EPSC Abstracts
Vol. 6, EPSC-DPS2011-1325, 2011
EPSC-DPS Joint Meeting 2011

Robust extraction of channel parameters from HRSC data of Warrego Valles

R. Koenders and R.C. Lindenbergh
Delft University of Technology, Delft, The Netherlands (R.Koenders@tudelft.nl)

Abstract

Detailed and regional studies of Martian hydro-landforms and modelling of the process responsible for those landforms have been performed in the last decades, but a global understanding of the evolution of water systematics of Mars requires a global and systematic analysis and integration of the tell-tale signs of water at the surface. In the coming years HRSC will obtain high-resolution stereo-imagery with near-global coverage of Mars. This will result in an unprecedented detailed look of the morphology of the Martian surface. In anticipation of this we have developed an algorithm to systematically and quantitatively extract the relevant morphological parameters to identify the formative process classes of Martian hydro-landforms from these data. At this conference we will present our first results through a case study of the Warrego Valles system.

1. Introduction

Detailed and regional studies of Martian hydro-landforms and modelling of the process responsible for those landforms have been performed in the last decades, but a global understanding of the evolution of water systematics of Mars requires a global and systematic analysis and integration of the tell-tale signs of water at the surface.

Previous efforts to identify valley networks and channel networks on Mars consisted of manual mapping of the networks. Automated extraction of these networks from digital elevation models employ local multi-scale filtering to separate hill slopes, valleys and channels [3] or global criteria (e.g., flow accumulation area and surface contour curvature) in a cost function [5] to directly extract the entire channel network (after some processing of the raw data to suppress noise and to enhance natural physical boundaries).

These studies assume an active system with few interruptions in steeply-sloping drainage basins. However, the Martian valley and channel networks are heavily eroded, with interruptions due to later crater impacts. Here we suggest a technique, rooted in biomedical image analysis, for robust and automatic extraction of channel networks. The proposed methodology is based on the second order local structure of an image and is demonstrated to allow for accurate and fast determination of basic morphometrics from a DEM (e.g., drainage density).

2. Channel extraction and characterization

In order to interpret an image one not only looks at the image itself, but also its first and second order derivatives. The second order local structure of an image or a DEM has a perpendicular maximum and minimum direction that are named the principal curvatures. If both principal curvatures are small, the surface is locally flat, if one is small while the other is large the surface has a local semi-cylindrical shape, i.e. it has the shape of a valley or a ridge [2].

We are currently publishing an article describing this part of our method in detail as it successfully extracts valley networks from terrestrial digital elevation models.

By pre-filtering the terrain with a directional smoothing we are able to reconnect channel pieces that have small interruptions due to erosion or impact cratering, reconstructing the original pattern of the network.

To characterize the valley and channel networks we extract an initial set of two categories of parameters: network-based parameters and location-based parameters. Network-based parameters require a complete network to be extracted from the terrain and include: Strahler order, valley longitudinal

profiles, bifurcation ratios, length ratios, and cumulative area distribution. Location-based parameters can be calculated more-or-less independently from whether the complete network can be extracted from the terrain. These parameters include: stream power, width-depth ratios, drainage density, slope-area relations for channel heads [4], ruggedness number.

3. Results and Conclusions

At the conference we will present a case study where we have applied the methodology to the Warrego Valles valley network. This valley network has been described as having morphometric properties similar to terrestrial fluvial networks [1]. We have chosen this area because it presents a mix of eroded and relatively pristine channels on which we can test our methodology.

The final aim of the project is to scale-up our methodology and apply it to many of the DEMs obtained by HRSC to identify the spatial and temporal distribution of formative process classes of Martian hydro-landforms in a uniform manner.

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