GIScience & Remote Sensing, 2018
Vol. 55, No. 2, 155–158, https://doi.org/10.1080/15481603.2018.1436953

EDITORIAL

Special issue: Remote sensing of our changing landscapes with Geographic Object-based Image Analysis (GEOBIA)

1. Evolution of GEOBIA

The physical surface of our planet is in constant changes resulting from natural phenomena and anthropogenic activities. High-resolution remote sensing provides possibly the only feasible solution to monitor and analyze landscape dynamics over large areas while still demonstrating uniquely fine-scale spatial patterns. In remote sensing, "high resolution" is typically considered as an image resolution finer than 5 m. However, it is also a relative concept, where individual pixels capture only a portion of the interested geographic objects (e.g., buildings/neighborhoods and trees/forest stands) or a part of changed patches (e.g., conversion from trees/forest stands to buildings/neighborhoods). Following the rising criticisms of the classic "per-pixel" approach since circa 2000, the "object-based" approach – Geographic Object-based Image Analysis (GEOBIA) – has emerged as a new paradigm in analyzing high-resolution remote-sensing imagery (Hay and Castilla 2008; Blaschke et al. 2014).

Over the past two decades, geo-object-based modeling experienced two main stages. The first stage (circa 2000–2010) emphasized on developing GEOBIA theoretical foundations and frameworks. During this stage, a number of proof-of-concept studies were conducted to investigate fundamental, yet crucial, issues in object-based modeling, such as segmentation (e.g., Size-constrained Region Merging; Castilla, Geoffrey, and Ruiz-Gallardo 2008), scale determination (e.g., Estimation of Scale Parameter; Drăguţ, Tiede, and Levick 2010), object-based feature extraction (e.g., SEperability and the corresponding Thresholds; Nussbaum, Niemeyer, and Canty 2006), and accuracy assessment (e.g., object-fate analysis; Schöpfer and Lang 2006). In some cases, the superior performance of GEOBIA had to be demonstrated through a comparison with the pixel-based approach (e.g., Chen et al. 2011). Meanwhile, internationally joint efforts were made to facilitate the development of foundation and framework of GEOBIA. For example, the first GEOBIA international conference was held in 2006, which was followed by biannual meetings hosted in Europe, North America, and South America. The book "Object-Based Image Analysis" edited by Blaschke, Lang, and Hay (2008) brought together a collection of interdisciplinary perspectives on the topic. Special issues on GEOBIA started to appear in high-profile international journals, such as *Photogrammetric Engineering & Remote Sensing* [edited by Hay and Blaschke (2010)] and *International Journal of Geographic Information Science* [edited by Addink, Van Coillie, and De Jong (2012)]. The increasing popularity of GEOBIA has drawn wide attention not only from academia but also from industry. While eCongition (Trimble, California) continues to dominate the market due to its early introduction to the field, traditional remote-sensing software packages, e.g., ENVI (Harris Geospatial Solutions, Colorado) and ERDAS (Hexagon Geospatial, Georgia), have also developed new modules for high-resolution image analysis.

The second stage of the GEOBIA evolution (circa 2010 to present) has focused on the advancements of geo-object-based models for a wide variety of real-world applications. During this stage, the GEOBIA community has greatly extended the interest from land-use/land-cover mapping to many other fields, such as improving urban energy efficiency (Hay et al. 2011), capturing latent spatial phenomena under policy concern (Lang et al. 2014), and forest burn severity estimation (Chen et al. 2015). Accordingly, new GEOBIA algorithms were developed with emphases on analyzing novel data types (e.g., hyperspectral; Schäfer et al. 2016), multi-source data integration (e.g., optical and LiDAR; Godwin, Chen, and Singh 2015), automation of scale determination (e.g., enhancing intra-segment homogeneity and inter-segment heterogeneity; Yang, He, and Weng 2015), semantic segmentation (e.g., employing Deep Convolutional Neural Networks (DCNN); Marmanis et al. 2016), feature selection (e.g., utilizing machine learning; Ma et al. 2017), automating the adaptation and adjustment of rule sets (e.g., agent-based image analysis; Hofmann et al. 2015), ontology-driven modeling (e.g., Arvor et al. 2013), etc. The maturity of GEOBIA foundations, frameworks, and software allowed researchers and practitioners to effectively analyze high-resolution imagery, while research findings further published in non-remote-sensing journals, such as *Journal of Environmental Management, Landscape and Urban Planning, Ecological Informatics, Natural Hazards and Earth System Sciences*, and *Journal of Archaeological Science*.

2. Synopsis of the special issue

This special issue aims to review and synthesize the latest, leading-edge advances in GEOBIA evolution. Our objective is to provide a relatively broad sample of different research topics in GEOBIA from a number of submissions.

Chen et al. present a review of the emerging trends in GEOBIA and discuss potential opportunities for future development. The review reflects recent developments in multiple subfields of GEOBIA, including data sources, image segmentation, object-based feature extraction, and geo-object-based modeling frameworks.

Wittharana et al. present an integration of LiDAR and GEOBIA framework for automatically detecting relict charcoal hearths that lie abandoned in dense forested terrain. The utilization of new object-based features derived from LiDAR data and adapted rule sets in classification provides a viable alternative to time- and labor-intense human-augmented image interpretation for archaeological study.

Lu et al. present an evaluation study of the effects of spatial resolution of unmanned aerial vehicle (UAV) imagery in grass species classification. The authors argue that it is essential to select the optimal spatial resolution of UAV imagery for investigating vegetative ecosystem.

Georganos et al. present a systematic evaluation of feature selection in GEOBIA. The authors evaluated and compared four feature selection algorithms, Correlation-Based Selection, Mean Decrease in Accuracy, Random Forest (RF)-based Recursive Feature Elimination, and Variable Selection Using Random Forest, and tested their performance when combined with the Extreme Gradient Boosting (Xgboost), Support Vector Machine (SVM), K-Nearest Neighbor, RF, and Recursive Partitioning (RPART) classifiers, respectively. They further proposed a new metric to perform automatic model selection – Classification Optimization Score.

Liu et al. present a comparison study using two representatives of deep learning networks, Fully Convolutional Networks (FCN) and patch-based DCNN, and two conventional classifiers including RF and SVM within a framework of GEOBIA for land-cover classification. Their findings indicate the potential of applying deep learning networks FCN to achieve superior classification performance regardless of the number of training samples.

Han et al. present a novel image change detection algorithm called entropy query-by fuzzy ARTMAP object-based joint classification comparison (EQFAM-OBJCC). The algorithm demonstrates effectiveness in reducing the salt-and-pepper effects in results and mitigating the error accumulation issue that is common to change detection.

Johansen et al. demonstrate the possibility of using GeoEye-1 imagery and GEOBIA to detect the greyback canegrub (*Dermolepida albohirtum*) damage in sugarcane crops. The risk maps created following the damage detection are valuable for visualizing the likelihood of canegrub damage risk in the growing season.

We wish to thank all the authors and reviewers who participated in the submission and review processes. We would also like to express our sincere gratitude to Dr Jungho Im (Editor-in-Chief of *GIScience & Remote Sensing*) for his invitation of writing a review and tremendous support. Without a doubt, their work has greatly enhanced the quality and the coherence of the special issue.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Gang Chen http://orcid.org/0000-0002-7469-3650
Qihao Weng http://orcid.org/0000-0002-2498-0934

References

Addink, E. A., F. M. B. van Coillie, and S. M. De Jong. 2012. “Introduction to the GEOBIA 2010 Special Issue: From Pixels to Geographic Objects in Remote Sensing Image Analysis.” *International Journal of Applied Earth Observation and Geoinformation* 15: 1–6. doi:10.1016/j.jag.2011.12.001.

Arvor, D., L. Durieux, S. Andrés, and M. A. Laporte. 2013. “Advances in Geographic Object-Based Image Analysis with Ontologies: A Review of Main Contributions and Limitations from a Remote Sensing Perspective.” *ISPRS Journal of Photogrammetry and Remote Sensing* 82: 125–137. doi:10.1016/j.isprsjprs.2013.05.003.

Blaschke, T., G. J. Hay, M. Kelly, S. Lang, P. Hofmann, E. Addink, R. Q. Feitosa, et al. 2014. “Geographic Object-Based Image Analysis – Towards a New Paradigm.” *ISPRS Journal of Photogrammetry and Remote Sensing* 87: 180–191. doi:10.1016/j.isprsjprs.2013.09.014.

Blaschke, T., S. Lang, and G. J. Hay, Eds. 2008. *Object-Based Image Analysis. Spatial Concepts for Knowledge-Driven Remote Sensing Applications*. Series: XVII Lecture Notes in Geoinformation and Cartography. Berlin: Springer-Verlag, 818.

Castilla, G., J. Geoffrey, and J. R. Ruiz-Gallardo. 2008. “Size-Constrained Region Merging (SCRM): An Automated Delineation Tool for Assisted Photointerpretation.” *Photogrammetric Engineering & Remote Sensing* 74: 409–419. doi:10.14358/PERS.74.4.409.

Chen, G., G. J. Hay, G. Castilla, and B. St-Onge. 2011. “A Multiscale Geographic Object-Based Image Analysis to Estimate Lidar-Measured Forest Canopy Height Using Quickbird Imagery.” *International Journal of Geographical Information Science* 25: 877–893. doi:10.1080/13658816.2010.496729.

Chen, G., M. R. Metz, D. M. Rizzo, W. W. Dillon, and R. K. Meentemeyer. 2015. “Object-Based Assessment of Burn Severity in Diseased Forests Using High-Spatial and High-Spectral Resolution MASTER Airborne Imagery.” *ISPRS Journal of Photogrammetry and Remote Sensing* 102: 38–47. doi:10.1016/j.isprsjprs.2015.01.004.

Drăguţ, L., D. Tiede, and S. R. Levick. 2010. “ESP: A Tool to Estimate Scale Parameter for Multiresolution Image Segmentation of Remotely Sensed Data.” *International Journal of Geographical Information Science* 24: 859–871. doi:10.1080/13658810903174803.

Godwin, C., G. Chen, and K. K. Singh. 2015. “The Impact of Urban Residential Development Patterns on Forest Carbon Density: An Integration of LiDAR, Aerial Photography and Field Mensuration.” *Landscape and Urban Planning* 136: 97–109. doi:10.1016/j.landurbplan.2014.12.007.

Hay, G. J., C. Kyle, B. Hemachandran, G. Chen, M. M. Rahman, T. S. Fung, and J. L. Arvai. 2011. “Geospatial Technologies to Improve Urban Energy Efficiency.” *Remote Sensing* 3: 1380–1405. doi:10.3390/rs3071380.

Hay, G. J., and G. Castilla. 2008. “Geographic Object-Based Image Analysis (GEOBIA): A New Name for A New Discipline?” In *Object-Based Image Analysis – Spatial Concepts for Knowledge-Driven Remote Sensing Applications*, edited by T. Blaschke, S. Lang, and G. J. Hay. Chapter 1.4, 75–89. Berlin: Springer-Verlag.

Hay, G. J., and T. Blaschke. 2010. “Forward: Special Issue on Geographic Object-Based Image Analysis (GEOBIA).” *Photogrammetric Engineering & Remote Sensing* 76: 121–122.

Hofmann, P., P. Lettmayer, T. Blaschke, M. Belgiu, S. Wegenkittl, R. Graf, T. J. Lampoltshammer, and V. Andrejchenko. 2015. “Towards a Framework for Agent-Based Image Analysis of Remote-Sensing Data.” *International Journal of Image and Data Fusion* 6: 115–137. doi:10.1080/19479832.2015.1015459.

Lang, S., S. Kienberger, D. Tiede, M. Hagenlocher, and L. Pernkopf. 2014. “Geons-Domain-Specific Regionalization of Space.” *Cartography and Geographic Information Science* 41: 214–226. doi:10.1080/15230406.2014.902755.

Ma, L., T. Fu, T. Blaschke, M. Li, D. Tiede, Z. Zhou, X. Ma, and D. Chen. 2017. “Evaluation of Feature Selection Methods for Object-Based Land Cover Mapping of Unmanned Aerial Vehicle Imagery Using Random Forest and Support Vector Machine Classifiers.” *ISPRS International Journal of Geo-Information* 6: 51. doi:10.3390/ijgi6020051.

Marmanis, D., J. D. Wegner, S. Galliani, K. Schindler, M. Datcu, and U. Stilla. 2016. “Semantic Segmentation of Aerial Images with an Ensemble of CNNs.” *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences* III-3: 473–480. doi:10.5194/isprsannals-III-3-473-2016.

Nussbaum, S., I. Niemeyer, and M. J. Canty. 2006. “SEATH – A New Tool for Automated Feature Extraction in the Context of Object-Based Image Analysis.” *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* 36 (Part 4/C42): 6.

Schäfer, E., J. Heiskanen, V. Heikinheimo, and P. Pellikka. 2016. “Mapping Tree Species Diversity of a Tropical Montane Forest by Unsupervised Clustering of Airborne Imaging Spectroscopy Data.” *Ecological Indicators* 64: 49–58. doi:10.1016/j.ecolind.2015.12.026.

Schöpfer, E., and S. Lang. 2006. “Object Fate analysis–A Virtual Overlay Method for the Categorisation of Object Transition and Object-Based Accuracy Assessment.” *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* 36 (Part 4/C42): 6.

Yang, J., Y. He, and Q. Weng. 2015. “An Automated Method to Parameterize Segmentation Scale by Enhancing Intrasegment Homogeneity and Intersegment Heterogeneity.” *IEEE Geoscience and Remote Sensing Letters* 12: 1282–1286. doi:10.1109/LGRS.2015.2393255.

Gang Chen
Laboratory for Remote Sensing and Environmental Change (LRSEC), Department of Geography and Earth Sciences, University of North Carolina at Charlotte, USA

Qihao Weng
Center for Urban and Environmental Change, Department of Earth & Environmental Systems, Indiana State University, USA