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Data Perception on Maps based on 2D and 3D presentation of Data and Terrain

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ABSTRACT

We investigate how accurate and efficient people are when performing data visualization tasks for different combinations of 2D and 3D displays of a data visualization in a photo-realistic digital environment. We also look at the strategies that people employ to perform complex tasks when provided with a mosaic of 2D and 3D displays, by analyzing eye-tracker data. We start by defining a space for displaying abstract representations of data in an environment according to two axes: the dimensional aspect of the representation (2D or 3D), and the dimensional aspect of the terrain (2D, 2.5D or 3D). Then, we present a suitable data source and the interactive data visualization system we designed to study our research questions. Our next step is to conduct the designed study and provide answers to the research questions based on the study results.

Index Terms: Human-centered computing—Visualization—Visualization techniques; 2D Visualization—3D Visualization—Visualization design and evaluation methods

1 INTRODUCTION

Almost 60-80% of existing data can be interpreted as spatial data [4]. With increasing spatial information, and computer capabilities that support visualization in real time using 3D graphics, the question of whether to represent data in 2D or 3D is often raised (e.g., [2, 6]).

A systematic review of how to represent spatial data on maps was introduced by Dubel et al. [3]. They proposed four types of representations based on a combination of 2D and 3D presentation of the attribute (data) and reference (terrain) space. Cockburn et al. [2], when evaluating spatial cognition capabilities moving from flat 2D to 3D presentation, further divided the reference space into three categories - 2D, 2.5D, and 3D. We combine these two approaches into a new space that characterizes displays based on the dimensionality of the presentation of the data (2D, 3D) and of the terrain (2D, 2.5D, 3D) (see Figure 1).

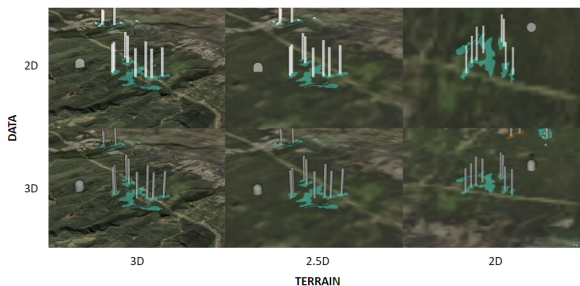


Figure 1: The six combinations of dimensionality of presentation of data (2D or 3D) and dimensionality of terrain (2D, 2.5D, 3D).

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Previous studies have compared the effectiveness of displaying data in 2D or 3D [1, 2, 5–7], but only looking at either the dimensional aspect of data or of terrain. We aim to compare people’s performance in completing *low-level tasks* in the six display variations.

Real-world applications do not necessarily provide a single display of a scene. For example, many video games in 3D virtual environments also feature a mini-map in 2D that results in an overview+detail interface. Thus beyond simply establishing which display is “best”, we are also interested in studying how complementary different displays are, and in unveiling what strategies users adopt while solving tasks when provided with multiple views.

2 SYSTEM

For the purpose of our research, we are using a real data source that is used for conducting Visual Impact Assessments. It is used for the analysis of the potential visual effect that proposed forest operations/projects might have on the scenic landscape and is conducted by the B.C Government.

We use Unity to display the data in the environment. The elements shown in the system are polygonal areas (that represent areas in the real-world environment), bars (one polygonal area corresponds to one bar whose length represents abstract data dimensions), and viewpoint symbols (that represent the location of viewpoints as defined in the dataset).

These graphical elements are placed on top of a photo-realistic terrain that depicts a research forest area provided by our research collaborator. The system supports interactive selection and deselection of bars and polygons, filtering using viewpoints, and navigation. The system supports two modes: in the single display mode, one of the six displays is shown. In the mosaic mode, all six displays are shown (see Figure 1) and navigation is coordinated in all views by syncing the center point and zoom factor in all displays.

3 STUDY AND PLANNED ANALYSIS

The study is divided into two phases. **Phase I** consists of simple low-level tasks such as finding the longest bar or finding two bars with the closest distance measured in the X-Y plane. In this phase, participants will perform each task multiple times using each display separately. We will conduct a quantitative comparison of accuracy and efficiency to complete tasks according to display.

Phase II consists of higher-level real-world tasks from the domain of visual impact assessments. Participants will perform each task once using a mosaic of the six displays. An eye-tracker will be used to record eye movements, like has been done in relevant work (e.g., [5, 7]). We will conduct a qualitative analysis of eye-tracking movement complemented with think-aloud and a post-study semi-structured interview to derive strategies that participants adopt to solve high-level tasks with a combined display of 2D and 3D views.

We plan to use the findings from the study to propose recommendations in terms of which display to use for which task, and to help designers of visualization tools understand how people might use multiple complementary views to achieve visualization tasks in 3D photorealistic environments.

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