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Knowledge Visualization in Spatial Analysis

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Abstract

This study applied knowledge visualization to the spatial analysis process. Focus was laid on improving the transparency of analysis results by developing concepts for the visualization of knowledge input throughout the spatial analysis process. In a case study two specific knowledge visualization concepts and a conceptual design of a user interface were developed. These concepts allow tacit spatial knowledge to be made explicit and the reasoning of the analyst in the analysis process to be studied.
Keywords: knowledge visualization, spatial analysis, analysis process, knowledge input

1 Background

The personal knowledge of the analyst plays an important part in the spatial analysis process. The analyst makes decisions in many stages of the process but usually the reasons behind these decisions are lost. This has gained increased attention in the scientific community recently and, among others, Thomas and Cook [1] recommend that knowledge representations to capture, store and reuse knowledge created throughout an entire analysis process should be developed. Knowledge visualization, which studies the use of visual representations to improve the transfer and creation of knowledge between people [2], can lead to representations that support the spatial analysis process.

One field of application for knowledge representations is spatial analysis in environments that are neutral in a sense that they do not include any inherent experiences and values but decisions are based on knowledge inserted by the analyst. Typically, this knowledge is not documented but remains tacit. If we could capture and store the knowledge input of the analyst, the whole process would become more transparent improving the assessability and credibility of the results.

This research focused on developing concepts for the visualization of knowledge input to attain improved transparency of the results. It was conducted as a case study.

2 Knowledge Input

During the analysis, the analyst forms chains of reasoning that articulate and defend his or her decisions. These chains of reasoning are partly based on tangible pieces of information, called reasoning artifacts, which the analyst identifies (e.g. patterns in a map) or creates (e.g. various visual views) during the analysis. [1]

The chains of reasoning and the reasoning artifacts are an essential part of the knowledge input and they need to be recorded in order to visualize the knowledge input. To improve the transparency further, also links to supporting information associated with each analytical product need to be stored. The knowledge representations should also provide a mapping between the reasoning artifacts and the original data used to produce them along with information about data quality and how the reasoning artifacts were created. [1]

3 The Case Study

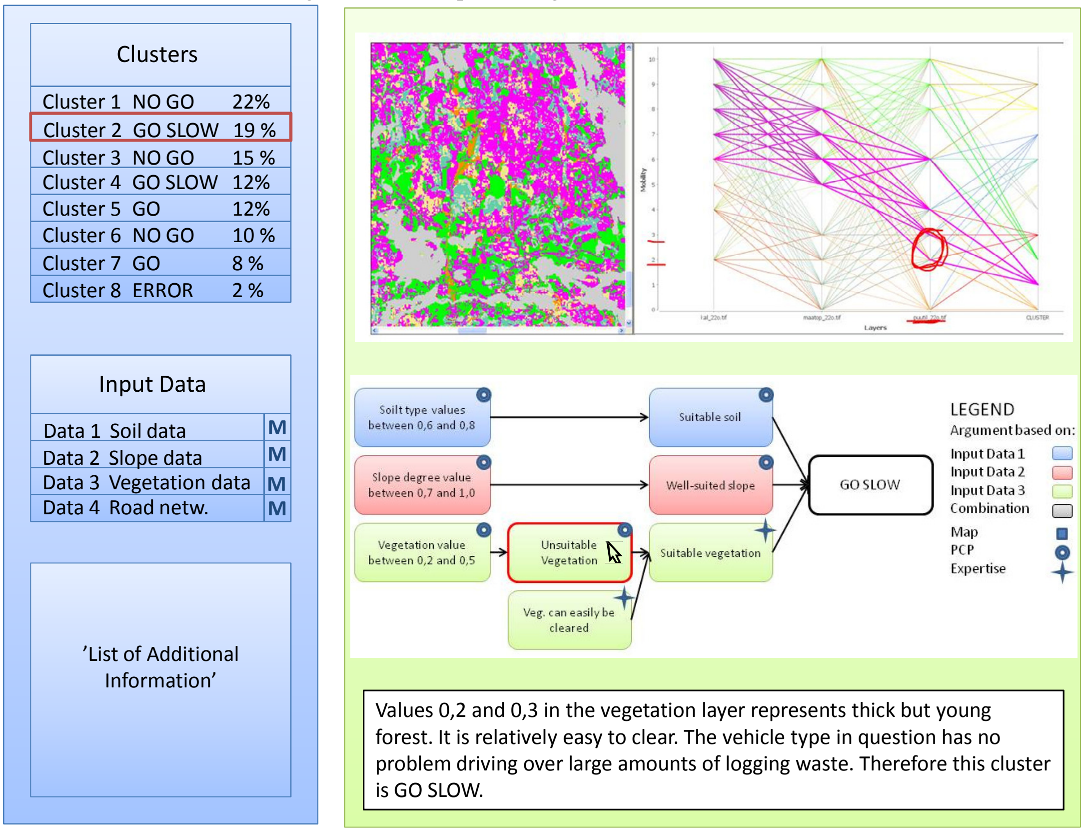
The case study was performed with a user-controlled cross-country mobility analysis environment [3]. In this analysis, areas are classified as GO, GO SLOW or NO GO based on various source datasets. An exploratory approach is used; areas are clustered together according to their similarity and the user classifies these clusters by the help of a linked map and parallel coordinates plot (PCP) view. The analysis is an interaction process where the analyst´s knowledge is the key resource.

To make the results transparent, the knowledge input had to be made explicit and available for other people. This means that the reasoning artifacts, the PCP and the map view, needed to be stored. It also had to be possible to identify the pieces of information that were decisive for the analysis results from them. Furthermore, the chains of reasoning behind the classification decisions needed to be visualized and linked to supporting information.

4 Results

The research resulted in two specific knowledge visualization concepts: sketches on top of reasoning artifacts and a variant of the causal graph. These concepts where used in the conceptual design of a user interface, see Figure 1 for an example view. In the figure the knowledge relating to Cluster 2 (which is highlighted) is studied through the causal graph and the original map and PCP connected to this cluster. In addition to these are clarifying comments made by the analyst presented. The original input data along with its

Figure 1: A conceptual design of the user interface.



transformation history and useful additional information are also accessible through the interface.

In Figure 1, the analyst has made a sketch on top of the PCP. This view is linked to the causal graph that can be seen in the middle of Figure 1. The sketches become visible when the related element of the causal graph is mouseovered. The causal graph stores the chains of reasoning behind the decisions made during the analysis. The causal graph in Figure 1 explains why cluster 2 is classified as GO SLOW. Colors and icons function as additional information carriers.

5 Discussion

Sketches on top of reasoning artifacts enable the analyst to make tacit spatial knowledge explicit in ways not possible by solely using words. They enable the identification of the important pieces of information in the map and PCP. Sketches are good for this purpose as they are versatile as well as easy and fast to create and process.

The causal graph allows the reasoning of the analyst to be studied and traced back to its origin. When making decisions, the analyst tries to maximize the utility of the outcome. Causal thinking [4], i.e. what causes what, is fundamental in this process. In the same way, we can understand decisions if we get to know the reasons behind them.

Knowledge visualizations appear to have great potential in the management of knowledge in spatial analysis but further research is needed to better understand the reasoning process and to develop the tools for the documentation and visualization of knowledge input. Of special importance are questions regarding how to make explicit the tacit knowledge used by the analyst and how the documentation of the analyst´s knowledge should be included in the analysis process. The suggested visualization concepts also need to be verified through user testing. This research continues by detailing the knowledge elements and their visualization.

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