Environmental Object Recognition in a Natural Image: An Experimental Approach Using Geographic Object-Based Image Analysis (GEOBIA)

Jagannath Aryal, Discipline of Geography and Spatial Science, School of School of Land and Food, University of Tasmania, Hobart, Australia

Didier Josselin, UMR ESPACE, University of Avignon, Avignon, France

ABSTRACT

Natural images, which are filled with intriguing stimuli of spatial objects, represent our cognition and are rich in spatial information. Accurate extraction of spatial objects is challenging due to the associated spatial and spectral complexities in object recognition. In this paper, the authors tackle the problem of spatial object extraction in a GEOgraphic Object Based Image Analysis framework taking psychological and mathematical complexities into account. In doing so, the authors experimented with human and GEOBIA based recognition and segmentation in an image of an area of natural importance, the Ventoux Mountain, France. Focus was given to scales, color, and texture properties at multiple levels in delineating the candidate spatial objects from the natural image. Such objects along with the original image were provided to the human subjects in two stages and three different groups of samples. The results of two stages were collated and analyzed. The analysis showed that there exist different ways to comprehend the geographical objects according to priori knowledge.

Keywords: *Environmental Object, GEOBIA, Human Subjects, Perception, Recognition, Scales*

1. INTRODUCTION

Environmental images are a rich source of spatial information and represent the real world. Natural complexity in these images can best be explored using spatial analysis tools based on concepts of landscape as process continuums that can be partially decomposed into objects or patches (Burnett & Blaschke, 2003). Extracting spatial objects from environmental images demands localised knowledge of real world features along with associated semantics. Interpretation of spatial objects and their recognition by human subjects are of prime importance in environmental/agricultural information science. Object recognition has been studied from different perspectives, for example using shape context (Serge et al., 2002), a spatial relationship model (Zhu & Yuan, 2008) and using spatial and functional compatibility (Gupta et al., 2009).

DOI: 10.4018/ijaeis.2014010101

However, precise recognition of spatial objects in remotely sensed imagery for the purpose of interpretation and analysis of real world features still requires improvement on the methods developed so far, given the complexity of imaging applications (Lang, 2008). Efforts have been made by scientists in the field of remote sensing to extract accurate image objects and relate them to corresponding real world spatial objects (Benz et al., 2004; Lang et al., 2004). Previous studies demonstrate that accurate interpretation of image objects is possible given a prior knowledge on the associated perception on object formation. The perception is indeed controlled by psychological and mathematical foundations. Significant progress has also been made in image and aerial photography analysis by defining selective and dichotomous keys for interpretation (Paine & Kiser, 2012).

In this article, our focus is to contribute to the understanding of spatial object recognition in satellite images, taking into account the psychological and mathematical bases of object formation and recognition. In particular, among many aspects of spatial object formation, we investigate the Boundary Contour System (BCS) and the Feature Contour System (FCS). BCS activates a boundary completion process taking texture into account whereas FCS activates a diffusion filling-in process that spreads featural qualities like color across the perceptual domain (Grossberg, 1988). The role of color and texture in forming spatial objects in satellite images is extremely important. With this realization, in this paper, we developed a protocol for spatial object delineation and performed an experiment on a high resolution image segmented at multiple scales taking color and texture into account. The segmented images were presented to human subjects for the experiment.

The main goals of this experiment were to quantify the human subjects' ability to delineate spatial objects in a very high resolution satellite image and to compare at multiple scales their results with software generated results. Further, the human subjects were asked to suggest optimal scales to characterize particular spatial objects in the real world. Image object recognition is based on both objective and subjective dimensions; the objectivity is informed by parameters like color, texture, shape, size and scale, whereas the subjectivity is guided by the perception and cognition of the interpreters (Lang et al., 2004). In this paper, we aim at answering a fundamental question that is open to GIS and remote sensing community: can human cognition be characterized when identifying a spatial object? Or, in other words, do human subjects agree with each other when defining an object with their own cognition, for example, by choosing the same scales of representation and the same criteria (*e.g.* color, texture)?

The organization of this paper is as follows: in section 2, we review and critically assess GEOBIA, touching on the advancement of color and texture studies in object recognition. Section 3 presents a brief background to human visual spatial object formation taking into account associated psychological and mathematical bases. Section 4 presents an overview of data used in the study and the experimental set up using GEOBIA. Section 5 presents our experimental results, section 6 presents our discussion and conclusions, and section 7 proposes future work.

2. GEOBIA, COLOR AND TEXTURE FEATURES IN OBJECT RECOGNITION

From about 2000, GEOBIA has become a quite widely adopted approach to object recognition by remote sensing community when analyzing the aggregation and dis-aggregation of real world features at multiple levels and scales. This approach to some extent incorporates human cognition in recognizing the spatial objects and is a new discipline of thinking and extracting image objects (Hay & Castilla, 2008). More than 800 publications using this approach have been reported, for diverse fields ranging from environmental mapping and monitoring to medical image analysis (Blaschke, 2010). In addition to application research, there have been theoretical advancements such as quantifying semantic accuracy in segmented images (Stein & De Beurs, 2005), quantifying the robustness

Related Content

Smart Cities and Municipal Building Regulation for Energy Efficiency
Eleonora Riva Sanseverino, Gianluca Scaccianoce, Valentina Vaccaro, Maurizio Cartaand Raffaella Riva Sanseverino (2015). *International Journal of Agricultural and Environmental Information Systems (pp. 56-82).*
www.irma-international.org/article/smart-cities-and-municipal-building-regulation-for-energy-efficiency/137163

Operation of a Hydrogen Storage-Based Smart DC Microgrid
Mahesh Kumar (2022). *Optimal Planning of Smart Grid With Renewable Energy Resources (pp. 145-172).*
www.irma-international.org/chapter/operation-of-a-hydrogen-storage-based-smart-dc-microgrid/293177

Social Cooperation in Autonomous Agents to Avoid the Tragedy of the Commons
Shagun Akarsh, Avadh Kishor, Rajdeep Niyogi, Alfredo Milaniand Paolo Mengoni (2017). *International Journal of Agricultural and Environmental Information Systems (pp. 1-19).*
www.irma-international.org/article/social-cooperation-in-autonomous-agents-to-avoid-the-tragedy-of-the-commons/179580

Quantifying Urban Sprawl with Spatial Autocorrelation Techniques using Multi-Temporal Satellite Data
Gabriele Nolè, Rosa Lasaponara, Antonio Lanorteand Beniamino Murgante (2014). *International Journal of Agricultural and Environmental Information Systems (pp. 19-37).*
www.irma-international.org/article/quantifying-urban-sprawl-with-spatial-autocorrelation-techniques-using-multi-temporal-satellite-data/114684

Analysis of Extraction Algorithm for Visual Navigation of Farm Robots Based on Dark Primary Colors

Jin Wang, Yifei Cui, Hao Wang, Mohammad Ikbaland Mohammad Usama (2021). *International Journal of Agricultural and Environmental Information Systems (pp. 61-72).*

www.irma-international.org/article/analysis-of-extraction-algorithm-for-visual-navigation-of-farm-robots-based-on-dark-primary-colors/275243