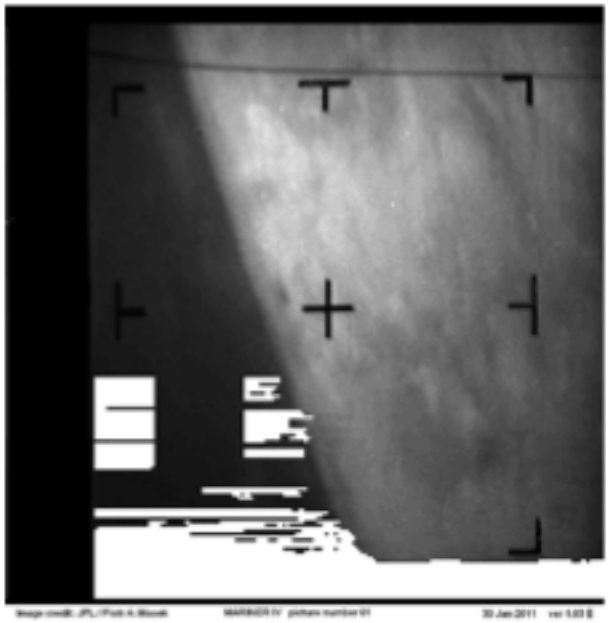
Mars Rover Routing System
Marcel Llopis
NASA's Jet Propulsion Laboratory

Introduction

For ages, humans have been fascinated with Mars. What we fail to realize, sometimes, is that ages, might mean thousands of years – the first written record of a person looking at Mars is from about 4,000 years ago –, to hundreds of years – the first known time someone postulated that Mars was a planet was in 1543 (and that bold claim was made by Nicolaus Copernicus).

The first close approach to Mars done by humans – by proxy, was completed by the Mariner 4 spacecraft in 1964. The Mariner 4 spacecraft was an outstanding piece of engineering that included a magnetometer, a Geiger counter, a radiation detector, a cosmic dust detector, and a visible light camera, among other instruments.

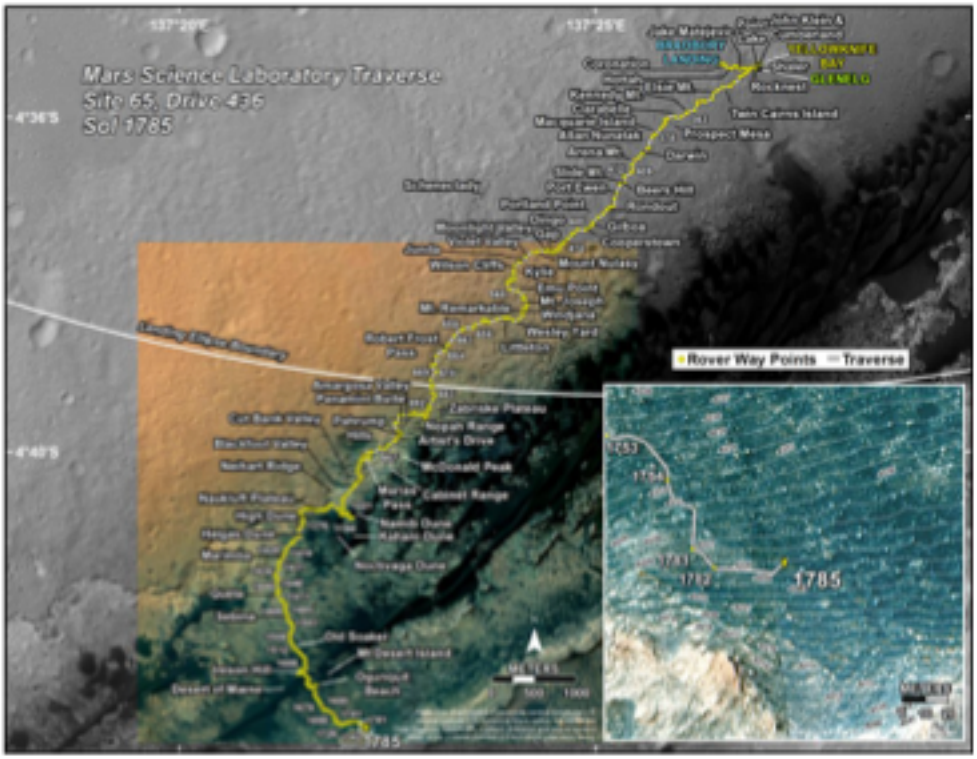
All of Mariner 4's science returns fit in 635 kB, which is a really small amount of information for today's standards. Even though the amount of information was small, it was information that provided one of the most beautiful sights to be seen in that era: the first-ever close-up of Mars.



Humanity's first Mars close-up

Today, the Jet Propulsion Laboratory is one of the world's leading centers when it comes to the exploration of Mars. In our laboratory, we have operated more than 20 missions that have either flown by Mars, orbited Mars, landed on Mars, and/or are roving on Mars. We currently have two operational rovers on the planet, one is Opportunity, and the other one is Curiosity.

As you may be aware, Opportunity recently completed a very important distance milestone when it broke the marathon distance mark – 26.2 miles – in 2015. This milestone is significant because routing a rover through the tough Martian terrain is not an easy job as operators have to always be cautious about the terrain the rovers are moving over.



Curiosity rover route as of sol 1785

In this project, we would like to make the operators' jobs a bit easier by trying to implement some degree of autonomy onboard a hypothetical future Mars rover mission.

The Project

The purpose of this senior design project will be to design a software that will ingest:

- An elevation map of a section of the Martian terrain – an example of this are Digital Elevation Models, or DEMs, which are files that contain a grid of terrain elevation points.
- The rover start coordinates on the map.
- The rover desired finish coordinates on the map.

The software shall find, if they exist:

1. A path from the start coordinates to the finish coordinates assuming that, (1) the rover can't climb hard climbs*, (2) the rover can't descend steep descents*, (3) the rover can't see too far ahead*. The rover is essentially discovering the terrain as it moves.
2. A path from the start coordinates to the finish coordinates assuming that, (1) the rover can't climb hard climbs*, (2) the rover can't descend steep descents*, (3) the rover is aware of all of the terrain. We can assume we've preloaded the elevation map into the rover's internal memory.

The first route is an exploration in which there could be backtracking involved because the rover might try paths that end up in places where it can't continue, whereas the second type of route involves the calculation of an optimal route where the terrain is known. Routes would be an ordered list of coordinate points.

As an added bonus, the software also could:

- Provide distance calculations and total elevation gains for both routes.
- Provide a 2D r of the elevation map and the start/finish coordinates, along with the two routes displayed in it.

A more detailed list of requirements would follow, but many of the choices for implementation are open-ended. It is my hope, however that this will be an interesting and fun project for students that would like to be involved in what could be a real-life problem that NASA would have to solve, while at the same time being mentored and getting guidance from a NASA engineer.

* Requirements will be specified in more detail

Notes and references

For more information about the location of the different Mars rovers, please follow these links:

- https://mars.nasa.gov/msl/mission/whereistherovernow/
- https://mars.nasa.gov/mer/mission/traverse_maps.html

For more information about elevation maps on Earth and Mars, please follow these links:

- https://en.wikipedia.org/wiki/Digital_elevation_model
- https://pubs.usgs.gov/imap/i2782/i2782_sh1.pdf
- https://webgis.wr.usgs.gov/pigwad/down/mars_dl.htm
- https://astrogeology.usgs.gov/search/map/Mars/GlobalSurveyor/MOLA/Mars_MGS_MOLA_ClrShade_merge_global_463m