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Visualization of uncertain catchment boundaries and its influence on decision making

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Abstract

In this poster, we introduce an on-going project where uncertainty-aware drainage divides were calculated, visualized, and tested as background data for the decision-making process.

Keywords: Drainage divide, uncertainty, DEM, decision making.

1 Introduction

Societal decision making is often based on background information and its analysis, with a large portion of the information being spatial data. Common examples of this can be found in the fields of civil engineering, land use and transport planning, health care, and education. One objective of the Finnish National Geographic Information Strategy 2010–2015 is to use spatial information broadly in government decision making and to improve the political processes [1].

However, decisions are difficult to make based on uncertain data and models. Metadata reports on individual datasets are insufficient and do not effectively communicate the degree of uncertainty to users [2]. The uncertainty may take a variety of forms, such as errors, missing values, and deviations, which may originate from, for example, primary measurements, processing techniques, modeling, or interpolation. To ensure that the background data do not have a misleading impact on decisions, the characteristics of the underlying uncertainty should be provided to decision makers [3]. One way of doing this is to visualize uncertainty in a manner that is both intuitive and comprehensive. When designing an optimal visualization method for uncertainty, the varying goals, environment and types of information must be considered [4]. Many methods have been developed in past decade, but there is a little real world verification, that uncertainty visualization has been helpful [5].

In this poster, we introduce an ongoing project where uncertainty-aware drainage divides were calculated, visualized, and tested as background data for the decision-making process. Our objective was to study whether uncertainty information has an impact on decision making. Our study was part of a larger project in which the goal was to update the Finnish Drainage Basin System and Register in 2009-2013, taking into account the user requirements and INSPIRE specifications.

2 Materials and methods

The project involved three sets of spatial data: A digital elevation model, laser scanner data and hydrographic data. This data were used together with a topographic map of Finland, which supplied the background for the visualization experiments. Three firstly mentioned were input for a process to calculate uncertainty-aware drainage divides in our test area, the drainage basin of the Vantaa River, which locates in southern coast of Finland and covers an area of 1700 km^2.

The propagation of DEM errors for the drainage divide uncertainties was carried out using the Monte Carlo simulation method [6]. The uncertain drainage divide surface was generated by repeating the catchment delineation 400 times, each time with a different DEM. The values in the resulting surface represent the probability of each pixel to lie on the catchment boundary.

The uncertain catchment boundaries were visualized using seven methods, which differ from each other based on their color scheme, level of generalization (continuous/ categorized), and data model (raster/point). The visualization methods employed included:

A) A single hue mask,
B) A continuous color ramp, where the lightness of a single hue changes (light blue – dark blue),
C) A categorized color ramp, where the lightness of a single hue changes (light purple – dark purple),
D) A continuous color ramp between two hues (yellow – brown),
E) A continuous color ramp, where the lightness of a single hue changes (light purple – dark purple),
F) A continuous color ramp between three hues (blue – yellow – red), and
G) A graduated point symbol representation.

Methods A, C, and G represent generalized data, whereas methods B, D, E, and F show all of the details of the uncertainty surface. The surfaces were visualized by 40%

transparency on top of a topographic map of Finland at scale of 1:8000.

2.1 User survey

In order to study the impact of uncertainty visualization on decision making, we organized a user survey. The participants were the end users of the Finnish drainage basin dataset and all of them worked in governmental agencies. We invited a select number of persons to take part in an internet query.

The questionnaire had three sections: (1) background questions, (2) decision-making tasks, and (3) comparison of the visualizations.

For the decision-making tasks, we displayed a point on top of two different catchment boundaries overlaid on the base map. The first map showed the boundary without uncertainty information (fig. 1), while the second map displayed the uncertainty information (fig. 2). After seeing each of the images, the user was asked in which drainage area and how likely the point belongs to.

For comparing the visualizations, we showed the user seven different representation of the same surface and asked which visualization was (1) the most easy to read, (2) the most informative, (3) the most visually pleasing, and (4) the best choice for drainage divide analysis. We also asked users if they needed uncertainty information in their work and in which situations they found it useful.

3 Preliminary results

The preliminary results showed that providing uncertainty information did have an impact on decisions. Nearly 60% of the participants changed their answers after being provided uncertainty information and 76% found information about uncertainty useful in their work. The visualization comparison answers were scattered among the different methods, but regardless of the criteria the categorized color ramp and the continuous color ramp between yellow and brown received more votes than the other methods.

Figure 1: Sample decision-making task: The drainage divide is represented without uncertainty information and the user is asked in which drainage area (H or I) and how likely the point belongs to.

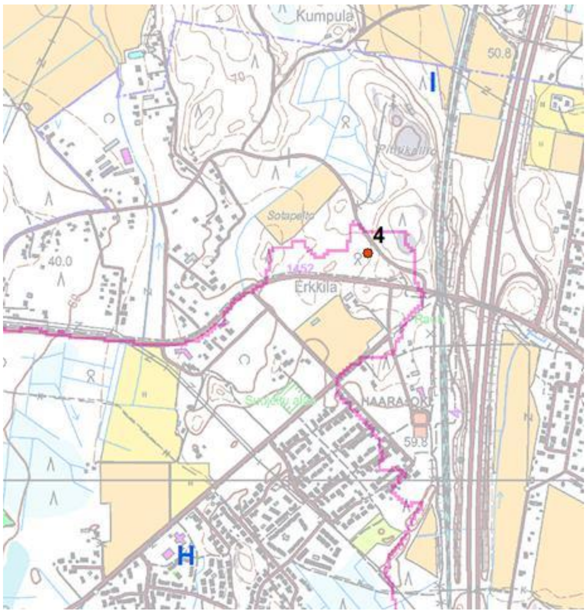
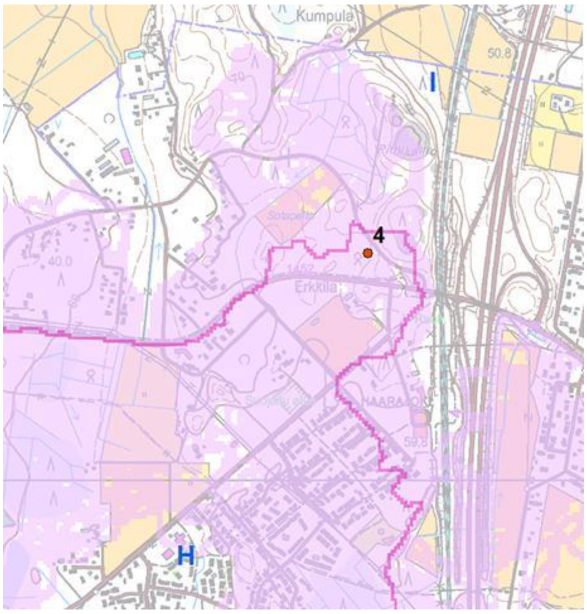


Figure 2: Sample decision-making task: The drainage divide is represented with uncertainty information and the user is asked in which drainage area (H or I) and how likely the point belongs to.



References

[1] Inspire-network and National Council for Geographic Information. Location combines – Finnish National Geographic Information Strategy 2010-2015, *Publication of the Ministry of Agriculture and Forestry,* 3/2010, pp. 28, 2010.

[2] S. Hope and G.J. Hunter. Testing the effects of positional uncertainty on spatial decision making. *International Journal of Geographical Information Science*, 21(6), pages 645-665, 2007.

[3] H. Griethe and H. Schumann. The visualization of uncertain data: Methods and problems. In *Conference on Simulation and Visualization*, pages 143–156, 2006.

[4] A.M. MacEachren. Visualizing uncertain information. Cartographic Perspectives, no. 13, pages 10–19, 1992

[5] A.M. MacEachren, A. Robinson, S. Hopper, S. Gardner, R. Murray, M. Gahegan and E. Hetzler. Visualizing Geospatial Information Uncertainty: What We Know and What We Need to Know. *Cartography and Geographic Information Science*, Vol.32, No.3, July 2005, pages 139-160, 2005.

[6] J. Oksanen. Digital elevation model error in terrain analysis. Ph.D. thesis. University of Helsinki, Faculty of Science, Department of Geography, 2006.