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Self Organizing Neural Network: A Method for Feature Analysis of Lands

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ABSTRACT

The exploration and categorization of Shuttle Radar Topography Mission (SRTM) data for classification and extraction of topographic features is a challenging task. This paper presents a semi-automatic approach using artificial neural networks -Self Organizing Map (SOM) and SRTM data for analysis and identification of land features in Lut Desert. Lut Desert or Dasht-e Lut is among the hottest, driest desert regions in the world. This area is characterized by homogeneous repetition of wind-eroded landforms, some of the world's highest mega dunes and salt flats in southeastern Iran. In this hyper area region the extremely unidirectional winds have fluted the bedrock outcrops and old lake beds to aerodynamic forms, called yardangs. A SOM with a low average quantization error was used for further analysis. Feature space analysis, morphometric signatures, three-dimensional inspection and auxiliary data facilitated the assignment of semantic meaning to the output classes in terms of geomorphometric features. Results are provided in a geographic information system as thematic maps of landform entities based on form and slope. The results demonstrate that a SOM is an efficient tool for analyzing and recognition of desert lands features.

Keywords: Self Organizing Map; Radar data; Neural Network; Desert

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SELF ORGANIZING NEURAL NETWORK: A METHOD FOR FEATURE ANALYSIS OF LANDS

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Abstract

The exploration and categorization of Shuttle Radar Topography Mission (SRTM) data for classification and extraction of topographic features is a challenging task. This paper presents a semi-automatic approach using artificial neural networks -Self Organizing Map (SOM) and SRTM data for analysis and identification of land features in Lut Desert. Lut Desert or Dasht-e Lut is among the hottest, driest desert regions in the world. This area is characterized by homogeneous repetition of wind-eroded landforms, some of the world's highest mega dunes and salt flats in southeastern Iran. In this hyper arid region the extremely unidirectional winds have fluted the bedrock outcrops and old lake beds to aerodynamic forms, called yardangs. A SOM with a low average quantization error was used for further analysis. Feature space analysis, morphometric signatures, three-dimensional inspection and auxiliary data facilitated the assignment of semantic meaning to the output classes in terms of geomorphometric features. Results are provided in a geographic information system as thematic maps of landform entities based on form and slope. The results demonstrate that a SOM is an efficient tool for analyzing and recognition of desert lands features.

Keywords: Self Organizing Map, Radar data, Neural Network, Desert

1. Introduction

The Lut desert or Dasht-e Lut in the south east of Iran is described as the “thermal pole of the Earth”. With an area of about 80000 square kilometres it is regarded to be among the hottest, driest desert regions in the world [1-3]. The eastern part of Lut desert is characterized by a great massif of dunes and sand rises, while the western part contains Yardangs, some of the world's largest desert forms separated by large wind-swept corridors [4]. The yellowish-red Pleistocene clay deposits of the former Lut lake are now sculptured into straight bizarre shapes resembling buildings known as yardang (they are called by the Iranian Baluchis *Kalut*, desert cities) up to 80 m high and 120 km long running in NW-SE direction [2]. Yardangs a Turkmen word used by the Swedish explorer Sven Hedin[5] meaning ‘steep bank’ occur also on Mars and possibly on Venus . They are streamlined forms up to 150 km long and 75 m in height resulting from a number of formative processes, including wind abrasion, deflation, fluvial

incision, desiccation cracking, slumping, weathering and mass movement [6, 7].

2. Literature Review

Self-Organizing Map (SOM) is an unsupervised and nonparametric artificial neural network algorithm that clusters high dimensional input vectors into low dimensional (usually two dimensional) output map in such a way, that topology of the data is preserved. Preserving topology means that the SOM mapping preserves the relations between input items. Points that are near to each other in the input space are mapped to nearby map units in output space [15].

3. Research Methods

In this paper, we use 90 m DEM data, produced from SRTM 3 arc sec. version 3, and the SOM algorithm for identification of yardangs in the western part of Lut desert. For morphometric analysis [11]. The second order derivatives of DEM are affected by geomorphological processes [11, 14]. To calculate the morphometric

features, a local window is passed over the DEM and the change in gradient of a central point in relation to its neighbours is derived by a bivariate quadratic function:

$$Z = ax^2 + by^2 + cxy + dx + ey + f \quad (1)$$

Where: x , y , Z are local coordinates and a to f are quadratic coefficients [11].

Yardang identification and analysis in the study area was performed using the data set proposed by Wood [14]. Slope, cross sectional curvature, maximum curvature and minimum curvature are derived by fitting a bivariate quadratic approximation surface. Kohonen's Self Organizing Map (SOM) is an unsupervised artificial neural network for clustering and visualization of information, preserving the topological relationship in the input [15]. It converts the nonlinear statistical relationships of high dimensional input data to low dimensional (usually two dimensional) output grid [15].

The SOM characteristics like learning ability, abstraction with topology preservation and visualization can be utilized in complex tasks such as morphometric analysis and landform classification [16, 17]. The frequency histogram and average quantization error of the results are compared. Using feature space analysis, spectral signature analysis, three-dimensional inspection, auxiliary data, Landsat ETM+ data and high resolution satellite imagery from Quick Bird, dependency of optimal map units to morphometric features i.e. yardangs were defined.

4. Discussion and Conclusion

The thematic map of distributional pattern of yardangs in the entire area can be obtained by the SOM outlined earlier (Fig 1).

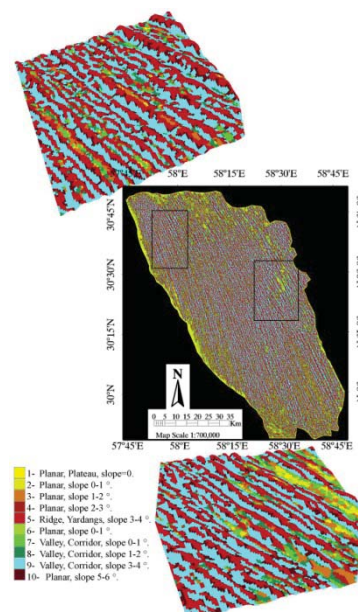


Figure 1. Desert land features by SOM method.

Result of this method revealed that from the total 6481 km² coverage of the study area, about 2035 km² (31%) are classified as yardang while corridors, described by 3 classes (7, 8 and 9), in total cover 2732 km² (42%). Class 6 characterizes planar area with slope 0-1°, which is smallest detected area with only 18 km². And external factors e.g. one-directional strong winds, fluvial incision and occasional rainfall (Gutierrez-Elorza et al [21]. Nevertheless, other non 117eolian processes such as cracking, weathering, slumping, piping, etc., are important for their evolution. In this paper, a semi-automatic method, SOM, as an unsupervised neural network algorithm was very effective and useful for identification and recognition of yardangs in the Lut desert, Iran.

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