Improving the update of geospatial information databases from imagery using semi-automated user-guidance techniques

David Holland and William Tompkinson

Research & Innovation, Ordnance Survey, C530,
Romsey Road, Southampton, SO16 4GU.
Tel +44 (0)23 80792808;
Email: dholland@ordsvy.gov.uk,wtompkinson@ordsvy.gov.uk

Biography

David Holland: Senior Research Scientist in the Research & Innovation Group, Ordnance Survey. Co-chair of ISPRS Working Group IV/4 (Spatial data infrastructures), Research interests in remote sensing, automatic feature extraction, change detection and digital elevation models.

William Tompkinson: Research Scientist in the Research & Innovation Group, Ordnance Survey. Specific research interests within the field of remote sensing are related to change detection and data fusion. Other research interests in the modelling and visualisation of landscape-scale spatial phenomena.

Introduction

One of the long-term goals of a national mapping agency is to optimise the collection of spatial information, by capturing richer sets of high-quality data in the shortest possible time. A step along the way to achieving this goal would be the development of an automatic method of change detection from remotely-sensed imagery. Such a method would automatically identify all the regions in any given area which have changed since the spatial information was last updated. Ideally, this would be followed by an automatic extraction of all the features which had changed. Even though this subject has been an active area of research, the utilisation of such techniques is still very limited. One reason for this is that, despite 20 years of research in digital photogrammetry and computer vision, no universal edge detector exists that can “both identify and track edges with sufficient success” (Agouris et al, 2000, p.2).

However, even the narrowing down of the search area over which a human operator would manually capture the features, would be beneficial to the data capture process. This paper reports on early stages of research to develop such a system. The authors assert that, in addition to the development of automatic feature detection algorithms, there is valid research to be done in the design of systems that increase the productivity rate of manual data capture, using automated recognition of cues of change.

Prototype Of A Change Detection System

In most cases, change detection techniques rely on the presence of two sources of imagery, collected at different times (normally separated by several years). Once any sensor distortions, chromatic differences and viewing geometries have been resolved, the two images can be compared and any differences highlighted. To take the process further, i.e. to automatically and reliably capture the features which have changed into a spatial database, requires a level of machine intelligence which is beyond that of most, if not all, current systems. All is not lost, however, since the mere process of guiding the user to the areas that have changed could significantly speed up the data collection process.

Part of the research presented here describes a prototype system that performs the following functions:

- Runs an image-to-image change detection process (in this instance based on a comparison of polygons determined by image segmentation, but this is not a requirement of the system)
- Selects those regions in the image where significant change has been detected.
- Via a graphical user interface, guides the operator to each area of change and displays the two images and the corresponding vector and polygon features from the database
- Provides the operator with a visual cue to those polygons that have a high probability of having changed.

In a production environment, the prototype would be improved to produce a system that would then allow the operator to edit the vector data in line with the changes identified in the image.

Cues Of Change Detection

A photogrammetrist will be skilled in identifying changes in the landscape from remotely sensed imagery. During manual comparisons between temporal image pairs, or between an image and map data, changes may be identified in several ways. In one method, the operator will use indicators such as alterations in the shape of landscape features; in another, the detection of artefacts within large homogeneous topographic objects. For example, a new building development results in a texture change upon a large land parcel, whilst a new wall may be identified through indirect recognition such as its shadow.

By placing change detection within the context of the system in which it is applied, research presented in this paper places an emphasis upon the application of computational methods to simulate the thought processes of a manual interpreter. Figure 1 illustrates how such a change detection system might be organised according to a generic tiered structure commonly used in system design (e.g. as described in Bennett *et al.*, 1999). It is seen in this diagram that emphasis is placed upon utilising cues of change detection to assess where change has taken place and presenting this information to the user. This information is then used to iteratively ‘drive’ the user to the location of the change.

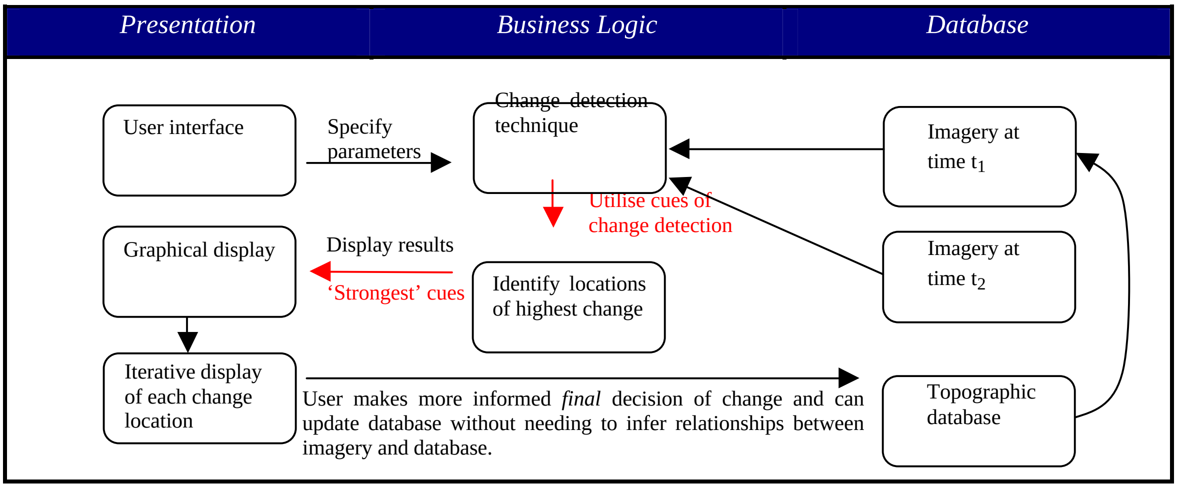

Figure 1: System diagram to illustrate the location of information of change detection cues within an automated user-guidance change detection system.

Presently the prototype system uses changes in the shape of objects in an image as the cue of change. Changes in these objects are measured using size and compactness ratios between co-located objects, derived after applying a consistent segmentation routine to a temporal imagery pair. This technique is similar to that described in Ware and Jones (1999). Completed and on-going research is now addressing 'disturbance' in large homogeneous objects, and indirect cues such as extracted shadows.

Using Shadows As Cues of Change

Shadows can be a good indicator of the presence of buildings and other objects, and they are usually easier to detect than the often-complex multi-textured objects which cast them (Irvin and McKeown, 1989). Until recently, the presence of shadows in satellite imagery was of very little interest, since the length of a shadow cast by a typical object (e.g. a suburban house) would often be smaller than the size of an image pixel. In contrast, the latest satellites from Space Imaging (IKONOS) and Digital Globe (QuickBird) provide imagery in which shadows are quite easy to detect. The QuickBird imagery used in our research (supplied by Eurimage) has pixels with a ground sample distance of 64cm. Even in the late morning when the image was acquired, the shadows cast by a small house comprise 40-50 pixels.

The shadow detection process described in this paper uses a simple threshold technique, followed by a filtering process. This highlights those areas which show strong light-to-dark transitions in a direction 180° from the sun's azimuth. A second process uses the existing building vector data to predict where building shadows should be found in the image. The shadows thus predicted are removed from the real shadow image, leaving an image of "unidentified shadows" that could not be predicted from the existing spatial data. In an ideal world, these would indicate the presence of new features, which could then be captured. In reality most of the detected shadows were cast by bushes and trees, even in the urban area under consideration. Most of these "new" features, although real enough, are not part of a mapping agency's typical data specification. On first inspection, those shadows which really are cast by new buildings are very difficult to separate from those cast by trees. Further research will develop the processes described here (for example by using high-resolution aerial imagery) and determine whether the tree shadows and building shadows can be separated in some way. If this technique proves viable, it could be used as a further cue within the change detection system proposed above.

Other indicators of change are also under investigation. Current research focuses upon utilising texture measurements in comparing imagery against topographic data. This will concentrate on areas in the image for which there are no existing features in the vector data (i.e. it is recorded as “bare land”). It is hoped that the detection of significant image-texture differences in these areas will provide a further cue to the presence of changes to the features on the ground.

Conclusions

This paper advocates that, aside from developing computational methods for the automatic recognition and extraction of new spatial features, there is equally valid potential in research that produces systems which reduce the time of manual data capture through the automated recognition of cues of change. If the cues from shadows, from image segmentation and from texture measurements can be combined to reinforce each other, the goal of an automatic change detection system could be one or two steps nearer to being realised.

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