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Automated Detection and Analysis of Mars Surface Structures by Segmentation

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Former and recent Mars missions provide huge amount of data representing the surface of Mars at different scales and in different formats (e.g. points, grid models, etc.). Examples are globally available surface models derived from the laser altimeter MOLA or image matching points and terrain models derived from HRSC image data provided by MarsExpress. An effective, overall interpretation of these datasets might be a considerable challenge for the end user of the data: the experimenter has to have enough knowledge, experience and computer capacity in order to manage the acquired datasets properly and to derive areomorphologically relevant information from the raw or intermediate data products. Additionally, all this information might need to be integrated with other data like, for example, orthoimage maps (e.g. MOC, HRSC, HiRISE) or geomorphological maps. In general, interactive interpretation is necessary to determine areomorphic structures from such datasets to achieve an significant data reduction. Standard methods provide little support for the automatic determination of characteristic features and their statistical evaluation.

From the lessons learnt from automated extraction and modeling of buildings from LiDAR data of huge landscapes on Earth (Dorninger & Pfeifer, 2008), we expected that similar generalizations can be achieved for areomorphic structures. Our aim is to recognize as many features as possible from the terrain data - either available as inhomogeneous point clouds or as gridded terrain models - in the same processing loop, if they can be geometrically described with appropriate accuracy (e.g., as a plane). For this, we propose to apply a segmentation process allowing determining connected, planar structures within a surface represented by the given terrain data. It is based on a robust determination of local tangential planes for all (grid) points acquired (Nothegger & Dorninger, 2009). It assumes that for points, belonging to a distinct planar structure, similar tangential planes can be determined. The plane parameters are used to define a four-dimensional feature space which is used to determine seed-clusters globally for the whole area of interest. Starting from these seeds, all points defining a connected, planar region are assigned to a segment. Due to the design of the algorithm, millions of input points can be processed with acceptable processing time on standard computer systems. This allows for processing areomorphically representative areas at once. For each segment, numerous parameter are derived which can be used for further exploitation. These are, for example, location, area, aspect, slope, and roughness.

To prove the applicability of our method for automated areomorphic terrain analysis, we used the MOLA DTM (Digital Terrain Models), HRSC matching data (i.e. point clouds) and HRSC DTMs. The results are provided as color-coded maps to be used as overlays in combination with other data sources (e.g. orthoimages, areomorphogical maps) and as attributes for each given (grid) point. The latter allow for statistical interpretation of their local distribution. A high correlation of significant distributions of the investigated parameter and well known surface structures was observed.