Absolute Lunar Orientation using Solar Azimuth and Ephemeris

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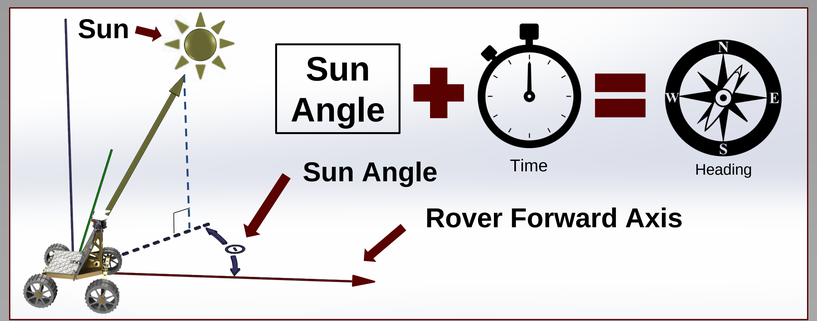
Introduction

- Lunar path reconstruction can be improved by incorporating absolute cardinal bearing
- This is not currently done because the moon and mars both lack a magnetic field or radio positioning system
- By comparing a lunar rover's perceived sun azimuth and time to the DE421 ephemeris from NASA Jet Propulsion Laboratory (JPL), a lunar bearing can be inferred



Approach

- A sky image is captured using a vertical camera with a spherical fisheye lens
- OpenCV and blob detection are used to fit a circle onto the sun, and the azimuth and elevation angles are measured
- The measured angles are adjusted to compensate for rover tilt with input from an accelerometer
- The difference in known sun azimuth and perceived azimuth from the rover indicates absolute bearing

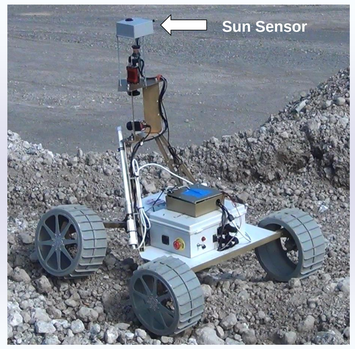
Hardware

2 Mega-pixel MT9D111 Color Camera
PC: www.arducam.com

Sunex DSL215 185° F.O.V. Fisheye Lens
PC: www.sunex.com

ArduCAM
PC: www.arducam.com

Accelerometer: EPSON V340
PC: www5.epsondevice.com

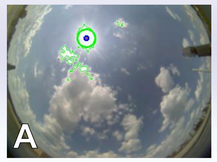


Andy 2 Lunar Rover with Sun Sensor mounted

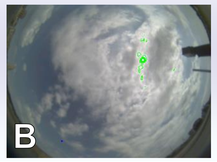
Sun Occlusion and Size Rejection

Clouds occasionally occluded the sun, blocking or skewing the fitted circle; a radius parameter was used to accept (A) or reject (B) data points

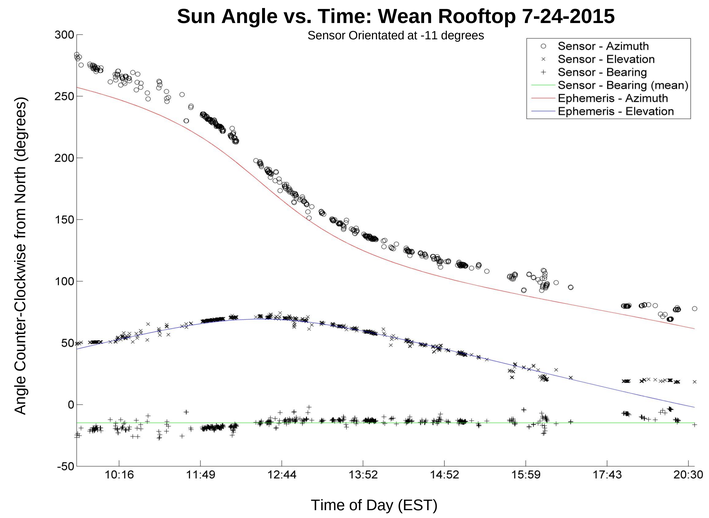
Example A:
The circle fit to the sun is within an acceptable range; this data point is accepted



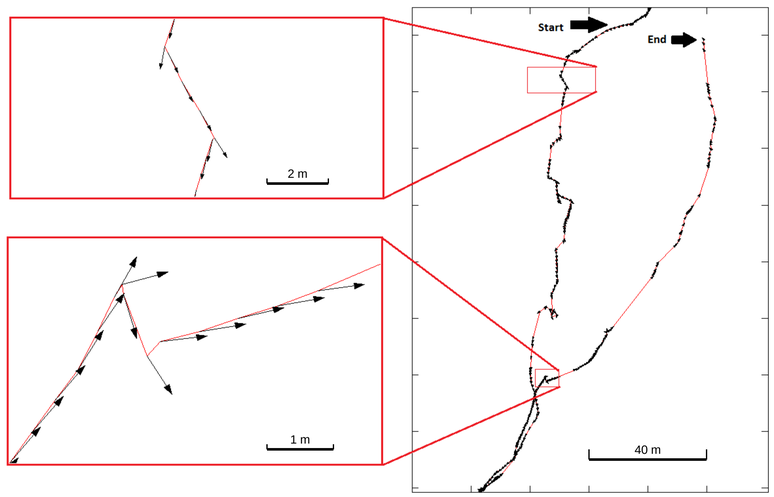
Example B:
The circle fit to the sun is not within an acceptable range; this data point is rejected



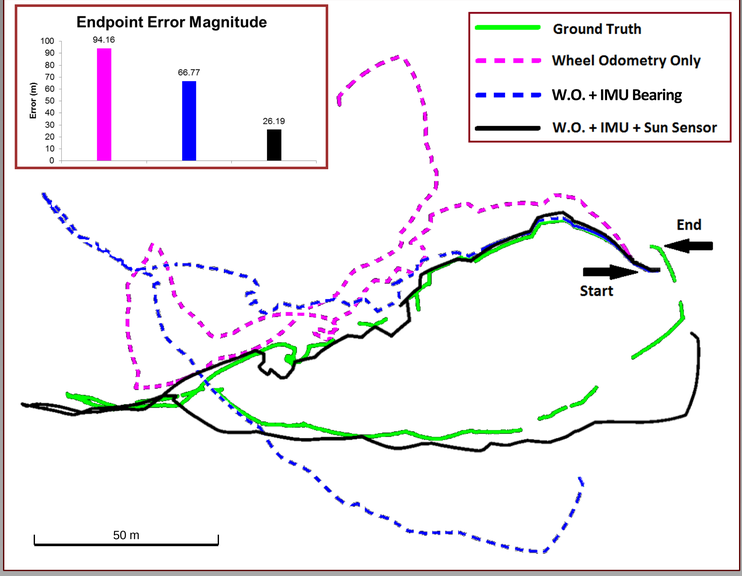
Testing



Sun Sensor Bearing plotted over Field Test Ground Truth 7-16-2015



Field Test Path Reconstruction



Discussion

Absolute bearing based on solar azimuth and ephemeris significantly improves path reconstruction. This is true despite noise introduced in the data by cloud occlusion and atmospheric diffraction.

This setup can be improved in several ways. Firstly, a more configurable camera could be used to dynamically select the best shutter speed and ISO to detect the sun while ignoring atmospheric diffraction. A solar filter could also be implemented, considering an actual lunar experiment would experience greater light intensity.

Acknowledgements

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