Automatic Geomorphic Mapping

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Unsupervised Learning

- Uses clustering techniques.
- Applicable in cases of exploratory mapping.
- Expedites creation of maps in planetary science context where surfaces are still being explored and landform classes are not yet defined.


Supervised Learning

- Uses classification techniques.
- Applicable in cases of exploitation mapping.
- Exploitation mapping finds application in creating geomorphic maps for terrestrial and planetary sites for which constituting landform classes are known a priori.


All our tools are based on features derived from topography
Approaches to assigning geomorphic labels to topographic data

(A) Pixel-based approach
- Input data
- Pixel-based feature vector \(\{u_1, u_2, \ldots, u_n\}\) is assigned to each pixel
- Mapping tool
- Each pixel is assigned individually to a landform class
- Labeled data

(B) Segmentation-based approach
- Input data
- Pixel-based feature vector \(\{u_1, u_2, \ldots, u_n\}\) is assigned to each pixel
- Segment-based feature vector \(\{U_1, U_2, \ldots, U_m\}\) is assigned to each segment
- Mapping tool
- Labeled data
Our original approach to auto-mapping

- The physiographic map is the thematic map of landforms. The purpose of such a map is to visualize spatial relations between different landforms. The map provides insights into geologic processes that shapes the landscape of the study area.

- Developing an effective method for automatic mapping of Martian physiography is of interest because creating such maps manually is expensive and suffers from lack of standards.

- Our goal: To develop a computer algorithm for auto generates of physigraphic map that matches an appearance and usability of manually drawn maps and is compliant with GIS standards.
Effective, Segmentation-based, Unsupervised Terrain Classification

- Stepinski and Bagaria (2009), GRSL, 6(4), p733-737

DEM

Automatically generated physiographic map

Chaitanya Bagaria
graduate student

Iwahashi and Pike, Geomorphology 86, 2007
Nested means

Iwahashi and Pike, Geomorphology 86, 2007
Goal: To auto-map physiography in a style of analyst-drawn maps.
Our two-step approach

**INPUT DATA**
- DEM

**TERRAIN ATTRIBUTES**
1. Slope gradient
2. Surface texture
3. Local concavity

**BASE CLASSIFICATION**
- Pixel-based
- 16 terrain types

**SECONDARY FEATURES**
1. Frequencies of terrain types in a moving window (16 features)
2. Terrain types texture measures (3 features)

**META CLASSIFICATION**
1. Segmentation
2. Clustering of segments into 9 terrain classes

**OUTPUT**
- Segment-based physiographic map elevation grid

**BASE CLASSIFICATION MAP**
- Focus pixel
- Moving window 11 X 11 pixels

**FREQUENCIES OF TERRAIN TYPES**
- Neighborhood radius = 1
- Neighborhood radius = 2 not shown
- Neighborhood radius = 3

**CLASS TEXTURE**

Recursive Hierarchical Segmentation (RHSEG) Algorithm*

- Simultaneously segments the DEM and clusters the segments
- Iteratively produces hierarchies of segments and clusters
- User selected geographical and feature-space resolution
- Clusters correspond to generalized terrain units
- Terrain units are interpreted in terms of Iwahashi and Pike terrain classes

* Tilton [NASA Case Number GSC 14, 2000]
Mapping Tharsis region on Mars

- RHSEG stopped at level 11
- 2382 segments
- 9 terrain units
Physiographic provinces on Mars
- Classification -

- 4 km/pixel resolution, 5335 x 2667 pixels
- Each tile 1024 x 1024 pixels
Physiographic provinces on Mars
- Combining tiles -

- For each tile RHSEG is run and 20 classes are saved
- Total of 15 x 20 = 300 classes are saved altogether
- Average 19-features vector is calculated for each segment
- Each segment is assigned into one of 300 classes
- Agglomerative clustering is used to reduce number of classes
Four provinces
Twelve provinces

106 different geologic units
Conclusions

- Planetary geomorphometry has future!
- Two step classification is effective in mapping terrain units.
- The method can be generalized to obtain global maps of Martian physiography.
- Hierarchical classification of terrain units allows for multilevel mapping of physiographic provinces.