Multi-scale pattern analysis of geographic entities

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INTRODUCTION

Our perception and understanding of landscapes has become increasingly filtered through digital representations of landscapes such as satellite images and DEMs (Dietrich & Montgomery, 1998). Such models are conceptualized as fields and represented through discretization, usually as regular grids. However, the discrete objects (e.g. grid cells) characterizing a field have no meaning in reality and only exist for reasons of representation (Fisher, 1997; Goodchild et al., 2007).

Especially, since the advent of ever finer spatial resolutions, which present too much detail for various applications, there is the need for aggregating field elements into objects. Objects relate to real-world features and better mimic the way humans perceive their environment. The usual approach for aggregating field elements into objects is classification. Though, classification, and in particular multi-scale classification, is a subjective task, as the decision on both the definition and number of classes as well as on spatial scales is up to the user.

Currently, only a few approaches exist, which assist the user in the selection of appropriate spatial scales. Additional data-driven methods for multi-scale pattern analysis are required to reveal the organization of discrete objects in digital representations across scales and to enable more objective selection of scales for classification purposes.

METHOD

In our research we thoroughly investigated the statistical method of local variance (LV) for multi-scale pattern analysis of both satellite images and land-surface models (Drăguţ et al, 2009; Drăguţ et al., 2010). The method belongs to the category of data-driven approaches and builds upon the fundamental idea of the relationships between spatial structure of images, size of the objects in the real world and pixel resolution (Woodcock & Strahler, 1987).

Segmentation is an elementary procedure in object-based image analysis (OBIA) and a proper solution to aggregate field elements into objects based on minimum heterogeneity.

We performed multi-resolution segmentation to compute successively coarser image patterns. At each level we measured LV as the value of standard deviation of each object, then calculating the mean of these values for the entire scene. Recently, Drăguţ et al. (2010) have automated the process by introducing the ESP-tool (Estimation of Scale Parameter). When plotting LV values against scale, peaks/steps in the graph indicate those levels, where local variability is relatively high and hence, where objects approximate the size and shape of geographic entities.

RESULTS AND DISCUSSION

In our study we demonstrated that LV is an effective data-driven method to analyze the spatial pattern of images across scales. In all generated LV graphs we observed peaks indicating characteristic scales for the mapping of geographic entities. Due to different degrees of continuity in digital representations, thresholds in the curves obtained from satellite images were more prominent than those in the graphs derived from land-surface models. Visual assessment of results confirmed that LV graphs accurately indicated suitable segmentation scales. At these scales meaningful objects were delineated as part of patterns representative for various levels of organization within the scenes of interest.

OBIA provides a powerful framework for linking the concepts of fields and objects through image segmentation. The presented method is practical for the selection of spatial scales in multi-scale analysis of geographic entities. Eventually, the LV approach to pattern analysis could be the basis for objective multi-level classification, due to the convenient linkage of scale structures of real-world entities and class hierarchies.

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