Usability of Uncertainty Visualisation Methods: A Comparison between Different User Groups

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Abstract: This paper presents the results of a web based survey assessing the usability of main uncertainty visualisation methods for users belonging to different key domains such as GIS and Climate change research. We assess the usability of the visualisation methods based on the user's performance in selected learnability tasks, in addition to assessing user preferences. A correspondence analysis between these two results was further carried out to find the association between the user's performance and preference. The key outcome of our study is the ranking of uncertainty visualisation methods according to their suitability for different user domains, as tested for within our study. The gained results are a valuable basis for tools, such as our *Uncertainty Visualisation Selector* (described later) which can recommend the most appropriate uncertainty visualisation methods according to user defined requirements.

1. Introduction

Uncertainty visualisation presents quantified uncertainties of data in a visual context. This is important for thorough data analysis, information derivation and decision making. Van de Kassteele & Velders [6] showcase this necessity in a setting for air quality analysis. Advances in cartography have led to the development of a wealth of spatio-temporal uncertainty visualisation methods in fields such as climate change or decision support to visualise *positional*, *thematic* and *temporal* uncertainties. Pang [4] has presented various uncertainty visualisation methods matching one or more of the visual variables to uncertainty quality measure. MacEachren [2] further described the basic coincident and adjacent representation methods to visualise spatio-temporal uncertainties. With the evolvement of different uncertainty visualisation methods, their complexity in terms of usage increases as well. I.e., to understand the impact of visualisation methods they need to be assessed on their usability [1]. Usability is the extent to which a user can understand and utilise the functionality of a system [3]. This understanding comes from the experience and the background of the user. Further research on usability of different visualisation methods show that the various visualisation methods differ upon their usability among users of different *domains* [5]. Senaratne et al. [5] evaluated in a previous study the following visualisation methods: Contouring, Adjacent maps, Symbols, Error bars & Intervals as well as Statistical dimensions in a GIS (SDGIS). The scope of this usability study was to derive suitable uncertainty visualisation methods for users coming from different user domains: GIS, map visualisation, urban planning, decision support, and statistics. By building up on this previous study, we here extend it and include three additional user domains: climate change research, climate change administration, development practitioners. Further we provide an empirical comparison between those eight user domains on the *learnability* and *likability* components of usability [3]. The ultimate goal of this study is to derive a ranking of methods as per suitability for each user domain, through exploring the association between the user's performance (learnability) and preference (likability) within each uncertainty visualisation method.

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2. The Usability Study

In our web-based usability study, 48 participants took part. They categorised themselves in to one or more of the eight user domains. Three data sets were used to produce the five visualisations; (i) PM10 concentration data for Contouring, Adjacent maps and Statistical dimensions in a GIS (ii) simulated ground level Ozone concentration data for Error bars & Intervals, (iii) land use data for Asia with Symbols method. Aside from the three static methods (Contouring, Adjacent maps, Symbols), the two interactive tools to depict the Error bars and Intervals, and SDGIS, were presented to the users in the form of a video which showed the basic functionality of the tools. Following a three step approach, first the users acquainted themselves with the visualisations, at the second stage the users had to assume the role of decision makers to answer questions, where their performance was assessed. Thirdly, the users had to pick their preferences unbiased of the data's nature. The visualisations and the datasets were selected based on the requirements of the UncertWeb project[1]. Figure 1 gives an overview of the utilised visualisations.

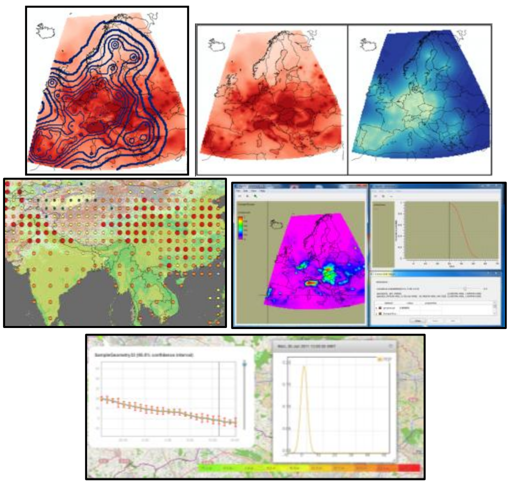

Figure 1. (Left to right) Contouring, Adjacent maps, Symbols, Statistical dimension in a GIS, Error bars.

2.1 Evaluation - Performance

For each visualisation method we assessed the user's performance and preference through which learnability and likability components of usability were assessed. Performance was taken as the proportion of correct answers

[1] www.uncertweb.org

to each visualisation method. As also evident from [5] the majority of users from all domains performed well in Adjacent maps, Symbols and Contouring. The two interactive tools proved to be the most difficult to answer. Some users suggested that these two tools would be most suitable to be used by expert users in the field of geo-spatial uncertainty analysis, due to their complexity.

2.2 Evaluation - Preference

As for user's preference, which was based on the visual appeal and comprehensibility of the visualisation methods, the results differed from [5]. As the users were given the options of choosing more than one visualisation method, a majority of the users from urban planning, decision support, and GIS chose Symbols as their preferred method with Adjacent maps and SDGIS as their secondary choices. Map visualisation, statistics, climate change research, climate change administration and Development practitioners chose Adjacent maps as their first choice of preference and SDGIS and Symbols methods as their following choices. Some users explained the reason for choosing the two tools, (though performing poorly) due to the dynamic/interactive nature of the visualisations which provide the user with analytical capabilities.

2.3 Correspondence Analysis between Performance & Preference

To analyse the association between the user performance and preference we have conducted a correspondence analysis (CA) between these two results. Through this analysis we conclude which uncertainty visualisation methods were easiest to learn and were also picked as preferred choice by each user category, thereby the most suitable method(s) for that user domain. For the map visualisation, urban planning, GIS, statistics, climate change research, climate change research administration, and development practitioner user groups a close association between performance and preference was evident for Adjacent maps uncertainty visualisation method. Further, the Symbols uncertainty visualisation method also showed a close association for the urban planning and GIS user group as well as for the decision support user group. An example CA biplot for the statistics user domain is presented in Figure 2, where performance and preference for each method are mapped in blue and red symbols respectively. The relative closeness (least horizontal distance) between performance and preference confers to highest association. In this case, the Adjacent maps method is the most suitable.

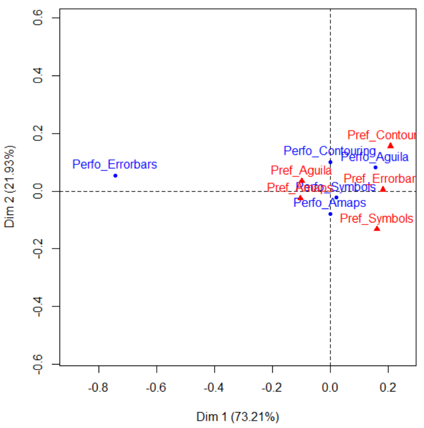

Figure 2. Example CA factor map: Correspondence analysis between performance and preference for Statistics user domain.

We have integrated those results into the *Uncertainty Visualisation Selector*[2] tool, which recommends suitable uncertainty visualisation methods to the user based on the user domain as well as various data requirements such as the measurement scale of the data, the data type, and uncertainty type of the dataset.

3. Conclusions

Extending the setup from [5], we conducted a usability study on selected uncertainty visualisation methods with different user domains. Specifically, we included the climate change research/administration and development practitioner user domains in addition to map visualisation, urban planning, decision support, statistics and GIS domains. This allowed us to do a comparison between performance and preference of users from these different user domains. To find the association between performance and preference we conducted a correspondence analysis between these two usability components. This analysis showed that all user groups except for decision support have a close association for the Adjacent maps method, and decision support has a close association for Symbols method. Further, the Symbols uncertainty visualisation method also showed a close association for the urban planning and GIS user group In future work these ranking results can be implemented into visualisation tools that can adapt the visual representation to the specific user domains at hand.

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[2] http://geoviqua.dev.52north.org/UVS/