Planning Hikes Virtually – How Useful are Web-based 3D Visualizations?

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1. Introduction

The development of new technologies has made it possible to digitally visualize information in interactive three-dimensional forms. Realistic 3D visualizations may be understood more intuitively than traditional maps (Meng 2003; Rase 2003) and distributing them over the Internet makes them accessible to a wide audience. This paper presents a study in which the usefulness of web-based realistic 3D visualizations enhanced with abstract information is explored in the context of planning hikes in the foothills of the Swiss Alps. Hiking is the most popular recreational activity of the Swiss (Kromer et al. 2001) and the tourism regions and organisations are looking for ways to promote their region and support hiking (Sloggett 1997 in Almer and Stelzl 2002). Here we address a particular need and test a new form of visualization in a specific context and with a specific task set.

1.1 Realistic 3D Visualization

Hiking tours in Switzerland are generally planned using the Swiss National Maps 1:25,000 (LK25). Several researchers suggest that people have difficulties interpreting the kind of 3D information that is essential to hike planning from 2D maps (Peterson 1999; Forer 1993 in Cartwright and Peterson 1999). This is used as a justification for the development of new types of maps and map-like representations which look more similar to the real world and may be easier to decode and to understand. Dickmann (2004) compares the user perception of spatial information from a web-based 3D visualization and a print-based traditional map, concluding that the 3D visualization is generally more effective in communicating the information presented. However, the acceptance and use of the 3D cartography is relatively low amongst certain user groups and the effort required to learn to use them effectively can be very high compared to the increase in knowledge achieved (Rase 2003).

This study employs the Virtual Reality (VR) technologies from Geonova AG - software tools that allow highly interactive 3D visualizations to be generated from digital terrain models and ortho imagery and subsequently distributed over the Internet. The realistic 3D visualization is based upon the Swiss National Maps 1:25,000 (LK25). For comparative purposes the 3D map contains approximately the same information as the LK25, but there are some key differences - whilst on the map the third dimension is encoded using contour lines and spot heights, this information is represented by a digital elevation model in the 3D scene. Lange (1999) shows that draping ortho images over terrain is the most important element for generating virtual environments that are perceived as realistic - land cover is represented by symbolism on the map and through the ortho imagery in the 3D visualization. MacEachren et al. (1999) recommend cartographic designs for virtual environments that combine abstract and realistic representations of geographic phenomena - abstract vector information showing a hiking route was added to the visualization in this study. One significant difference relating to information content is that place names and height labels are less dense in the 3D representation than in the 2D LK25.

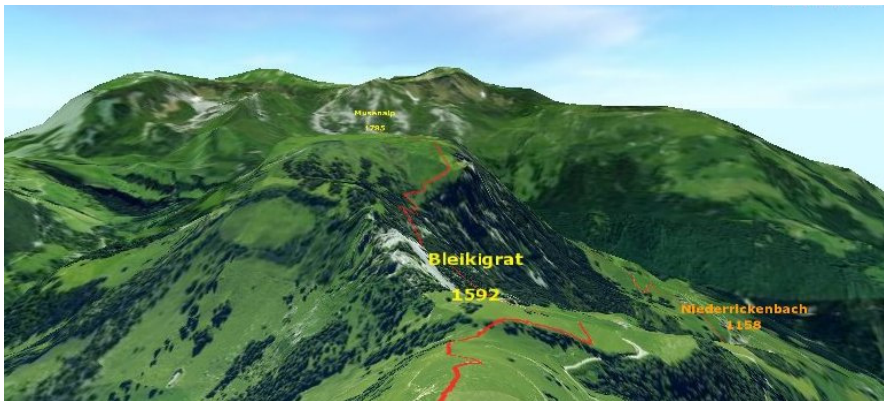

Figure 1. Realistic 3D visualization with hiking route and labels

1.2 Planning of Hikes

The Swiss Federal Office of Sports has a program called "Youth & Sport" (J&S) with guidelines describing the sequence of events involved in planning a hiking tour (Lehner and von Dach 2004). The J&S instructions are used as guidelines for measuring the utility of 3D visualizations for planning hikes. The guidelines can coarsely be divided into three categories: getting an overview of a hiking region; selecting a suitable route; and planning the hike in detail by checking the heights and distances.

2. Data Collection

2.1 Tasks

A number of specific tasks were designed in each of these categories by translating the guidelines into questions that users were asked to answer by interacting with the 3D visualization. Tasks that had been designed for paper-map hike planning were analysed according to their information content and translated into questions that required the same information to be discovered in the 3D visualization. For example, a height profile is created during the paper-map planning stage because this information is regarded as being difficult to interpret from contour maps. The aforementioned suggestion that realistic 3D visualizations are more intuitive than traditional maps (Meng 2003; Rase 2003) suggests that information about steep sections or the highest and lowest points of a route may be visually interpreted directly from the oblique views of the 3D visualization by interacting with the model.

2.2 Questionnaire and Interviews

A series of questions about the specific tasks were designed to record activities undertaken and levels of task completion (figures 3 and 4 show task titles that summarise the questions used). Users were also asked to record their feelings about their ease of completion and their confidence in the results. Details about prior map reading skills and demographic status were also recorded. Multiple choice questions were employed in some cases with one or more answer possibilities. Where appropriate, "Don't know" or "Other" was added with opportunities to provide further explanation. Short answer questions that could also be quantitatively analysed were used for some of the tasks. Open-ended questions allowed the participants to express their thoughts and feelings about the visualization. To generate more qualitative information and to follow up on written statements, interviews were conducted with a sample of respondents (see Rudestam and Newton 2001).

2.3 Sampling

The population that can be sampled for the purpose of this study consists of all people interested in hiking in the foothills of the Swiss Alps. The application and questionnaire were publicized through the Internet via Email to hiking contacts and colleagues and through hiking websites. All hikers informed about the study were asked to further distribute the information to acquaintances interested in hiking. As both the 3D visualization and the questionnaire were made accessible over the Internet only hikers with some IT knowledge were able to participate in the study. A subset of those who

completed the questionnaire were interviewed. Producing an unbiased sample of this diverse population is an extremely difficult task. In this study a sample of the hikers reached through the methods described was used as a surrogate for the background population, but may not be wholly representative. The findings are thus applicable only to this sample, but due to the similarities between the characteristics of those used in the sample and a proportion of the background population they may be more widely relevant.

3. Results and Findings

Approximately 600 people were informed about the study and 99 participants completed the questionnaire. A further 68 people provided other forms of feedback, such as not being able to access the 3D visualization or feeling motion sick when navigating. The questionnaire reached people from all age groups and about a quarter of the participants were women. Interestingly, most participants claim to have 'very good' or 'good' map reading skills. More than two-thirds of the participants state that they have come into contact with 3D visualizations prior to the study, perhaps suggesting a bias in the sample that may be associated with the Internet-based nature of both the software used and the dissemination techniques employed. More than half of the participants do not know the region. Qualitative statements from the questionnaire and interviews were used to triangulate the quantitative data obtained through the questionnaire.

3.1 Getting an overview of a region

The questionnaire answers are summarised in Figure 2 for the first of the J&S categories. They show that 55% of the participants preferred the realistic 3D visualization over the map for the task of 'getting an overview or an impression of an unknown region'. 75% of the participants preferred the 3D visualization for 'revisiting' a known region and 77% for helping with the decision as to whether to visit the region for hiking.

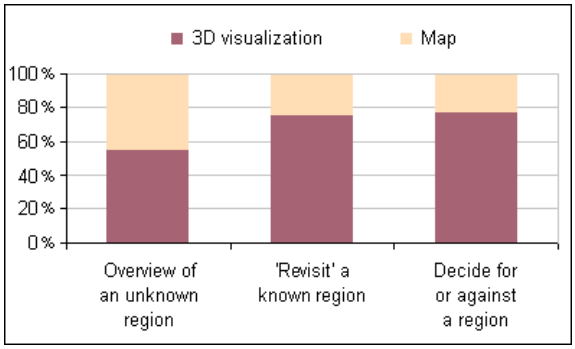

Figure 2. Questionnaire: 3D visualization or map preferences

3.2 Selecting a suitable route

Selecting a suitable hiking route involves the detection of possible tracks. 56% of the participants were able to locate routes along streets and marked paths. Only 15% located concealed paths such as those across pastures or through woodland. When no additional hiking routes are visualized in the 3D environment 68% of the participants prefer to use the traditional map for selecting routes.

3.3 Extraction of exact information

The participants were asked to gather exact information, such as heights, lengths, steepness and information about the nature of particular features from the 3D visualization. Figure 3 shows that tasks that can be conducted using additional abstract information are solved best (for example, the highest or lowest points can be extracted directly from height labels in the 3D visualization). This corresponds with qualitative feedback on the importance of the height labels in the 3D scene.

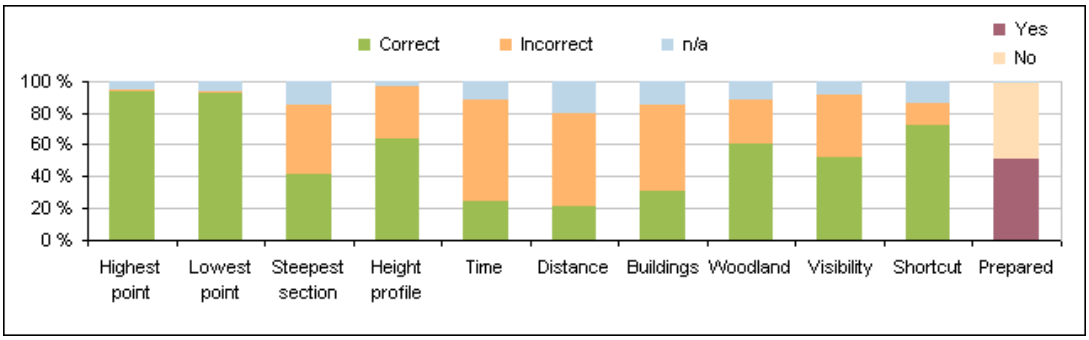

Figure 3. Questionnaire: Extraction of information

Tasks like estimating the length of the hike or finding the steepest section are rarely solved satisfactorily in the 3D visualization. Only 22% of the participants estimated the length of a 3km-section of the hike to within 500m and 41% were able to identify one or both of the steepest sections of the hike. This finding may be surprising as 3D maps are believed to be "understood more intuitively". It seems that whilst the form of the landscape might be "understood", the nature and scale of its variation may not be interpreted accurately or effectively from the 3D visualization. Additionally, those who solved the tasks correctly were not confident that this was the case. Interestingly, even though almost all participants were unable to use the 3D visualization to extract exact information with confidence about half of them felt sufficiently prepared to go hiking having used the 3D representation. These possible misinterpretations could have serious consequences.

3.4 Differences between user groups

The tasks were evaluated in the light of different user groups using Chi-square tests at a 0.05 significance level. Tests for differences between gender, occupation, age or prior experience with 3D maps suggested some trends but revealed no significant differences. Significant differences were found for some tasks when users were categorised according to completion time. Figure 4 shows that many tasks were solved more successfully by participants who spent longer with the 3D visualization.

Figure 4. Hike planning tasks by the time spent answering the questions

4. Conclusions and Outlook

Some sections of the public seem extremely interested in the new possibilities associated with planning hikes virtually. The findings reported here suggest that web-based 3D visualizations that combine realistic and abstract information may be helpful additions to the paper map for some when planning hikes but as implemented in Geonova AG software are not yet suitable replacements for all. 'Overview' tasks were completed more successfully than route detection and planning, whilst the extraction of exact information relied upon abstract symbols rather than realism. However, it appears that the usefulness of 3D visualization may improve when users spend longer with the visualizations. In combination these findings also suggest that "more intuitive understanding" may conceal some important misinterpretations and false impressions and support the suggestions of MacEachren et al. (1999). The qualitative information collected also indicates that the technologies employed can result in some frustrating impediments. 3D visualizations are likely to become more available, more realistic and more important in the near future and perhaps the obstacles will be reduced. However, to be useable by the public careful design is required that is appropriate for specific tasks and the combination of realistic and abstract information is key. Effective interaction design, supported by usability evaluation, should be considered an equally important factor as traditional cartographic design (see Bodum 2005). The suggestion that participants in this experiment underestimated the scale of the relief depicted in the 3D visualization, which appeared small and controllable, needs further research due to the potential dangers involved in underestimating hazards when planning hikes. This should be of particular concern to those promoting hiking using 3D visualization. Related research on the technical and human aspects of using 3D visualizations with additional abstract information in the field may be beneficial (e.g. Coors et al. 2005; Edwardes et al. 2003).

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Biography

Susanne Bleisch is a scientific collaborator for the e-Learning projects GITTA, CartouCHe and eLML at FHNW and a PhD student at City University London. She studied Geomatics at the University of Applied Sciences FHNW in Muttenz, Switzerland and has research interests in 3D geovisualization, cartography and geoinformatics and e-learning.

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