Framework for Detection and Analysis of Land Cover Changes Using Visual Analytics

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Methods for landscape monitoring play a major role for management and planning in a number of disciplines, e.g. in climate research, environmental science and urban planning. The analysis and documentation of spatiotemporal changes form the basis for such observations in which, apart from spatial relations, aspects of time can also be highly relevant. Depending on the application, diverse temporal scales can be of interest ranging from long-term changes (e.g. geologic processes) to relatively rapid developments (as in disaster management). A great many of these analyses are conducted based on remotely sensed data. Especially satellite based remote sensing data providing large-scale coverage of the earth at relatively low costs are widely used. For them, new fields of application are emerging since their spatial, spectral, radiometric and temporal resolution have been increased.

For conducting change detection and change analysis based on remote sensing data, various (semi-) automatic procedures exist. However, despite of research efforts in the past these are not yet applicable effectively and efficiently. Reasons for this include the high complexity and dimensionality of the data as well as the lack of transferability of parameters from one dataset to the other. The overall goal of complete automation does not seem promising anymore - for instance, Nichol et al. come to the conclusion that „[…] the development of 'black box' algorithms, implying complete automation, is probably neither possible nor desirable and researchers are encouraged to work with end users to develop realistic local solutions." [1].

To overcome the drawbacks of purely automatic methods, we propose the use of Visual Analytics methods for land cover change detection and analysis. Enriching existing procedures by visual interfaces and iterative techniques appears promising to keeping up a real improvement of the workflow and the results.

There are a few approaches bringing Visual Analytics to the field of remote sensing. One of them consists of an interactive visual system called *Parbat* developed by Arko Lucieer [2]. Its purpose is the optimization of segmentation parameters for the classification of remote sensing scenes including uncertainty visualization. Another example is *GTDiff* by Hoeber et al. [3], an interactive system for change detection in spatiotemporal data based on visual comparison.

But all in all from our point of view, there is still the necessity of a concept that really integrates existing change detection procedures with methods from Visual Analytics resulting in a powerful system connecting both worlds. We are developing such a concept for solving the task with a high level of interaction with the user (Figure 1). The central part of the process is the development of change hypotheses: Supported by visual tools, the user generates and revises hypotheses about possible changes using interaction (mainly navigation, filtering, brushing) to get the needed insight in the data. After this highly iterative part one is able to conclude if a change event has happened or not.

Most of the common (semi-) automatic tools are limited to bitemporal analyses neglecting the information beyond the pairwise examination of data from different points in time. Our concept is designed for a multitemporal evaluation of the data, heavily supported by visual tools.

Apart from this, the integration of uncertainty information into the workflow is another essential part of the system. There are investigations confirming that the visualization of uncertainties in complex geo data can actually influence the decision making process in a positive manner (e.g., [4]). As Deitrick states in [5], this influence does not depend on the visualization only, but primarily on the specific application. This leads to the conclusion that communication methods have to be tailored for different users and purposes. Within this context, we will concentrate on expert users.

In our contribution we will present the framework at an early stage as well as a software prototype to communicate the basic idea of the approach with the help of an example application.

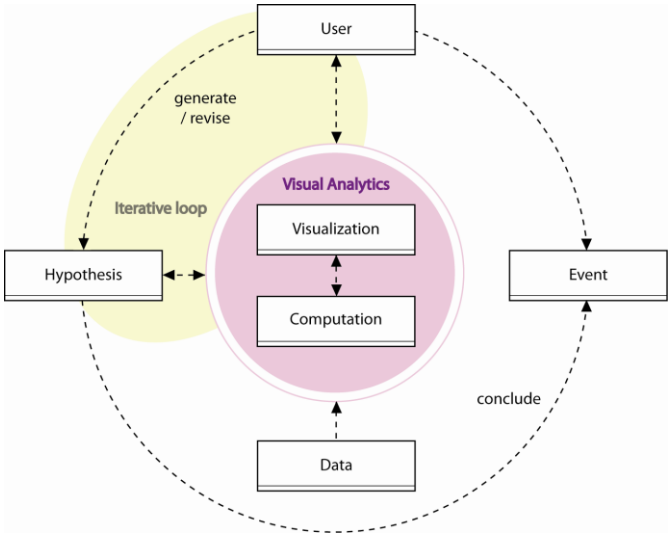

Fig. 1. Overall change detection / change analysis workflow incorporating Visual Analytics

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