Need for accurate positioning and distance determination for lunar rover missions
- Currently: To verify 500m traverse for Google Lunar X-Prize
- Subsequently: For strategic lunar exploration and science missions

Challenges of lunar localization:
- Lack of absolute positioning system (no GPS)
- Wheel odometry: Error from integration and wheel slip

**In situ calibrated wheel odometry**
- Using single calibration: +/- 31m distance estimate @500m
- Provides conservative distance estimate

**Map-based feature matching**
- Feature matches between 3D aerial map onboard camera (see right): +/- 21m distance estimate @ 500m
- Provides conservative distance estimate and rough position map

Plot showing total distance traveled estimate for both methods compared to ground truth. Both methods provide conservative estimate.

**Visual odometry**
- Dense point cloud with rover positions – scaled with aerial map
- Can be used for loop-closure at end of traverse

**Available data**:
- Wheel turns, onboard monocular camera, aerial landing map

**Determining Distance Traveled**:
1. **On-site calibrated wheel odometry**
   - updates continuously throughout traverse to account for changing wheel slip
   \[
   \text{distance} = \text{wheel turns} \times \text{odometry factor}
   \]
   - odometry factor = wheel turns between aerial map features / distance between features
2. **Map-based feature matching**
   - uses feature matches between onboard camera and aerial map
   - finds straight-line distances between features for conservative distance estimate

**Determining Rover Position - visual odometry**
- finds SIFT features between monocular camera images for structure from motion reconstruction w/ bundle adjustment for error minimization
- Scales reconstructed ribbon with aerial map

**Motivation**

**Strategy**

**In situ calibrated wheel odometry**
- Using single calibration: +/- 31m distance estimate @500m
- Provides conservative distance estimate

**Simulated Rover Mission: Robot City Analog Test Site**

Prominent landmarks (rocks, boulders, pits) can be seen in the 3D aerial map, enabling matching with onboard camera images.

**Future Work**

- Extended Kalman Filter (wheel odometry + visual odometry + IMU) for better localization and distance accuracy.
- Real-time visualization of rover position on 3D map.

**References**