On Evaluating Information Visualization Techniques

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ABSTRACT

Evaluating user interfaces is usually accomplished to detect design problems in layout and interaction. One possible way to evaluate image quality in computer graphics is visual inspection by experts. Information visualization techniques are usually presented showing their use in experimental situations, employing some kind of analysis. Nevertheless, few works have specifically addressed the evaluation of such techniques. This work reports our results towards the definition of criteria for evaluating information visualization techniques, addressing the evaluation of visual representation and interaction mechanisms as a first step.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *graphical user interfaces, evaluation, evaluation methodology.*

General Terms

Design, Human Factors.

Keywords

Information visualization techniques, evaluation criteria.

1. INTRODUCTION

There are many different information visualization techniques [2] and each application requires a particular study in order to determine if a selected technique is useful and usable. The *type of data* that should be represented and the *user tasks* or *analysis process* that the visualization should support usually guide these studies. Since visualization is intended to provide insight from data, it becomes clear that both visual representation and interaction techniques must not affect the ways the user needs to use the data in a variety of analysis procedures. Also, besides the usability aspects used to describe the quality of user interfaces, developers should also be concerned with data usability.

Our work separates usability issues in three main categories: a) visual representation usability, referring to the *expressiveness* and *semantic* quality of the resulting image; b) interface usability, related to interaction mechanisms to allow users interact with the data through the image; and c) data usability, devoted mainly to the quality of data that support users' tasks. Our approach is to link usability knowledge, concepts and methods with evaluation of the expressiveness, semantic content and interaction facilities of visualization techniques.

This paper presents two sets of criteria used to evaluate a specific hierarchical visualization technique as a first step towards an evaluation methodology for information visualization techniques.

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2. RELATED WORK

Contrasting with the large number of reports on usability of user interfaces, there are few authors addressing evaluation issues for information visualization techniques. Brath [1] proposes quantitative metrics to evaluate the efficiency of 3D static representations, basically plots, but do not address interaction mechanisms. For each display, he measured the number of data points (for data density), number of dimensions (for cognitive complexity), occlusion rate, and the number of identifiable data points.

Wiss et al. [8] describe the evaluation of three visualization techniques (Cam Trees, Information Cube and Information Landscape) based on the tasks (as defined by Shneiderman [6]) they support. The authors implemented these three mentioned techniques and analyzed them in terms of which tasks they support. Usability experiments were carried out to verify completion of tasks and difficulties in interaction using selected visual representations for a query result provided by NIRVE (the NIST Information Retrieval Visualization Engine) [4]. The goal was to specifically test design features adopted in NIRVE's alternative visual representations in relation to the cognitive load.

Although not directly related to information visualization, the effect of the reduction of quality on 3D images and the quality of information provided were tested by Watson et al. [7] using the naming time method, a special kind of usability evaluation method based on user testing. That study has demonstrated the use of some cognitive aspects of visual representation quality and user performance related to the time spent for achieving some goals (identifying objects and understanding information).

3. EVALUATION CRITERIA

In information visualization techniques, interface usability issues and both expressiveness and quality of visual representation are as important as data usability, since the main concern in this

applications are to give insight to expert users about the data they are analyzing. However, since the *use* of data is based on the interaction with its image, we choose to firstly address the evaluation of visual representations and interaction mechanisms. Through extensive analysis of the literature and experimental use of visualization tools, two sets of criteria were defined.

Four classes of criteria for testing usability of visual representations (*completeness, spatial organization, information coding* and *state transition*) and three classes for testing interaction mechanisms (*orientation and help, navigation and querying*, and *data set reduction*) were identified.

Completeness is associated with the concept of representing all the semantic contents of the data to be displayed. This is affected by the geometric or visual constraints (size of the display, maximum number of data elements, etc.) imposed by the visual representation as well as by its cognitive complexity, which in turn can be measured by data density, data dimension and by the relevance of the displayed information.

Spatial organization is related to the overall layout of a visual representation, which comprises analyzing how easy is to locate an information element on the display and to be aware of the overall distribution of information elements in the representation. Locating an information element can be hard if some objects are occluded by others, and if the layout does not follow a "logical" organization depending on some characteristics of the data elements. The spatial orientation, which contributes for the user being aware of the distribution of information elements, is dependent on the presentation of context while displaying a specific element in detail.

Additional *codification of information* is another aspect we can use for evaluating visualization techniques. Besides the mapping of data elements to visual elements, the use of additional symbols or realistic characteristics can be used either for building alternative representations (like groups of elements in clustered representations) or to aid in the perception of information elements.

Finally, an important aspect of information visualization techniques is the result of rebuilding the visual representation after a user action. The *time* spent by the technique to do that and the *changes in spatial organization* of the resulting image are important factors that can affect the perception of information.

The set of criteria for evaluating interaction mechanisms ultimately comprises functions that support common user tasks in visualization applications. Shneiderman [6] established tasks that a visualization technique should provide, and the analysis of interaction mechanisms corresponds to a usability test of the tool that implements the technique. Functions like support for the user to control level of details, redo/undo of user actions and representation of additional information (for example, the path a user follows while navigating in a complex structure) define *help and user orientation features*, for which usability should be evaluated.

Concerning to *navigation and browsing features*, techniques should be analyzed regarding the possibilities and easiness of selecting a data element, changing the user point of view, manipulating geometric representations of data elements, searching and querying for specific information, and expanding clustered/hidden data elements.

A last subset of criteria is related to the *data set reduction* features provided by the technique. Filtering allows the reduction of information shown at a certain moment, leading more rapidly to adjustment of the focus of interest, and clustering allows the representation of a subset of data elements by means of special symbols, while pruning simply cuts off irrelevant information for the understanding of a visual representation.

4. FINAL COMMENTS

The criteria briefly introduced in this work were used to inspect a specific information visualization technique, the Bifocal Browser [3]. It showed some potential problems concerning representation and interaction usability in that tool. Inspection of other browsers, including the hyperbolic browser [5] and the Microsoft Windows Explorer®, will allow us to refine the criteria and define metrics suitable for hierarchical information techniques. Ongoing work includes experiments with different subjects using the same browsers to allow comparison of results from both analyses.

5. REFERENCES

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