

ACCURACY-AWARE CHANGE DETECTION IN SPATIAL WEBS

A Position Paper

Peggy Agouris

Dept. of Spatial Information Science & Engineering
National Center for Geographic Information and Analysis
University of Maine
Orono, ME 04469-5711
peggy@spatial.maine.edu

Change detection is a fundamental operation in Spatial Webs, as it is essential for geospatial database updating, conflation, and redundancy management. Considering image-based change detection in particular, current practices typically use complex algorithms (e.g. snakes, template matching) to identify and automatically extract objects in a new image. Following object extraction, a GIS database is updated by comparing the newly extracted outline to the stored prior information. Usually, if the new outline is different, the older information is replaced by it, and the database is thus updated. In this context, information is treated as deterministic in nature: any difference between two outlines is considered as change. When the two datasets compared differ in their properties (e.g. resolution, scale, accuracy) this process would result into frequent false positives: change would be detected even though the object under examination has actually remained unchanged. Given the diverse nature of datasets in Spatial Webs, this deterministic approach to change detection is clearly inadequate, forcing us to consider accuracy-aware approaches.

Addressing this problem from an image analysis point of view, we have developed a novel automated approach that integrates object extraction and change detection into a single process by using accuracy information. Our approach is meant to function within an integrated geospatial environment, whereby image analysis proceeds by having access to pre-existing information for the processed area. We assume a process where incoming imagery is analyzed to update the GIS of an area of interest. Within this modus operandi we have available from the GIS database shape information in the form of outlines and corresponding accuracy estimates for objects in the area of interest. This prior information may have resulted from image analysis (exploiting older imagery), or by any of the other established methods of collecting GIS information (e.g. traditional surveying processes).

Our overall approach is described in Fig. 1. As previously mentioned, we make use of pre-existing information for the object outline. The older outline (e.g. available from an older map or GIS layer) is projected onto the new image, using standard orientation parameters and relevant transformations. Once projected onto the new image, the older outline together with its accuracy information becomes the input for our differential snakes tool that performs change detection and versioning.

In this stochastic approach, change is detected if and only if the content of the new image (pixel values and their distribution) indicates that an object's outline lies beyond the statistical range of its last record.

Otherwise, we cannot support the hypothesis that the object has changed, and consequently, we have to limit our analysis to versioning. Versioning occurs when we can detect the outline in the new imagery with better accuracy than the one with which it was recorded in the database, even though the outline itself is not beyond the statistical range of its prior record. The results of change detection and versioning are used to update the GIS record of an object by modifying its outline and/or updating its uncertainty estimates. An outline of this updating process is shown in Fig. 1. This approach falls within the framework of accuracy-aware conflation of geospatial information to support change detection of linear objects (e.g. roads) [Agouris et al., 2001], as well as closed-curve ones (e.g. lakes) [Gyftakis et al., 2004].

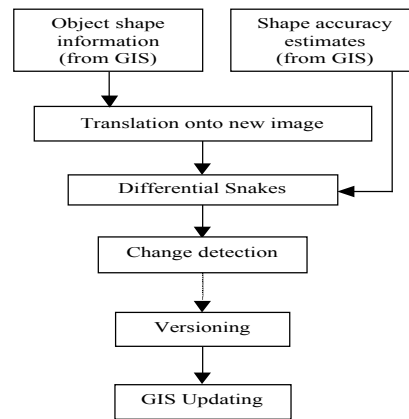


Figure 1: Accuracy-aware image-based GIS updating

This approach brings forward some interesting issues related to accuracy modeling and handling in Spatial Webs, including:

- *Modeling object accuracy:* Accuracy information may be available as an overall estimate for a class of features (e.g. defined by resolution and scale of available information), or it may refer to a specific object only (e.g. recorded when extracting a specific road segment from prior imagery). Thus, it could either be constant across a feature (e.g. a road known with an accuracy of 2 meters), or we may have different values for various nodes along this feature (allowing e.g. a corner partially covered by canopy to have poorer accuracy metrics than other visible nodes).
- *Storing and managing accuracy information in Spatial Web collections:* Accuracy can be stored as file metadata, or object metadata. Considering hierarchical grid architectures, we are also provided with several choices regarding the management of accuracy information in Spatial Webs.

REFERENCES

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- S. Gyftakis, P. Agouris & A. Stefanidis, 2004. Tracking Deformable Objects in Geospatial Applications, *IEEE International Conference on Image Processing (ICIP)*, Singapore (in press).