Abstract

Geographic Information Systems (GIS) provide unique capabilities to model and represent the physical environment while considering location, therefore they play an important role in many segments of human activity. To support technological progress, geographic representation or data modeling has been identified as one of the research priorities and perhaps the greatest research challenge of GIScience.

Scientific endeavor has not succeeded in overcoming the duality of the two main geographic representations, namely field and object. Discretization of fields in order to represent them as objects is particularly challenging on the way to integrate the two geographic representations.

The main goal of the candidate's research was to develop object-oriented models better suited to representation and analysis of geographic data, by discretization of fields relative to the multi-scaled patterns encoded within the data. The work to achieve the main goal is structured around two derived objectives: 1) To improve multi-scale optimization in object-oriented analysis, and 2) To develop models to translate from fields to discrete entities in geomorphometry.

The first objective is relevant to the role of geographic scale in translation from fields to objects. It is known that ecological systems comprise multi-scaled patterns and processes. Hidden in fields, however, the multi-scaled patterns challenge unbiased representations of the objects they belong to. Image segmentation methods have been increasingly adopted to discretize fields into objects, particularly for remotely sensed data. The multi-resolution segmentation (MRS) algorithm, for instance, enables production on multiple object representations from a given field. The objects are defined entirely by the purpose of the study, following a subjective control of the geographic scale via a "trial-and-error" setting of the segmentation parameters. While allowing flexibility in incorporating expert knowledge in segmentation, this procedure is hardly reproducible and raises important scientific issues with respect to the robustness of the approach. The scientific challenge addressed by this objective is the arbitrariness of geographic scale in the definition of objects.

The second objective addresses the applicability of object-oriented models to the land-surface, which is probably the most difficult field given the smooth transitions between the features represented numerically. Based on the work towards achieving the first objective, this objective addresses the scientific challenge of landform delimitation.

An application of the concept of local variance (LV) graphs to statistically guide multi-scale analysis when producing objects with a MRS algorithm was proposed by Drăguţ et al. (2010). Basically, this approach answers the question "What scales are in the data?". The

progress beyond the state of the arts consists in extending the LV concept into multi-scale analysis. The experimental results in three test areas confirmed that the inherent data properties can be effectively used in detecting levels where segmentation results match structures in the real world, at multiple scales.

This approach was extended into a multivariate dimension, by considering multiple layers of information, and an automated three-tiered hierarchical concept was implemented in object-oriented modelling with a MRS algorithm (Drăguţ et al., 2014). This work has important implications for automation of field discretization into objects.

A scale optimization approach of land-surface curvatures, in order to adjust the scale of the modelling to the physical processes to be modelled was proposed by Drăguţ at al. (2009). The procedure shall enhance terrain-based environmental modeling through selection of the most suitable land-surface derivatives, at the appropriate scale for the process considered. The workflow was exemplified through soil-landscape modeling.

A pioneer approach to discretize the altitude and its derivatives with MRS was presented by Drăguţ and Blaschke (2006). Land-surface derivatives were automatically delineated into landform elements, considering spatial position besides local geometry. The methodology was demonstrated in two study areas.

The potential of the LV method to guide landform delineation in a multi-scale approach was investigated by Drăguţ et al. (2011). We showed in this work that it is possible coupling multi-scale pattern analysis with delineation of morphometric primitives. From a geomorphometry perspective, this opens important roads to the discrete analysis of the land surface.

Drăguţ and Eisank (2011) described an application of the previous methods and concepts to perform a physiographic classification at global scale. Statistical assessment suggests that the object-oriented classification performs better than existing methods (Iwahashi and Pike, 2007) in partitioning the land surface, particularly in terms of roughness, according to the basic principle of regionalization (maximizing internal homogeneity and external difference).

The previous concepts were demonstrated through object-oriented models for extraction of specific geomorphic objects from fields (d'Oleire-Oltmanns et al., 2013). The methodology combines a statistical procedure to make multi-scale segmentation self-adaptive to the input data and a knowledge-based selection of the most transferable properties to be used in the classification. The method was applied to two distinct cases: mapping gullies from aerial photographs and drumlins from DEMs.

Candidate's professional activity and professional plans for the future are presented in a synthesis that completes this thesis.