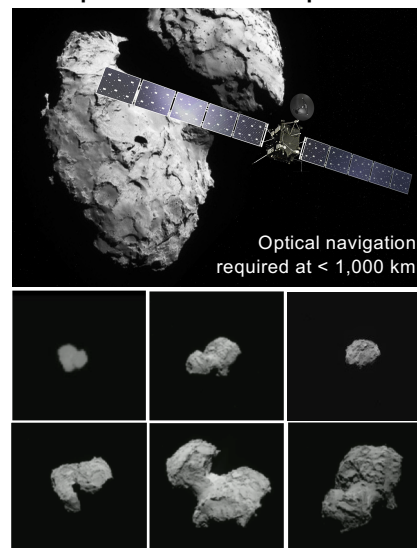
Develop algorithms to onboard estimate the **motion** and **shape** of a small unknown body during approach as well as recover the relative spacecraft trajectory

Benefits to NASA and JPL

A critical capability toward autonomous missions to small bodies, which could provide access to a larger number at more affordable cost. Allows maturing end-to-end autonomy capabilities.

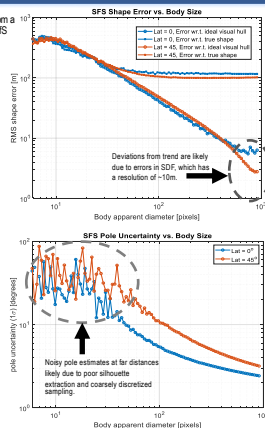
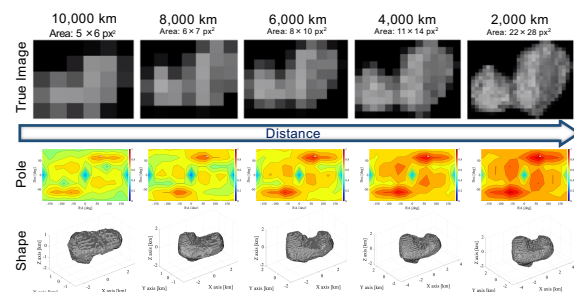


Example: 67P and Rosetta Spacecraft



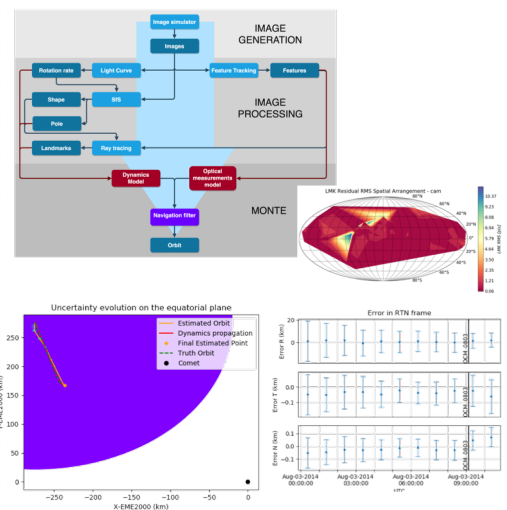
Shape from Silhouette (SFS)

Used distinct signature of silhouette at a large distance to estimate pole and shape



Orbit Determination (MONTE)

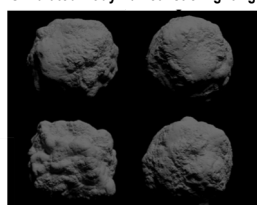
Use state-of-the-practice navigation filter with dynamic model and optical measurement from feature tracking to estimate orbit



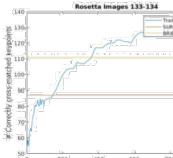
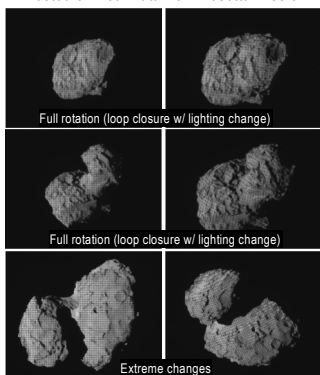
Landmark Feature Matching

- Used neural-network (CNN) feature descriptors distributed 10 pixels apart across image
- Trained on simulated data
- Tested on real data from Rosetta mission
- Compared to SOA descriptors (SURF and BRIEF)

Trained on Simulated Body w/ Realistic Lighting



Tested on Real Data from Rosetta Mission



	# Good matches			# Good cross matches			% Good cross matches		
	CNN	SURF	BRIEF	CNN	SURF	BRIEF	CNN	SURF	BRIEF
Set 1	253	58	73	212	46	62	99%	94%	21%
Set 2	246	126	67	191	95	66	96%	93%	20%
Set 3	47	19	1	20	15	0	95%	83%	0%
Set 4	4	1	1	4	0	0	95%	0%	0%

Publications:

- S. Bandyopadhyay, I. Nesnas, S. Bhaskaran, B. Hockman, B. Morrell, "Silhouette-based 3D Shape Reconstruction of a Small Body from a Spacecraft," IEEE Aerospace Conference, Montana 2018
- J. Villa, S. Bandyopadhyay, B. Morrell, B. Hockman, S. Bhaskaran, I. Nesnas, "Optical Navigation for Autonomous Approach of Small Unknown Bodies," 2nd RPI Space Imaging, Saratoga Springs, NY, October 2019.
- F. Baldini et. al., "Autonomous Small Body Mapping and Spacecraft Navigation", Proc. Int. Astronautical Congress, 2018.

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