Mix and match for quality

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Here's a system for the automatic quality assurance of geospatial core data. It can handle roads and settlement areas. The article presents details on the developed algorithms and shows examples. The system was developed in conjunction with the German Federal Office of Cartography and Geodesy (BKG). It has been installed at BKG, and has been tested and refined over a number of years. The achieved results fully meet the expectations reflecting in the fact that BKG has been able to speed up the quality assurance work by a factor of three

Geodata, i.e., information that has spatial reference (for example roads, buildings or parks), are the most persistent and valuable part of every geographical information system (GIS). As the landscape represented by these data is subject to continuous change, and the demands on data quality are increasing due to new applications, quality assurance of geodata has become a major issue. So, it is imperative that landscape changes be monitored continuously and database errors and inaccuracies detected and eliminated. Generally, the criteria for assessing geodata quality comprise the logical consistency of the data regarding the existing data model as well as the level of conformity of the data with the real world. The conformity can be judged by geometric accuracy, thematic correctness, completeness and temporal accuracy.

The project initiated five years back in cooperation between two institutes - the University of Hannover and the Federal Agency for Cartography and Geodesy (Bundesamt für Kartographie und Geodäsie, BKG) in Frankfurt/Main, developed an automated procedure for comparing the data of the "Authoritative Topographic-Cartographic Information System" (Amtliches Topographisch-Kartographisches Information System – ATKIS) with the real landscape. ATKIS data are geospatial topographic core data, which are used as reference for other thematic data. This comparison includes the verification of existing data regarding their geometric accuracy and thematic correctness as well as their completeness, and if necessary the acquisition of new objects not yet contained in the database. Mainly, up-to-date aerial images are used as data source.

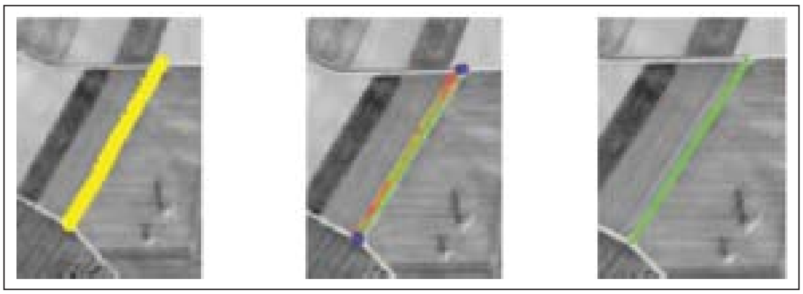

Figure 1: Road extraction on the basis of lines: left in yellow the region to be analysed; in the centre the different extracted lines; right, the verified roads in green

System architecture

The system architecture was developed aiming at a modular combination of an interactive GIS component and an automatic, knowledge-based image analysis component. As far as possible, commercial software was used which was appropriately extended.

ArcGIS of ESRI was used as the GIS

component. The data to be checked are automatically selected from the database and pre-processed for the following image analysis task. After the automatic comparison, the results are visualised on the screen, and auxiliary means for interactive post-processing by a human operator are available.

Using the image analysis component, the aerial images are interpreted and the results are compared with the data to be verified. For this purpose, the system GeoAIDA, developed by the Institute of Communication Theory and Signal Processing of the University of Hannover (TNT) is used (Liedtke et al. 2001). GeoAIDA is able to generate symbolic descriptions of objects from images for the following comparison to the ATKIS objects.

Roads

Since a country depends on its transportation infrastructure, roads are very important components of a geospatial database. In addition, they are subject to frequent changes. Two tasks must be mastered within this project: verification of the roads contained in ATKIS, and acquisition of missing objects (for details, see Willrich 2002). For the actual image processing task, a line-oriented road extraction algorithm developed at the Technical University Munich (Wiedemann 2002) has been incorporated.

Up-to-date black and white orthophotos with approximately 0.4 m ground resolution are used as the basis of the work. Orthophotos are aerial images, which are differentially rectified to the map geometry. For the verification of the existing roads, the applied algorithm first extracts lines within a buffer region around the ATKIS data (see fig.1). Gaps between line fragments, which can be caused by shadows and occlusions from closely neighboured objects (buildings, trees etc.) are inevitable in this step. As the main function of roads is to connect different places in the landscape, a search technique based on topology and graph theory is formulated to bridge these gaps and to extract complete road networks.

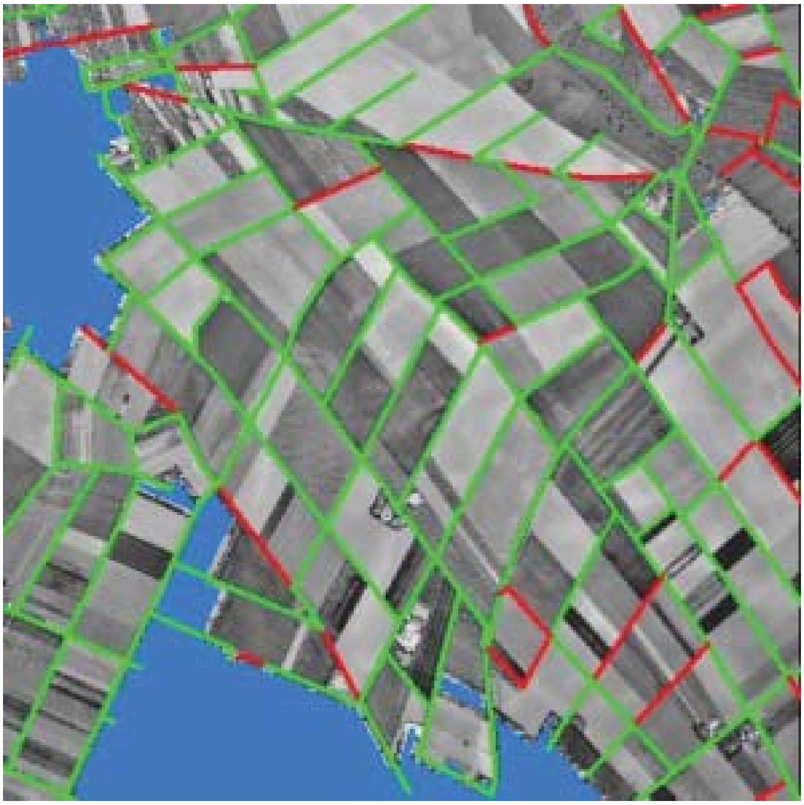

Figure 2: Typical result of road verification, divided into two classes: green (verified) and red (not verified), blue areas depict settlement areas not considered in this example.

The completed lines are compared with the existing ATKIS data; the roads are then colour coded and superimposed to the aerial image. The colour code comes from a paedestrian traffic light: green roads were verified by automatic image analysis, i.e. the ATKIS data may be regarded as correct, roads depicted in red were not found. This may be caused by incorrect ATKIS data or a by failure of the automatic extraction. Also quantitative information about a given dataset is computed. (for details see Heipke et al, 1998).

A rural area of 10 x 12 sq Km in the vicinity of Frankfurt/Main in Germany was used for an extensive test. The ATKIS and image data were acquired at approximately the same time in order to largely differentiate potential differences between ATKIS and the automatically extracted findings resulting from landscape changes. 79 % of the roads could be verified, 21 % were rejected. Rejection of ATKIS data mainly followed from two reasons: very poor contrast between the road and the adjacent areas, and roads bounded by a dark area on one side and a light one on the other (the latter case causes a known failure of the road extraction algorithm)

Figure 2 shows a typical result of the automatic quality assurance for roads. The areas depicted in blue are non-considered settlement areas. It is apparent that the operator may concentrate on the manual verification of the red roads. According

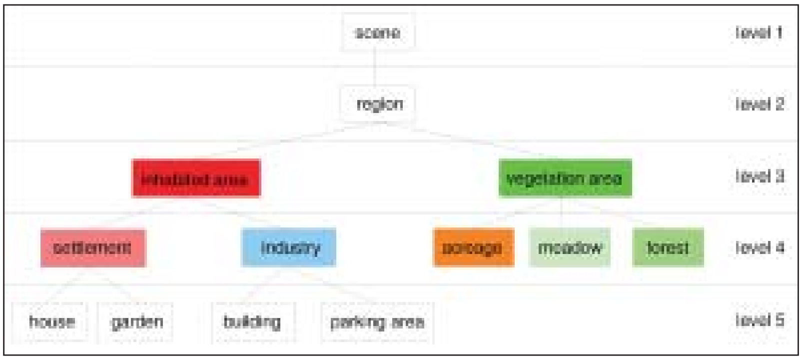

Figure 3: Semantic net for description of structural dependencies with respect to the verification of the area ATKIS objects in level 3 and 4.

to the conducted investigations, the green roads may be regarded correct.

Presently, work is going on the automatic acquisition of roads missing in the ATKIS database. At the moment, two different approaches are being investigated. On one hand, the road extraction is applied to the entire image, and road sections found are then combined with the previously verified data. On the other hand, existing planning data is used for verification.

Settlement areas

In addition to roads, settlement areas undergo many changes throughout the year. Therefore, verification of settlement areas is also of primary importance. Currently the automatic verification based on colour aerial orthophotos, as are regularly available today is being carried out.

Aerial image sections corresponding to settlement or industrial areas can neither be verified by uniform spectral nor by textural features. On the contrary, these areas are mainly characterised by their internal structures. Residential areas, for example, are characterised by their parts, i.e. by houses and gardens. The image analysis system GeoAIDA, developed at the TNT, is used to represent the structural context within the automatic image analysis.

The approach can be used for verification of ATKIS area objects as well as for recognition of land-use changes compared to ATKIS. In GeoAIDA, knowledge about the relations between ATKIS objects and those features relevant for the automatic detection, as well as knowledge on the image analysis strategy is formulated as a so-called semantic net (see figure 3). A semantic net mainly consists of nodes and edges.

The nodes are assigned to standard language terms, and represent the ATKIS objects to be verified as well as further relevant objects for the specific task and the analysis process. The edges describe the relations between the objects. In the present case, the relations between the objects can be characterised as "part of". This means that the section, called "scene" generally consists of different parts, initially two-dimensional objects, which in turn are characterised by their parts, as for example buildings and parking lots.

The image analysis strategy consists of establishing initial hypotheses for the objects defined in the nodes. In the following these are verified or rejected, depending on the existence of certain evidence. For example, the subdivision of a built-up area into `house' and `garden' describes the hypothesis that a built-up area can be characterised by the existence of houses and gardens. The nodes are connected to automatic procedures of visual pattern recognition, which allow the automatic detection of houses and gardens.

The selection of objects to be modelled in the semantic net is based on prior knowledge of the structure of the landscape, which is used by a human interpreter of aerial images. For identification of objects, the hypotheses are verified bottom-up, and thus only those areas are recognised as settlement areas, where houses and gardens are found in sufficient quantities.

Figure 4 exemplifies an analysis result. The ATKIS objects I-IV in the left part of fig. 4 are different vegetation areas and V-VII are settlement areas. The roads are displayed in yellow. Except

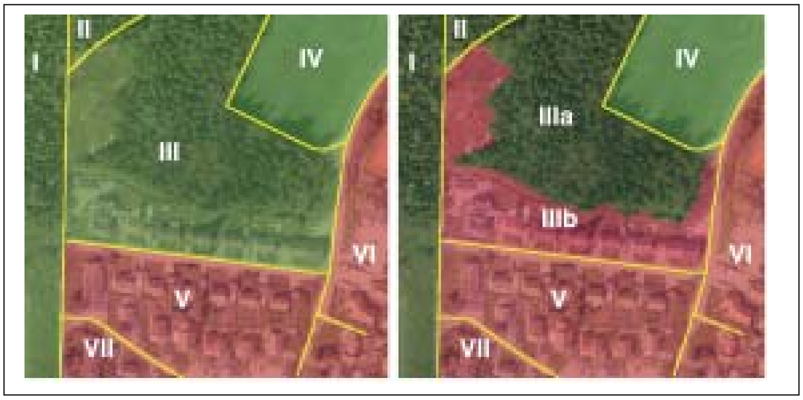

Figure 4: Typical analysis with regard to settlement and vegetation areas; left: expected ATKIS objects (numbered), right: the result of the automatic analysis.

for ATKIS object III, all regions could be verified (fig. 4, right). Obviously, part of the vegetation area III changed to a settlement area IIIb; in doing so the vegetation area III was reduced to the remaining region; thus the automatically obtained result is correct.

Outlook

The results lead to the conclusion that the method can be applied for practical use. In the future, the existing procedures and the workflow can be enhanced for obtaining more detailed information on the currently extracted objects (for example road width and the number of tracks). Beyond that, the modular configuration of the system will be used for integration of procedures, which permit the integration of additional ATKIS objects such as railway lines and waterways ■

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Online mapping tool from ViziWorld

ViziWorld LLC, announced the launch of ViziMap CreatorTM, an online multimedia mapping product focussed on satisfying people's desire to communicate with maps and photos, and to share these with one another.

"It has been estimated that over 50 billion digital photos will be created in 2005," said Doran Geise, President, ViziWorld LLC. "Each photo tells a story about people, places, and things. ViziWorld offers a unique and powerful way for people to share those stories around the world with maps and photos." The ViziWorld service lets people access a worldwide map database, select a custom map area, link their own photos to locations on the map, add descriptive text and colourful graphics to the map, insert descriptions and captions to the photos, store the finished ViziMapTM and then email it quickly and conveniently to multiple addresses.

"We are providing a way for people to enhance communication over the Internet quickly, easily and intuitively." says Keith Croteau, CTO of ViziWorld, "Along with text descriptions and photo titles and captions the ViziWorld service adds the key dimension of place to photos. Through our global map data, seeing the 'where' of a photo conveys richer meaning and directly places the viewer on the scene."