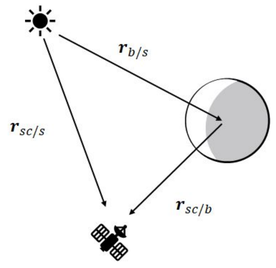
Relative Navigation via a Planet's Illumination Conditions

A warm start to the cold Lost-in-Space Problem

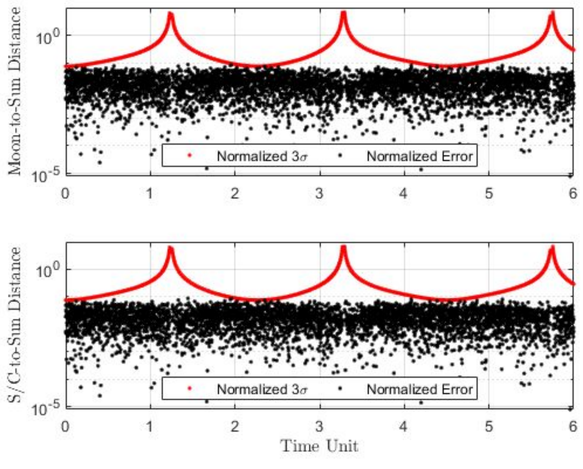
BACKGROUND: Rarely are spacecraft truly Lost-in-Space, however the Lost-in-Space problem addresses a worst case scenario. Using readily available planetary objects as navigation beacons serves as a robust back-up. Effective use of these beacons greatly reduces the search space of a spacecraft's current state. Here we use planets/moons and their lighting conditions to estimate the spacecraft's position. The estimate is useful for initializing an iterative or sequential estimator.

Process

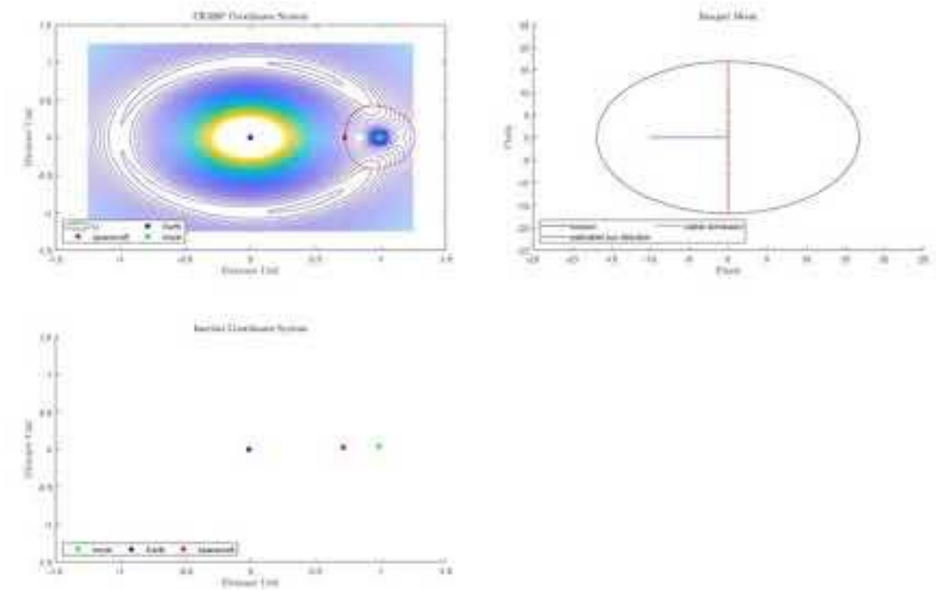
1. Get Line-of-Sight (LOS) to sun from sun sensor.
2. Estimate spacecraft position from imaged planet.
3. Estimate sun direction from planet's illumination (i.e. terminator)
4. From geometry estimate current planet-sun-spacecraft configuration



RESULTS OF LARGER DISTANCE ESTIMATES

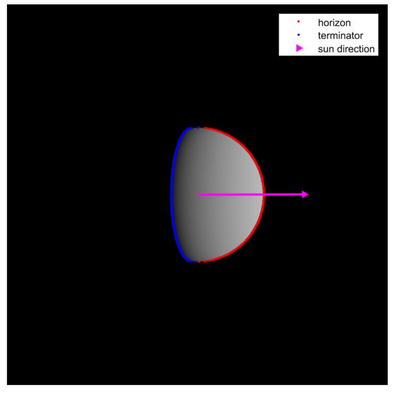


Estimate **current planet-sun-spacecraft configuration** from **one image** and **sun sensor**



Application of proposed technology to fictitious lunar orbiter in CR3BP Earth-Moon system. The spacecraft is in a Distant Retrograde Orbit (DRO) about moon, L1, and L2.

APPLICATION TO SYNTHETIC ELLIPSOID IMAGE



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SIMULATION MEASUREMENT PARAMETERS

Measurement	Instrument	Accuracy - 1 Sigma
Sun Direction	Sun Sensor	0.1 degrees
Planet Centroid Direction	Camera	0.01 degrees
Planet Range	Camera	0.025 of true range
Planet-to-Sun Direction	Camera	0.2 degrees
Edge Detection	Image Sensor	0.1 pixel

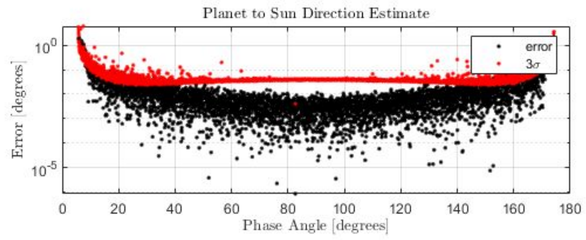
SIMULATION CAMERA PARAMETERS

Parameter	Value
Camera Field of View	53.13 degrees
Image Sensor Size	1024 1024 pixels
Pixel Field of View	0.052 degrees

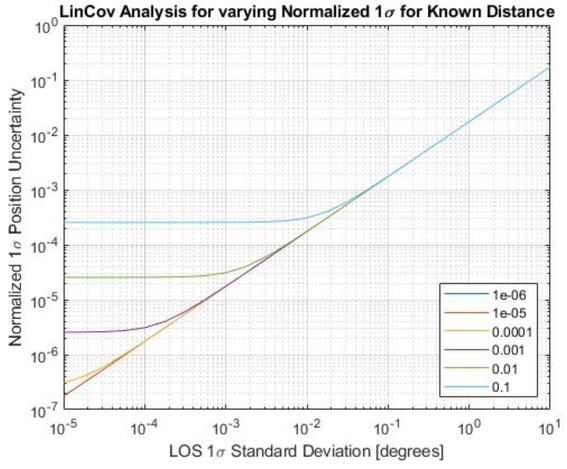
CR3BP PARAMETERS

Parameter	Value
Spacecraft Initial Conditions	$x0 = [0.725,0,0,0,0.645,0]^T$
Mu	Mu = 1/81
Sun Direction	$S \sim [0\ 1\ 0]^T$ in N

PLANET-TO-SUN DIRECTION ESTIMATE FOR VARYING ILLUMINATION CONDITIONS



LINEAR COVARIANCE ANALYSIS FOR VARYING LOS AND POSITION INPUTS



SSDS
SPACE SYSTEMS DESIGN STUDIO

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