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

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ABSTRACT

With the exponential increase of computer capabilities in the last decade, the question of whether to use 2D or 3D for data visualization has been gaining interest. In this study, we compare the accuracy and efficiency of tasks for different combinations of 2D and 3D displays and with the help of an eye-tracker also conduct a qualitative analysis of different strategies adopted by users while solving tasks in combined 2D and 3D displays. We start by first defining the different displays based on the dimensional aspect of spatial data and terrain from related works. Then, we select a suitable data source and design an interactive data visualization system for users to perform the tasks on. Finally, our aim is to evaluate the collected data and report the findings obtained in the form of results.

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

1 INTRODUCTION

Almost 60-80% of the data available can be interpreted as spatial data or geodata [5]. With increasing spatial information, and computer capabilities that have enabled us to visualize designs in real time using 3D graphics, the question of whether to represent data in 2D or 3D is raised frequently.

Moreover, there has also been an increase in the usage of multiple views with different dimensions. For instance, the use of a 2D minimap in a 3D environment video game. Thus another overarching question is what strategies users adopt while solving tasks when provided with multiple views.

Dubel et al. [4] provide a systematic review of the presentation of spatial data on maps by methodically dividing the combination of 2D and 3D presentation of attribute (data) and reference (terrain) space into four categories. There exist several other studies that evaluate the effectiveness of displaying data in a 2D or 3D environment [1, 3, 7–9]. However, they only change the dimensional aspect of either the data or the terrain, and fail to evaluate it for all four categories.

In this study, we build upon the work of Dubel et al. [4] and further divide the dimensions of reference space into 3 categories - 2D, 2.5D, and 3D. We evaluate and compare the data perception for all combinations of said dimensions of data and terrain. With the help of an eye-tracker, we also analyze if users adopt different strategies, for instance, if users use single or multiple views to solve a given task.

2 RELATED WORK

A systematic review of how to represent spatial data on maps was introduced by Dubel et al. [4]. They group the representation into four categories based on a combination of 2D and 3D presentation of the attribute (data) and reference (terrain) space. Cockburn et al. [3] evaluate the spatial cognition capabilities moving from flat 2D to 3D presentation and further divide the reference space (terrain) into three categories - 2D, 2.5D, and 3D.

Research has explored the evaluation of data perception on maps based on the dimension of terrain [6, 7], or spatial data [1, 8]. Eye-tracker technology has been used to analyze strategies adopted by users when solving tasks with combined [9] and separate [7] 2D and 3D views.

3 SYSTEM DESIGN

For the purpose of our research, we are using a real data source that is used for conducting Visual Impact Assessments (VIA). 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.

Using Unity, graphical data elements such as bars, viewpoints, and polygonal areas are placed on top of a photo-realistic terrain that depicts the research forest area in 6 different views based on the combination of 2D and 3D presentation of spatial data and terrain. Interactive features such as selecting and deselecting bars/polygons, filtering using viewpoints, and navigation are also included. Moreover, navigation is coordinated in all views for ease of understanding by syncing the center point and zoom distance of all views.

4 STUDY PROCEDURE

The study is divided into two phases. The first phase is used for quantitative analysis while the second phase is concerned with qualitative analysis. The complexity of the task is based on task taxonomy defined by Brehmer et al. [2]

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 and will be shown for each view separately

Phase II of the study consists of complex high-level tasks that are extracted from the domain and an eye-tracker will be used to record the eye movement of the user. Users will be shown a combined display and asked to solve the given task.

5 EVALUATION

We will conduct a quantitative evaluation of the data collected from Phase I of the study, where we will focus on the comparison of the accuracy and efficiency of tasks performed in each view. On the other hand, the data collected from the eye-tracker in Phase II will be used for qualitative analysis of different strategies that users adopt while solving tasks with a combined display of 2D and 3D views. The evaluation of data will be compared with hypothesis generated through literature review and domain knowledge and will be presented in form of results.

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