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Knowledge-guided Land Use Multi-scale Representation

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Abstract:

Remotely sensed imagery and field surveying have substantially contributed to the universal availability of land-use maps. Presently, multi-scale cartography techniques have also facilitated visual representations of land use. However, the multi-temporal, multi-scale, and multi-category characteristics of these data often lead to diversity and complexity in cross-scale outcomes (Zhu et al., 2022). The main factors are due to: (1) the single format of traditional fundamental geomatics products and the lag in updating at the map sectors; (2) the fragmented abstract representation and modeling at separate scales; and (3) the complicated intertwined geometric patterns, topological correlations and semantic attributes of land-use data at different scales. These cartographic mission discrepancies and incomplete perception regarding target scales may contribute to misjudgments in macro decision-making, overall planning, and mapping exports on land information. In Figure 1, for example, the results are misleading land information visualizations at different scales in some inappropriate ways. The centerline extraction at the end of the braided bayous is not satisfactory when smoothing the lake boundaries. New redundant regions may be triggered at adjacent land use necks during scaling.

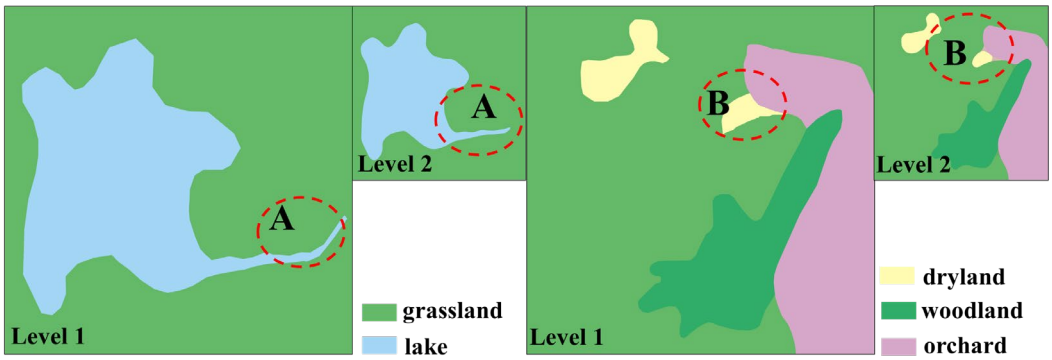

Figure 1. Differences in land use mapping at different levels: (A) uncollapsed narrow lake; (B) redundant land.

To fulfill the visualization coherence for land use data cartographic generalization, some services based on vector geometric morphological structure techniques have already been prevalent. Unfortunately, direct access to vector land use patches is relatively time-consuming and challenging for regular users. Meanwhile, a singular geometric transformation tends to ignore the semantic and topological information of land use. Therefore, this study explores the scaling methods with different modal knowledge information from graphs, thus, implementing cross-scale land use feature representation exports. A land use multi-scale representation framework (LUMRF, Figure 2) is constructed by integrating super-pixel segmentation and knowledge graph reasoning (Achanta et al., 2012; Peng et al., 2023). It supports effective individualized representation and intelligent reasoning of land use objects. Four crucial procedures are involved: (a) super-pixel segmentation and graph structure generation; (b) land use scaling oriented knowledge graph construction; (c) decision reasoning for land use based on the graph; and (d) multi-scale land use mapping.

Based on the proposed LUMRF, a multi-scale representation of land use is enabled. The restriction that the vector-based structure approach cannot be directly applied to remote sensing images might be partly alleviated. Under the super-pixel grids, the assisted aggregation, collapse, elimination, and simplification strategies are applied to visually deal with different geometrical patterns, while in the knowledge graph structure, the multi-level visualization mechanism and query rules are introduced to optimize for different semantic attributes and topological correlations.

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In sum, the LUMRF framework accomplishes a full-period cartographic production for land use maps at the stage of data structure representation and knowledge rules decision-making. In addition, with the inference rule mechanism based on geometrical patterns, topological correlations, and semantic attributes, the geographic laws and visual cognition in cartographic production might be preserved. This framework will offer a support in land use hybrid intelligent zed mapping approach for map users directly from remote sensing images.

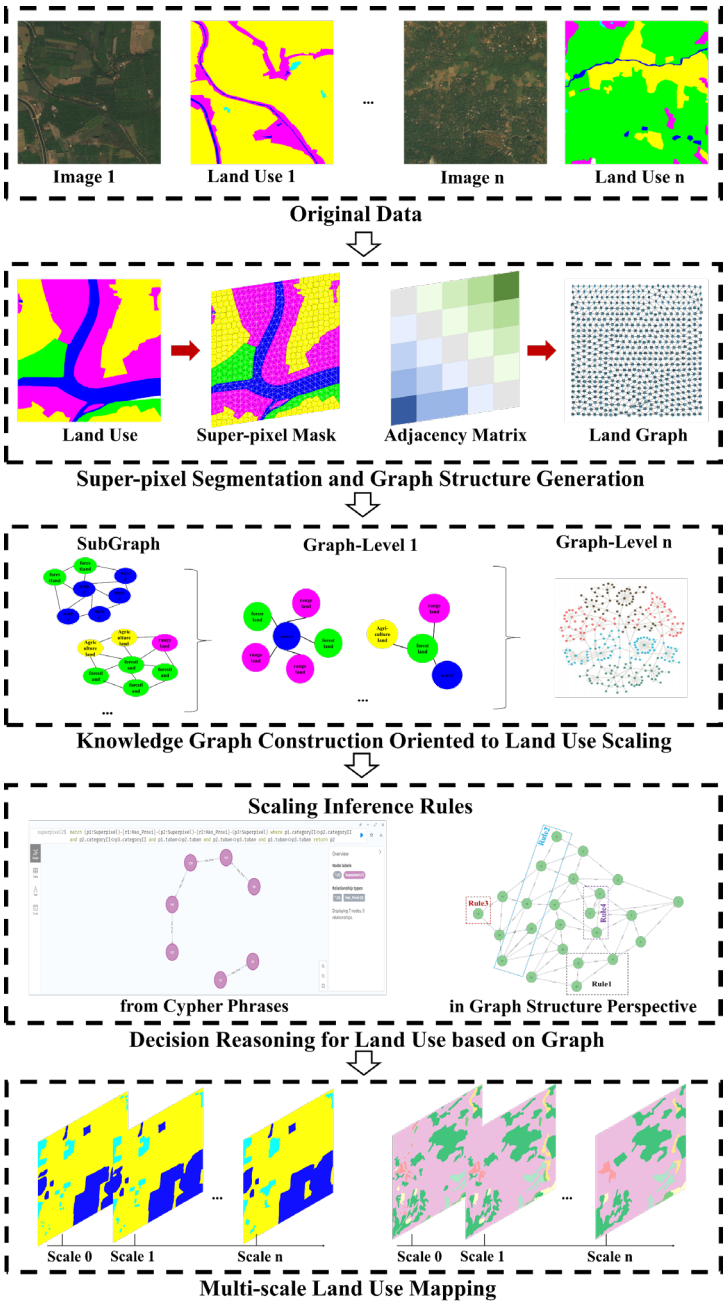

Figure 2. An integrating super-pixel segmentation and knowledge graph framework for land use representation.

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