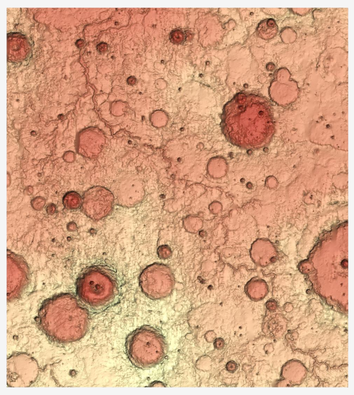
✂ Schnittkante ✂

Extraction of Valley Networks in Mars Elevation Maps

D. Günther[1], P. C. McGuire[2], S. Walter[3], T. Weinkauf[4], H. C. Hege[5]

(1) david.guenther@zib.de, Zuse Institute Berlin
(2) mcguire@geosci.uchicago.edu, University of Chicago
(3) sebastian.walter@fu-berlin.de, Freie Universität Berlin
(4) weinkauf@courant.nyu.edu, Courant Institute, New York University
(5) hege@zib.de, Zuse Institute Berlin

Motivation

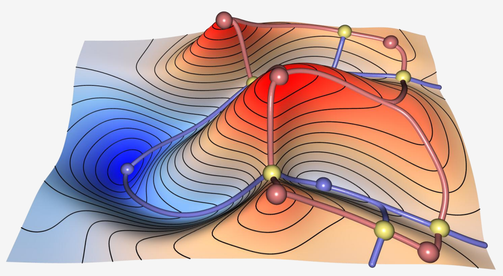


Valleys in Elevation Maps

- Extraction of valleys as extremal structures
- Minimal lines in the elevation map
- Change of monotony in a local neighborhood
- Varying strength of the valleys

Extremal Structures

- Critical points: minima (blue), saddles (yellow), maxima (red)
- Separatrices: integral lines connecting critical points – minimal (blue) and maximal (red) lines
- Partition of a map in monotone regions

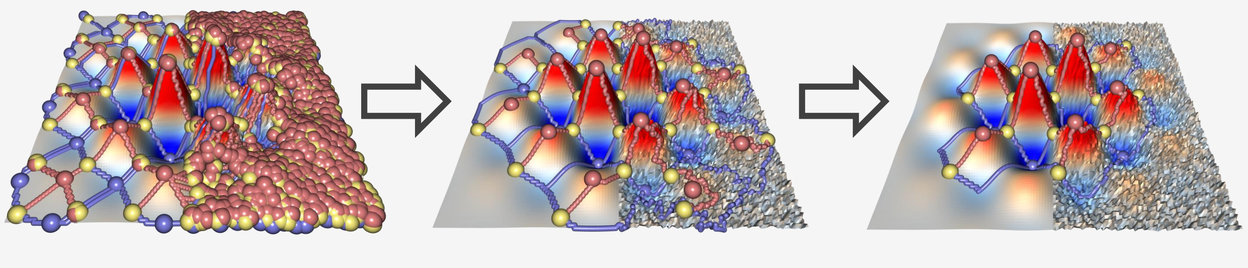


Combinatorial Topological Data Analysis

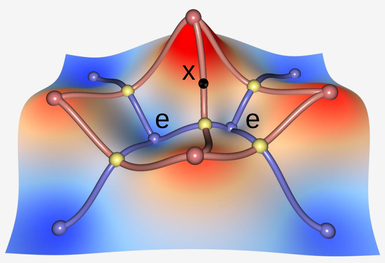
- Global analysis
- Derivative free extraction of extremal structures

- Natural hierarchy by persistence (level of detail)
- Differentiation of dominant and spurious features

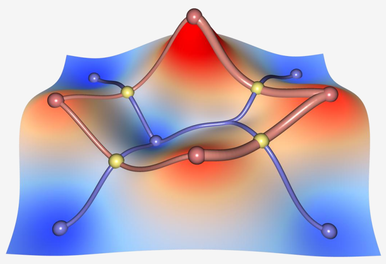
- No computational parameter
- Grid dependence



Strength of Monotony Breaks



Initial extremal structure



Simplified extremal structure

- Separatrices separate two extrema e
- Change of monotony in normal direction
- Strength depends on adjacent extrema

$$p(x) = \min_{e} |h(x) - h(e)|$$

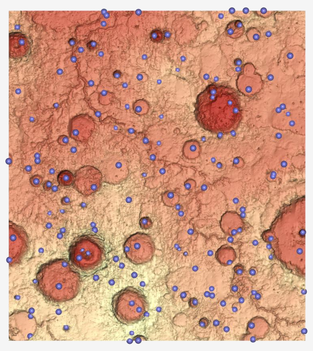
- *Separatrix Persistence*: Smallest height difference of the extrema and a point on the separatrix

- Global measure
- Dependence on the connectivity of critical points
- Monotonically increasing with respect to the hierarchy

Application to Martian Surface

Mars Orbiter Laser Altimeter data – gridded to 128 pixel per degree

Detection of Craters

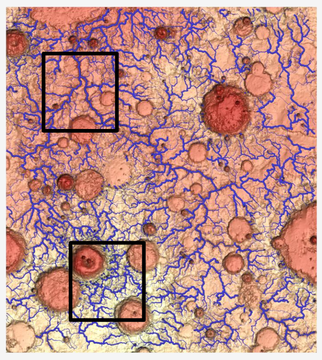


Minima as seed points

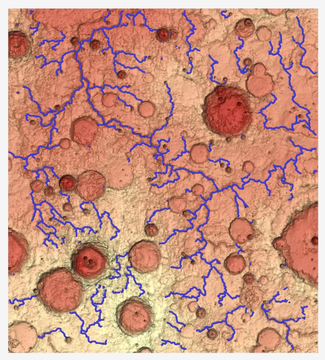
Binary mask

- Craters affect extraction of valleys
- Computation of the hierarchy for a given elevation map
- Level of detail: Craters are covered by at least one minimum
- Region growing for each minimum until each crater is covered

Extraction of Extremal Lines

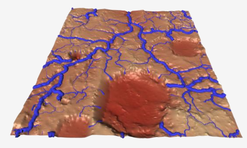


Initial minimal lines

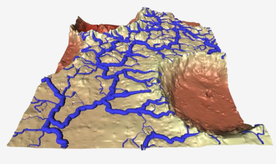


Reduced minimal lines

- Computation of the hierarchy for the masked elevation map
- Minimal lines (blue) are scaled by separatrix persistence

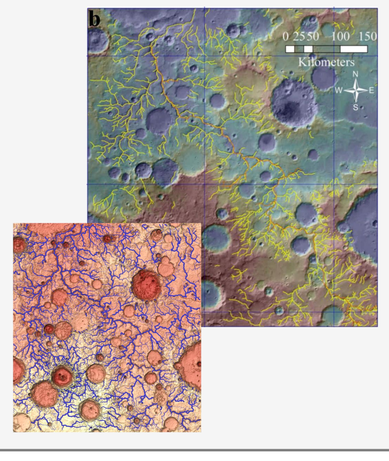


- Extraction of valley-like structures
- Separatrix persistence reflects the varying strength of valleys



- All extremal lines are extracted
- Uplift of crater impact

- Comparison with manually mapped valleys by Hynek et al.
- Correspondences of large-scale structures
- Similar branching behavior
- Differences in small-scale valleys



Conclusions and Future Work

- Semi-automatic extraction of craters
- Unbiased and automatic extraction of all extremal lines
- Result is robust with respect to noise
- Separatrix persistence allows for meaningful reduction

- Not all extremal lines are valleys
- Separation of valleys from other extremal lines (use of local information)
- Application to more highly resolved Martian topography (e.g. HRSC data)
- Application to terrestrial elevation data

References

J. Reininghaus, D. Günther, I. Hotz, S. Prohaska, H.-C. Hege. *TADD: A Computational Framework for Data Analysis Using Discrete Morse Theory*. 3rd Int. Congress on Mathematical Software ICMS 2010

T. Weinkauf, D. Günther, *Separatrix Persistence: Extraction of Salient Edges on Surfaces Using Topological Methods*, Computer Graphics Forum, Vol. 28 (5), pp. 1519-1528, July 2009

B. M. Hynek, R. J. Phillips, *New Data Reveal Mature, Integrated Drainage Systems on Mars Inidicative of Past Precipitation*, Geology, Vol. 31 (9), pp. 757-760, September 2003

04.09.2010