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A Super-pixel Scaling Approach to Detect Inconsistency of Cross-layer Tile Maps

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Abstract:

The release of the Google Maps API has contributed significantly to the ubiquity of web maps. Nowadays, the most widely utilized tile pyramid technology has promoted more and more mashup visualization and web interaction. However, the multi-temporal, multi-source, and multi-scale characteristics of varied-level tile map data lead to inconsistencies between mashup cross-layer data (Goodchild and Li, 2012). The main reasons exist in: (1) the rapid change of landscapes and the different production periods from map sectors; (2) the diversified data-intensive web maps and various geographic standards from mapping agencies; and (3) the complexity of the dimensional and morphological changes in the geospatial data at different scales. The inconsistent visualization of these cross-layer tile maps may not only result in cognitive confusion to understand geospatial features but also lead to matching conflicts during the integration of web maps. In the case of river rendering over cross-layer tile maps, for example, some inappropriate rendering services visualize rivers that should be orderly distributed at different levels, in a misaligned way. Narrow rivers may be fractured at low levels of representation, or even exist as intertwined and overlapped rivers at higher levels (Figure 1).

Figure 1. Inconsistencies in tile map rendering at different levels: (A) river breakage; (B) overlapping rivers.

To satisfy the coordinated requirement for rendering in the visualization of cross-layer tile maps, some services based on vector structure technology are commonplace. Whereas, it is relatively difficult for users who only have access to raster images of map tiles. Therefore, this study explores the detection of inconsistency between cross-layer geospatial data using a raster-based scaling method. Based on the super-pixel segmentation method (Achanta et al., 2012), a framework for cross-layer raster tile map rendering (CRTMRF, Figure 2) is constructed to support the structure and approaches for detecting inconsistencies of geographic objects. Three essential processes are involved: (1) pre-processing of the tile map (i.e. geographic object recognition); (2) inconsistent feature calculation and super-pixel segmentation; (3) the derivation and consistency comparison of cross-layer tile map considering scale transformation.

Based on the proposed CRTMRF, the cross-layer water images of the Baidu Map from China are tested. The constraint that the vector structure detecting method cannot be directly employed in raster tile maps might be partly alleviated. Some geometric change rules of geographic objects during scaling with the auxiliary aggregation, collapse, elimination, and simplification strategy are adopted under the super-pixel grid to visualize the inconsistency results from Level 14 to Level 13 in Figure 3. During the process of geographic object inconsistency detection from cross-layer tile maps: lakes and rivers are well identified; some neighbouring lakes that should be merged are successfully detected and the global characteristics of the integration are effectively maintained while those undeleted small lakes have been accurately discovered and removed. In addition, narrow bilinear rivers that should be converted to single-line rivers are identified and the derived river has the same trend as the original. Furthermore, those lakes whose shape boundaries are too straight are also found and smoothed with their preserved global and local features.

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In general, the CRTMRF framework has a competent embodiment for cross-layer tile map inconsistency detection. Moreover, its mechanisms for cross-layer tiles based on geographic laws and visual cognition may may maintain the geometric consistency of geospatial data in web maps. Therefore, the CRTMRF framework facilitates map users to detect the data inconsistencies of web maps directly from raster images and will support the new development in the intelligent cartography of web maps.

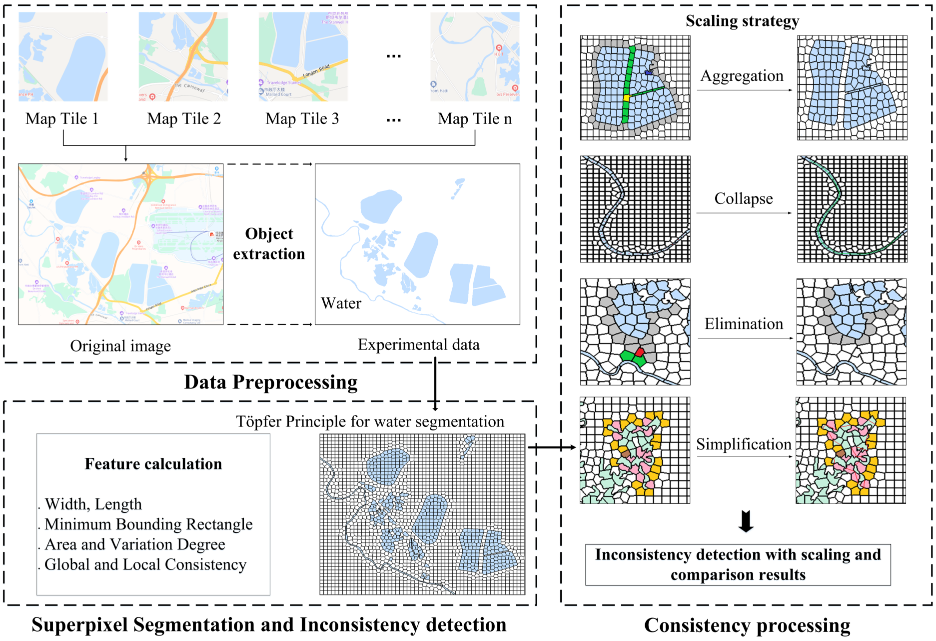

Figure 2. A raster-based scaling framework for data inconsistency detection over cross-layer tile map.

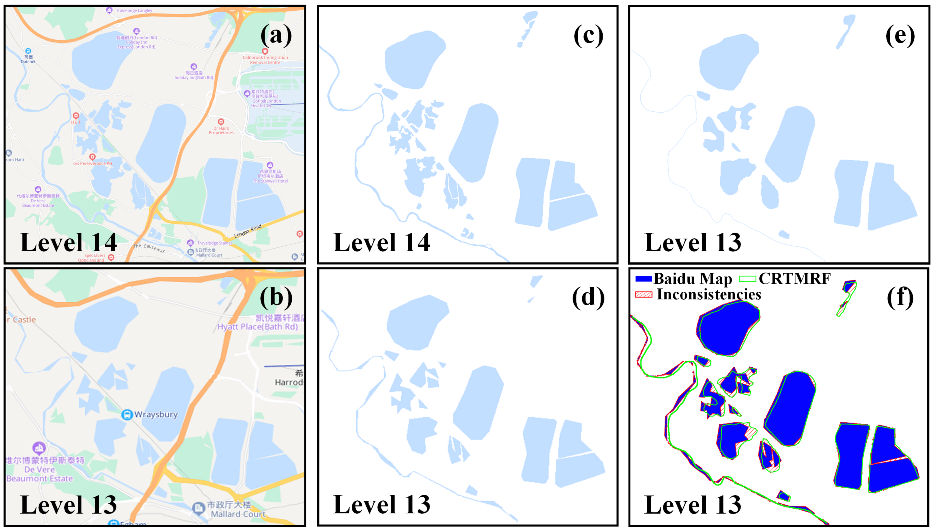

Figure 3. Visualization of cross-layer tile maps. (a) and (b): Original images at the fourteenth and thirteenth level; (c) and (d): Experimental data after pre-processing from Baidu Map at the fourteenth and thirteenth level; (e) the derived map from the CRTMRF; (f) inconsistency detection from the overlay between the derived and Baidu map.

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