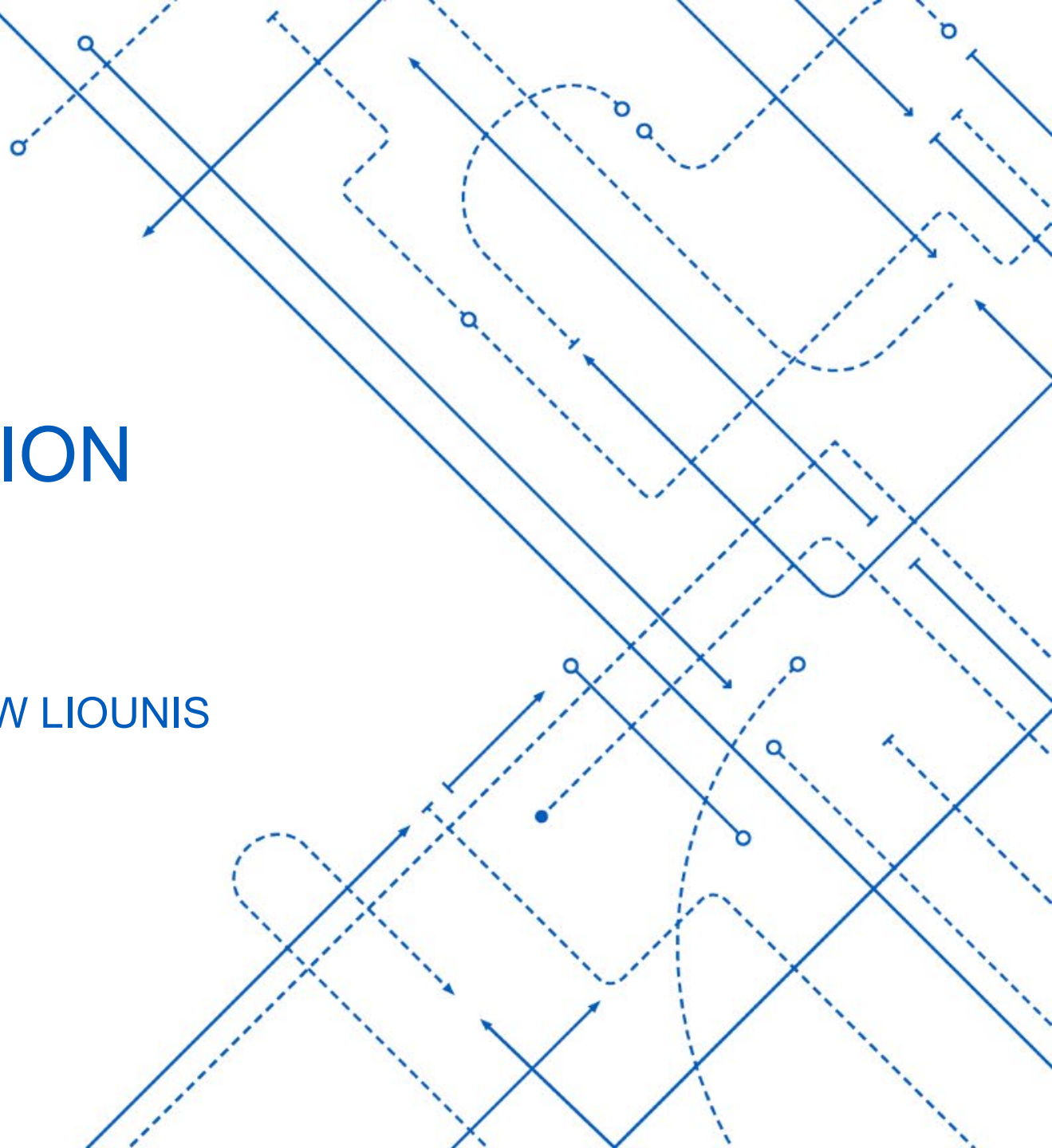

DEM QUALITY EVALUATION FRAMEWORK

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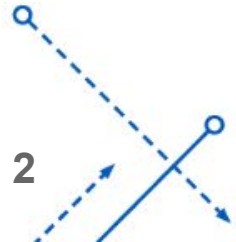
Our Goal

- We want to evaluate Digital Elevation Map (DEM) quality, specifically as it relates to Terrain Relative Navigation (TRN) performance
- **Issue:**
  - TRN performance best evaluated by simulating truth reference trajectory
  - Simulated scenario means simulating the navigation images (via a tool such as FreeSpace)
  - This is not, by itself, a good metric of DEM quality, since we are simulating both the true images and the predicted navigation templates, from various synthetic DEMs
- **Solution: Have two approaches**
  1. Compare the rendered DEMs to flight images to study their physical accuracy
  2. Look at how good a DEM is as a feature to be tracked in a fully simulated scenario



Two Distinct Approaches

COMPARE DEM DIRECTLY TO LROC NAC IMAGES

- Template correlates well with truth

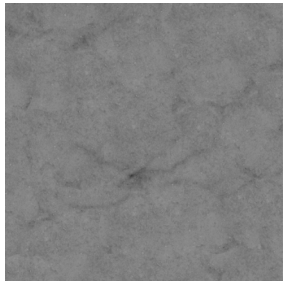
Good Match with Truth

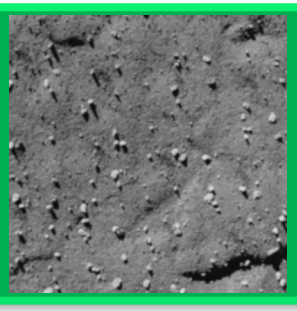
- Template does not correlate well with the truth (missing details)

Poor Match with Truth

TRUTH

TEMPLATE





Good Match with Truth

EVALUATE QUALITY OF DEM REGION FOR NAVIGATION

Poor Landmark to Track

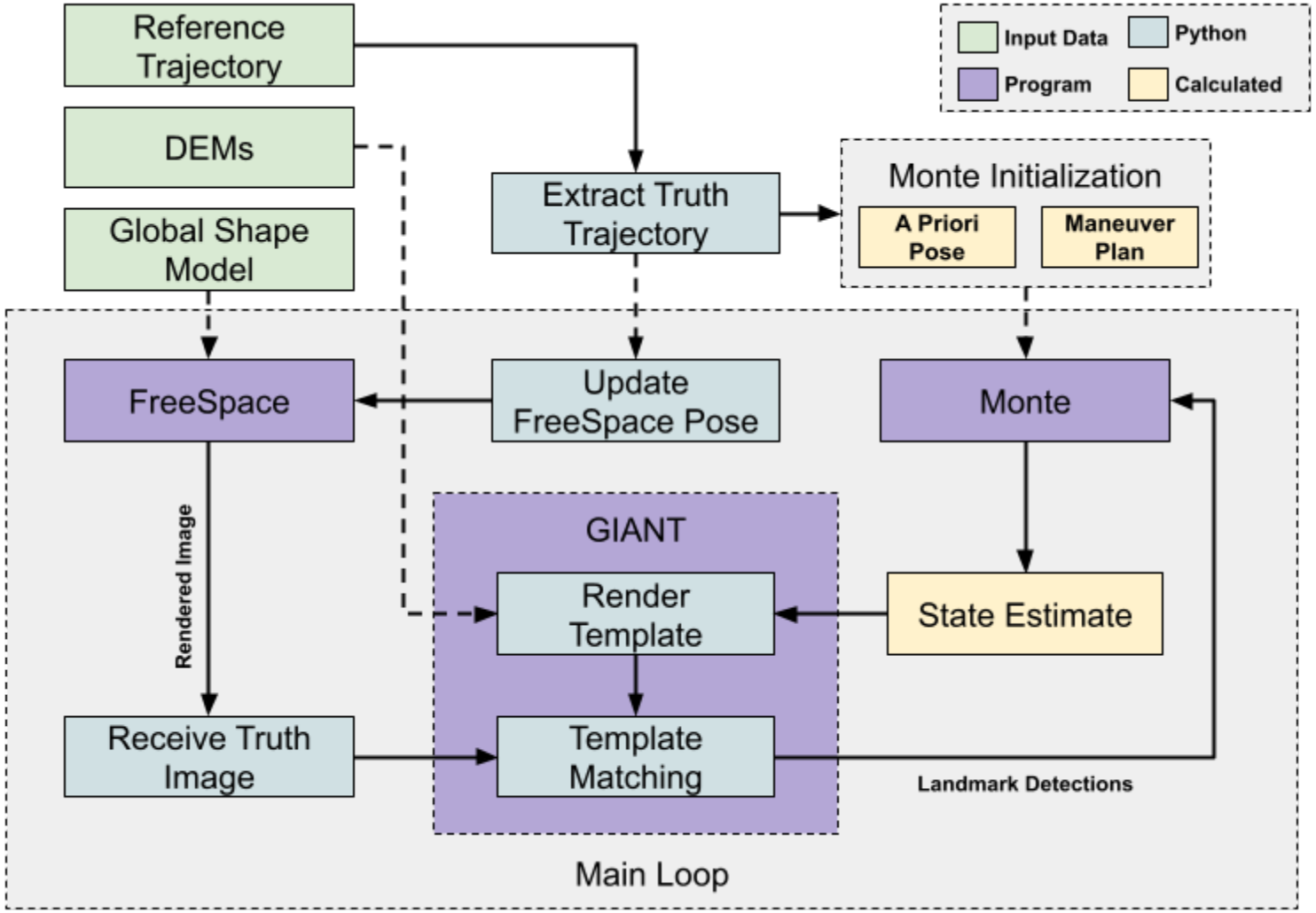
- No strong features and susceptible to errors when a priori knowledge is poor

Good Landmark to Track

- Strong features to “lock onto”

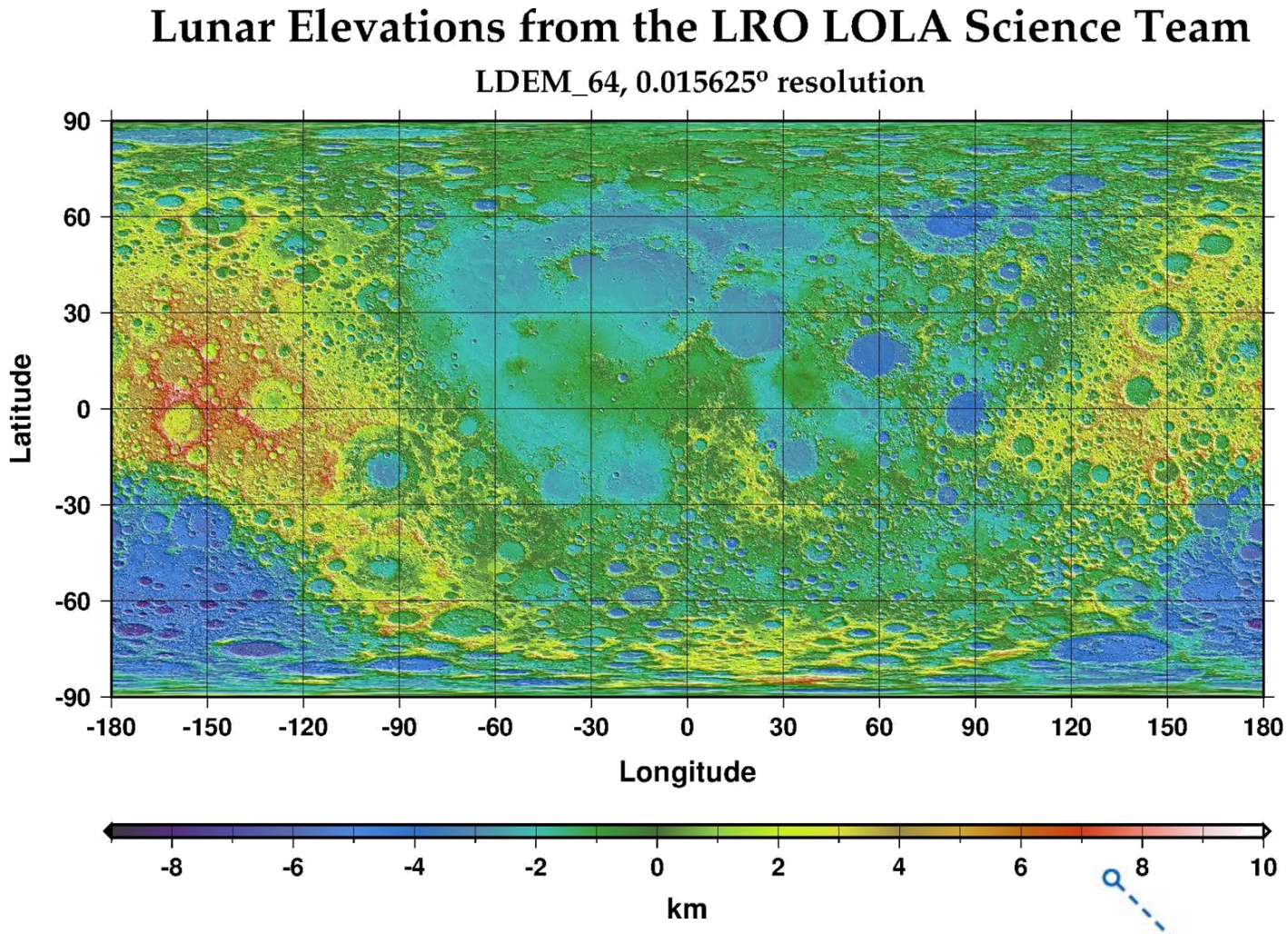
Good Landmark to Track

Pipeline for Evaluating Nav Performance



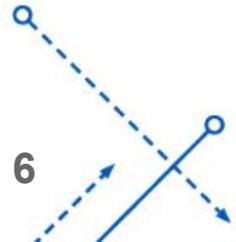
LOLA DEMs

- Used to obtain a shape model we can render using FreeSpace
- Started byt using the 1/64 deg/pixel resolution model
  - Even at this scale, we cannot load the entire geometry at once
- We need to intelligently split the geometry and load each segment only as needed.



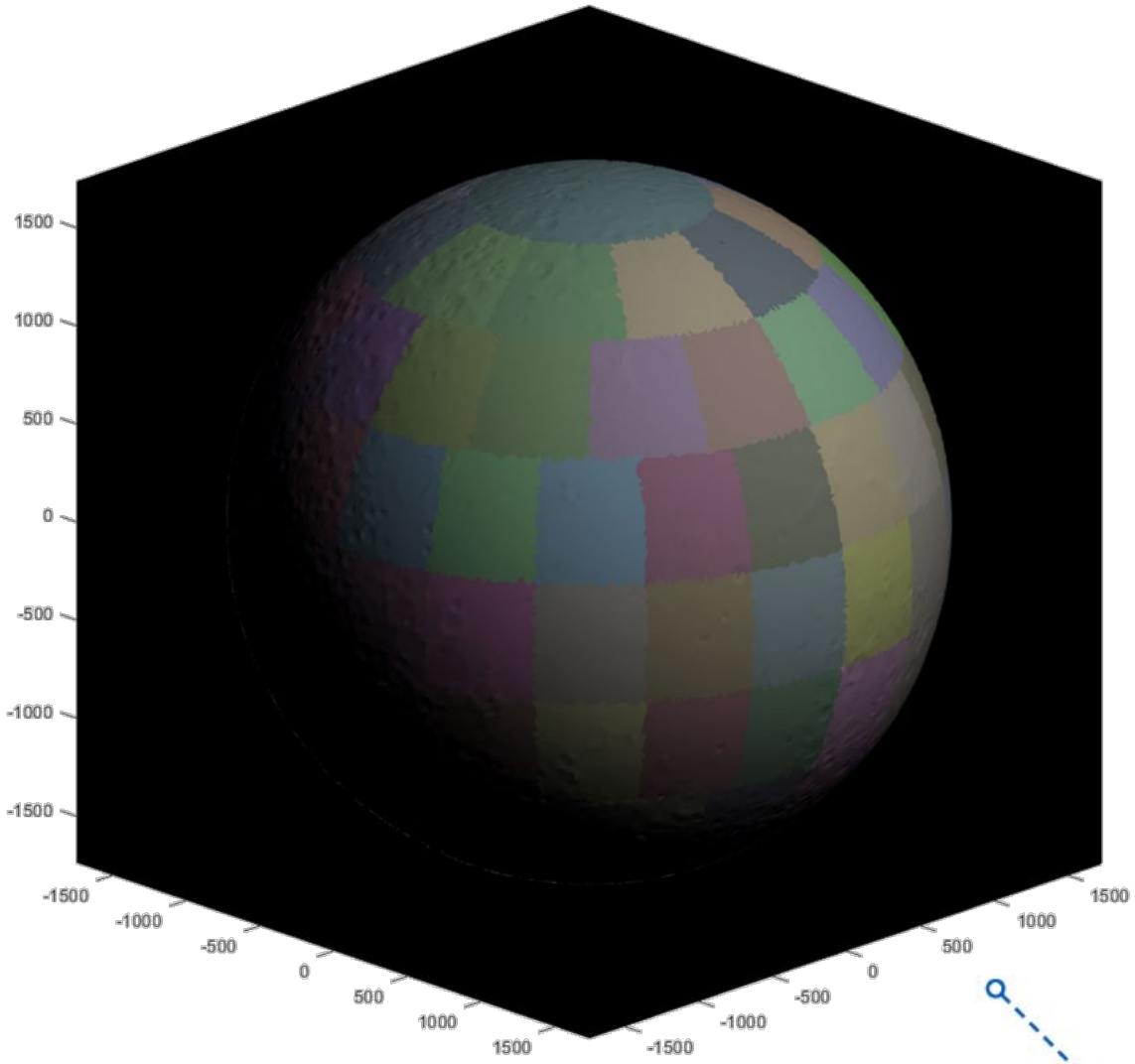
LOLA DEM Pre-processing

1. LOLA DEM is first converted from .IMG to .OBJ format.
2. Face centers are calculated for each polygon, which is used to determine which latitude/longitude segment each face belongs to.
3. Mapping from old face definition to new segmented face definition is calculated
4. The new vertices and face mapping are saved to a new .OBJ as a new tile
5. .OBJ files are converted to .CNB files for usage with FreeSpace
6. Trajectory is then analyzed to determine which tiles will be visible and only those are loaded into FreeSpace



Tiled Lunar Geometry

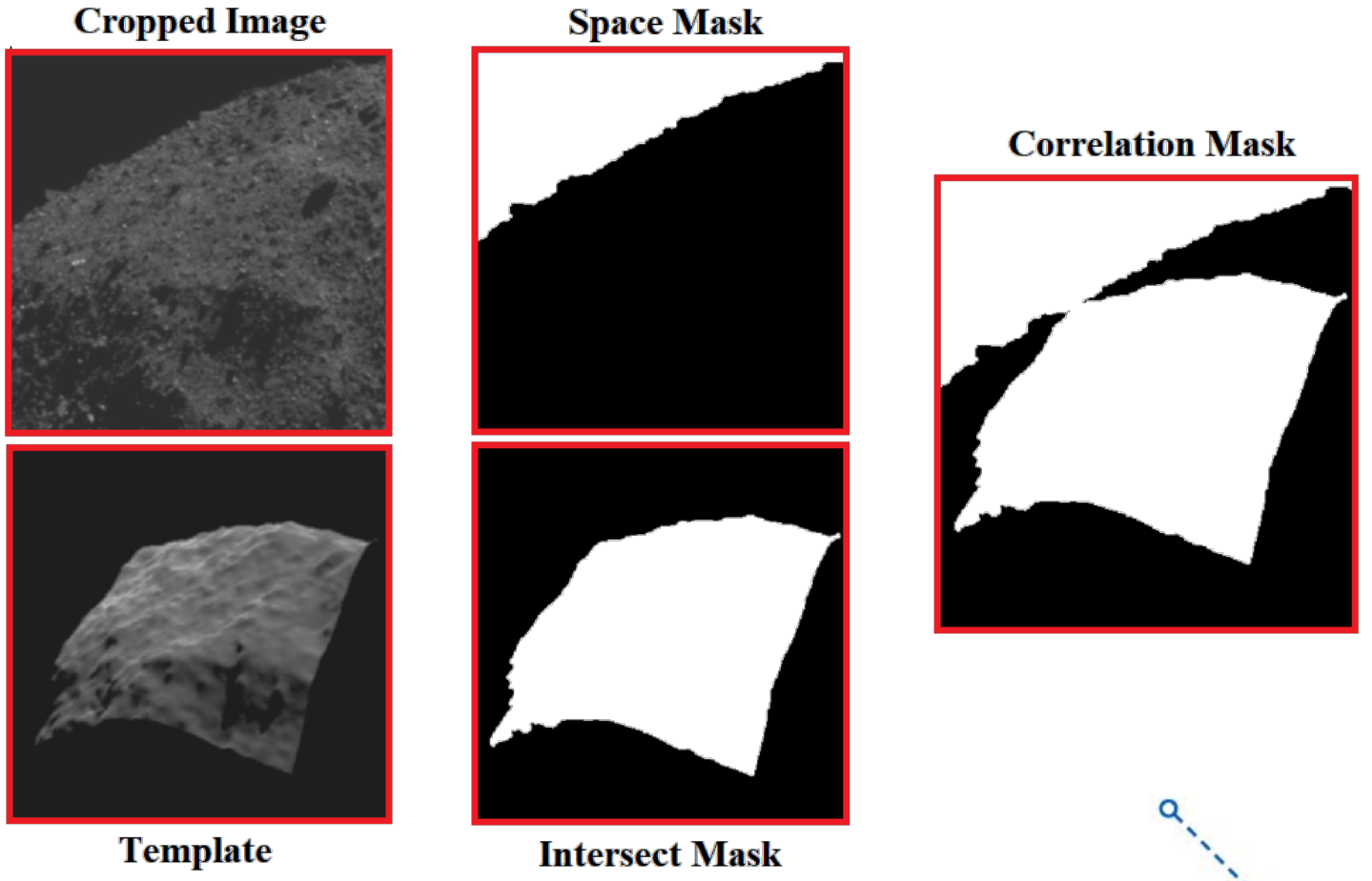
- Tool enables defining the number of longitudinal segments for each latitude level.
- Settled on: [1, 10, 16, 20, 20, 20, 16, 10, 1]
  - 1 segment at the poles, increasing towards 20 at the equator.
  - This gives each region roughly equal size and has each be small enough to be efficient
  - If we move to large shape models, the number of tiles may need to be increased (but that will be trivial)
- *This tiling was generated using the LOLA 4ppd model to the visualization could be generated efficiently*



GIANT Template Matching

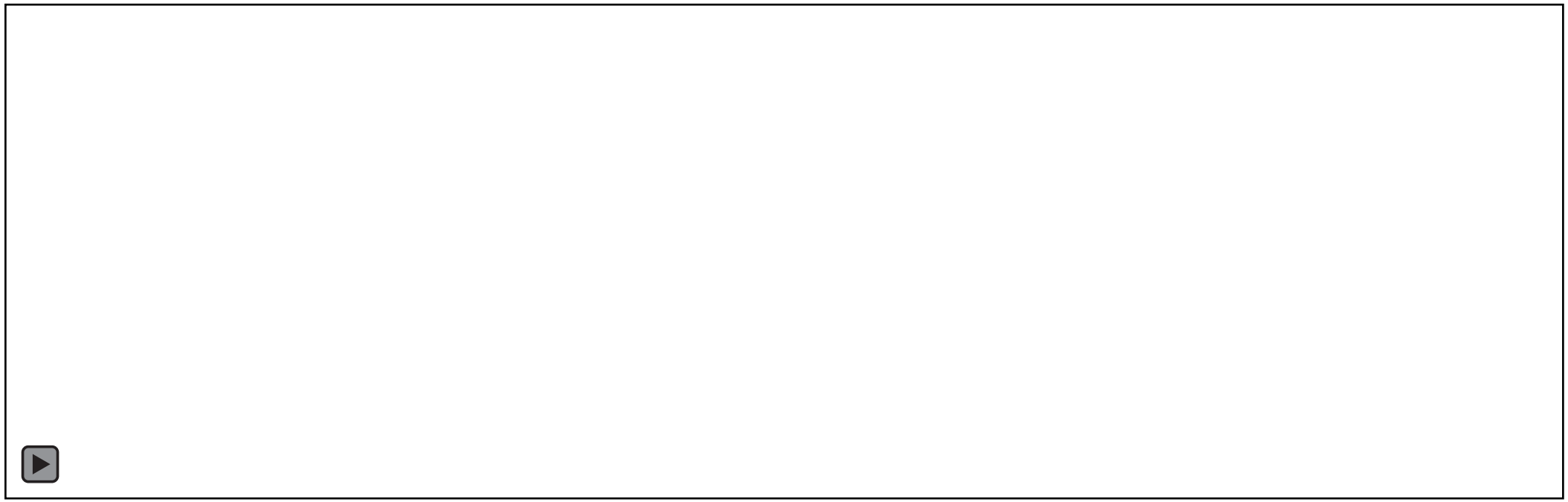
- Using an a priori map of the body, maplets are rendered using a raytracer.
- Using cross-correlation, the location of the landmark in the image space is determined.

- *I helped to develop this functionality in GIANT during a previous internship on OSIRIS-REx. The example images on the right are from that effort.*



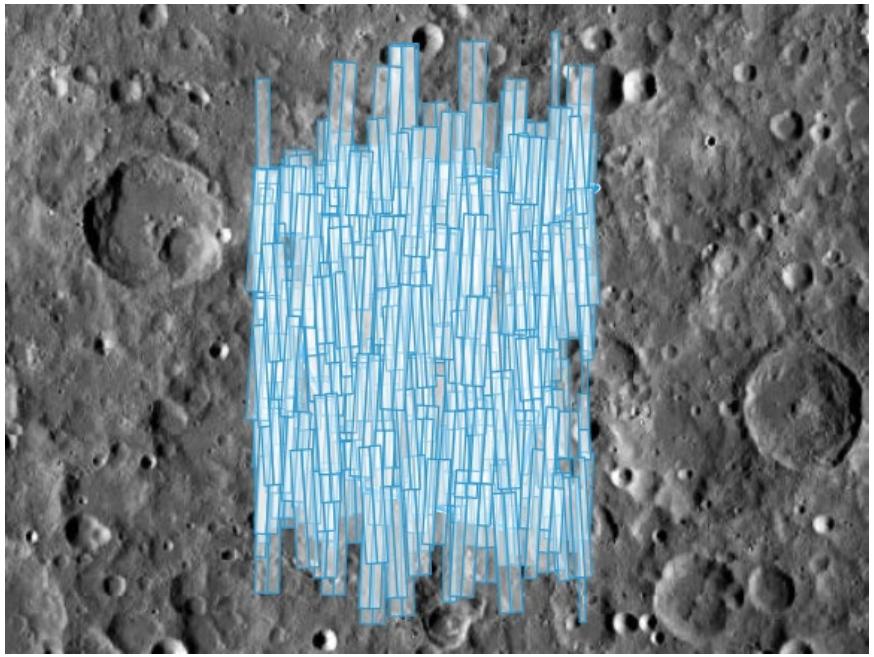
GIANT Template Matching

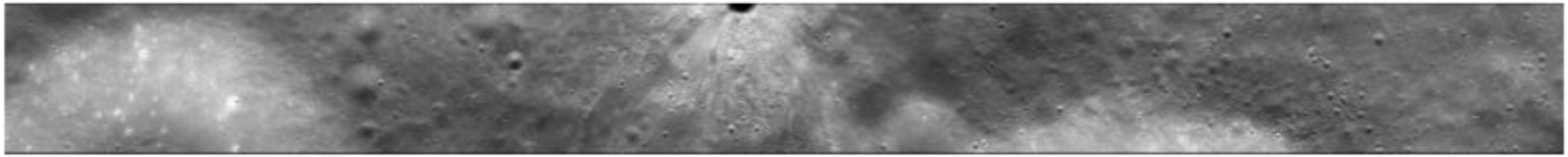
- Rendered template is correlated with the image in the region its expected to appear.
- It’s moved around that region, so the correlation score at each point generates a correlation surface.
- The peak of that correlation surface corresponds to the most likely position of that feature.



NAC Images (from PDS Node)

- Data obtained from LROC Quick Map tool
- Allows easy selection of regions to obtain NAC images from
- NAC image used as demonstration:
  - **LROC Observation M1112998800L**





Future Work

- Will be continuing this work in the Fall as a newly hired Pathways intern
- Run simulated cases using the flow outlined above and evaluate performance of the existing DEMs
- Swap MONTE for Geons
- Swap GIANT for RETINA

- Finalize pushbroom model implementation in GIANT
  - Use the new GPU acceleration
- Use multiple NAC images to determine accuracy of DEM location in the lunar body fixed frame