Spatial Informatics Project

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Team Size: 1 member

Project Title: Optimal Trajectory Planning for a Mars Rover Using Spatial Data collected by Mars Orbiters

Project Description: This project aims to plan an optimal trajectory for a rover traveling between two selected sites. The rover trajectory is optimized by considering terrain difficulty, obstacles, and energy consumption constraints.

Assumptions or Criteria:

1. **Landing Sites:** Criteria for landing sites include low slope, minimal elevation changes, proximity to water ice deposits, and scientific interest, etc.
2. **Rover Path:** The rover must traverse from one landing site to another, avoiding steep slopes, obstacles (rocks, craters), and minimizing energy consumption by avoiding regions with low solar exposure.

Data – Source and Characteristics:

1. **MOLA (Mars Orbiter Laser Altimeter):** Provides elevation and topography data for Mars.
2. **HiRISE (High-Resolution Imaging Science Experiment):** For detailed surface imagery to identify craters, rocks, and obstacles.
3. **Mars Odyssey THEMIS:** For temperature and solar exposure data, essential for energy-efficient pathfinding.
4. **CRISM (Compact Reconnaissance Imaging Spectrometer) - http://crism.jhuapl.edu/:** To locate potential water ice deposits and scientifically interesting features (like riverbeds or volcanic formations).

Other websites:

1. **Mars Global Datasets:** https://www.mars.asu.edu/data/
2. **JMARS:** https://jmars.mars.asu.edu/: This website provides various types of data related to mars captured over time through various missions. This also provides tools and tutorials. Here datasets can also be transferred to QGIS.

Spatial/Spatio-temporal (GIS) Methods I will be using

Rover Trajectory Planning

a. Criteria for Trajectory Planning:

- **Terrain Safety:** Low slopes and minimal elevation change.
- **Resource Availability:** Proximity to water ice or other potential resources.

- **Scientific Interest:** Proximity to interesting geological formations like riverbeds or volcanic areas.
- **Solar Energy:** Sites with sufficient sunlight for solar-powered operations.
- **Rover Limitations:** Maximum slope of 15°, avoidance of obstacles like craters or rocks.
- **Power Efficiency:** The path should maximize solar exposure and avoid areas of deep shadow.
- **Safety:** Avoiding rough terrain or steep inclines.

b. Pathfinding Algorithms:

A suitable pathfinding algorithm like Dijkstra or A* should be used.

c. Spatial Analysis Methods:

- **Slope and Elevation Analysis:** Using the DEM to map areas with safe terrain (e.g., slope ≤ 10°).
- **Proximity Analysis:** Buffering water ice deposits and geological features to identify areas that are both safe and scientifically valuable.
- **Solar Exposure Mapping:** Identifying areas with high solar exposure using THEMIS data for long-term rover energy needs.
- **Slope Analysis:** To identify steep areas that are unsafe for the rover.
- **Obstacle Mapping:** Using HiRISE data to identify and avoid craters and large rocks.
- **Cost Surface Creation:** A weighted overlay of slope, solar exposure, and obstacles to determine the least-cost path.

d. Results:

- **Map of the Optimal Trajectory:** A map displaying the rover's path between two selected landing sites, with layers for obstacles, slope, and energy-efficient regions.

Trajectory Planning:

a. **DEM Analysis (Slope, Aspect, Curvature) –** To assess terrain safety for potential places to maneuverer.
b. **Cost Surface Analysis –** Evaluate the relative difficulty of traversing various sites.
c. **Proximity Buffers –** To prioritize moving near water ice or scientific features.
d. **Least-Cost Path Analysis –** Use a combination of slope, obstacle data, and solar exposure to find the most efficient rover path.

e. **Flow Accumulation** – Identify terrain features that may present challenges (e.g., eroded regions).
f. **Raster Reclassification –** Simplify terrain data for easier rover navigation.

Please Note: This is a preliminary report, thoughts about implementation and considerations would change as I progress through the project.