Towards a Characterization of Guidance in Visualization

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ABSTRACT

Applying and parameterizing advanced visualization tools for solving different problems can be difficult for users, who are not necessarily visualization experts. The visualization community has begun to address this problem by developing assistive approaches under different labels. In this work, we propose an initial version of a characterization scheme for guidance in visualization. With the help of the characterization, the visualization community will be able to categorize existing approaches and to identify white spots, which are so far underrepresented and require more research.

Keywords: Visualization, guidance, characterization.

Index Terms: H.1.2 [Information Systems]: Models and Principles—User/Machine Systems; I.3.6 [Computing Methodologies]: Computer Graphics—Methodology and Techniques

1 INTRODUCTION

The explosion of data is accompanied by an abundance of available visualization options, as well as an increase in the number of users who utilize visualization for a myriad of different reasons. In this context, it becomes a challenge to decide on what data to show with which visualization technique in order to support different kinds of users with different application backgrounds in effective information gathering, insight generation, and decision making. As a response to this challenge, approaches have been developed that aim to guide the user towards choices that present the most interesting aspects of the data with the most suitable visualization technique.

However, usually these approaches address only a specific type of input data or a specific kind of user working in a particular application domain. Often the existing approaches are described using vague terms with disparate meanings, such as "user support", "degree of interest", or "recommender system".

With our research, we aim to develop a clearer understanding of what guidance in visualization means and to identify key aspects that characterize guidance approaches.

2 ASPECTS OF GUIDANCE

Assisting users in carrying out the steps most suitable for accomplishing the tasks at hand is a challenge across many application domains. Often the space of available solutions to a given problem is so large that users cannot decide ad-hoc which solution suits their needs best. And even if a solution has been decided upon, finding its *right* parametrization can still be hard. On top of this, in visualization, one also has to determine which parts of the data are relevant to the task to be accomplished.

Computational assistance in this regard can sail under different flags. Quite often one can find the term *recommendation*, which subsumes assistive tools that *recommend* techniques, parameterizations, or relevant data. Also the term *guidance* can be found frequently. Guidance aims to actively *guide* the user, be it in creating visual representations for different types of tasks or in navigating to different regions of interest. Less often, but also related is the term *incentive*, where the goal is to *incentivize* users more subtly to carry out steps that lead to promising results.

It is the contribution of this work, to bring together the different terms and concepts under the common hood of a larger conceptual framework. As a unifying term we shall use "guidance". Developing a broader understanding of guidance allows us to systematize the existing approaches and to discuss their interplay with respect to four key aspects captured by our framework. Each of the aspects considers guidance from a different angle, however, only in combination they are able to characterize guidance in a comprehensive way. In short, the four aspects are:

- **Guidance context:** specifies the prior knowledge the user is assumed or required to have.
- **Guidance domain:** denotes the matter or domain on which guidance shall be provided.
- **Guidance target:** details how the aim or goal of the guidance is declared.
- **Guidance degree:** grasps how much the guidance prescribes and how much freedom to deviate it still allows.

Next we will discuss in more detail the individual characteristics captured by these four aspects of our guidance framework.

Guidance Context Obviously any guidance approach must consider the knowledge or expertise of the user. The prior knowledge of users determines how and to which extent guidance needs to be provided. From a most general perspective, the guidance context can be characterized as:

- **Zero knowledge:** means neither the goal nor a path are known.
- **Goal is known:** means knowledge about the goal exists, but not about how to get there. This includes the ability to assess when the goal has been reached
- **Path is known:** means there is no knowledge about the goal, but about how to get somewhere. This essentially includes the ability to assess if progress has been made.
- **Full knowledge:** means that both goal and path(s) are known.

The implications for guidance are manifold. For example, if a user knows a path towards a goal, this path could be followed. But it could also be the case that the path is not optimal, prompting the guidance to recommend a different path. Furthermore, if users are in a context where they can only judge progress, but not success, they might need better, more elaborate guidance *prior* to arriving in such a context.

Guidance Domain Guidance can be categorized according to the basis of the provided support. We identified four different domains:

- **Data:** Guidance in the data space is done using techniques that (semi-)automatically identify subsets or features based on some kind of "interestingness" definition, such as degree-of-interest functions or recommender systems.

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- **Views/visualizations:** Guidance in the view space suggests suitable visualization techniques and/or parameterizations. A related point is the enrichment of visualizations with additional information (e.g., scented widgets or visual linking).
- **Infrastructure:** In terms of infrastructure, guidance means recommending which hardware (e.g., large public or small private displays) and which software (e.g., analytical or interactive exploratory tools) to use.
- **Users:** In collaborative scenarios, guidance can even recommend which specific task in a complex workflow should be assigned to which expert user. This avoids situations where users work on tasks that do not match their expertise.

Guidance Target We define a guidance target as any entity or situation (depending on the guidance domain) that users are interested in. Making targets known to the guidance system is crucial. The target can be specified according to its degree of indirection:

- **Direct:** *Take me to X!* In direct guidance, the user is able to directly pinpoint a target of interest to be investigated in detail. This is possible only if the user has a hypothesis that can be verified or falsified.
- **Indirect:** *Take me to all Y's that are like X!* In indirect guidance, the user wants to find a set of targets by specifying one or more exemplary representatives that are akin to the sought one. This is known as query-by-example approach.
- **Inverse indirect:** *Take me to all Z's that deviate a lot from X!* In inverse indirect guidance, the user has fixed an X and wants to inspect all targets that are most different from X. This correspond to the "discover the unexpected" motto from the Visual Analytics domain.

Guidance Degree The guidance degree defines how much guidance is provided. It can be defined as a continuous spectrum ranging from minimum guidance to maximum guidance. Apparently, the degree of guidance is inversely proportional to the users' freedom. Along the guidance spectrum one can pinpoint different notions of guidance such as:

- **orienteering** (little guidance, much freedom),
- **steering** (medium guidance, medium freedom),
- **storytelling** (much guidance, little freedom), and
- **annotated animation** (full guidance, no freedom).

In general, an effective guidance solution restricts navigational freedom as much as necessary, but as little as possible. If the degree of freedom is too high, there is a risk that users get lost. Yet, if users feel too restricted, they might refuse to utilize guidance.

A system can provide only one particular degree of guidance at a time. Therefore, it is essential that users can adjust the guidance degree on the fly. For instance, an analyst starts with an animated tour along a pre-defined path focusing on a certain kind of data features. During the tour, the analyst spots an unexpected pattern. In such situations it is essential to be able to stop the animation and to take a closer look at the observed finding – thereby switching to a lesser degree of guidance that offers more navigational freedom.

3 Examples for Guidance

Next we will illustrate by different examples how our framework helps in categorizing existing guidance approaches. The examples provide a good grasp of how to pinpoint a given guidance technique in our framework and how this aids in understanding differences and commonalities with respect to other approaches.

Gotz and Wen [1] present a system monitoring the interactions of users using interactive visualization systems. Its guidance aims at overcoming idiosyncratic, but less-than-optimal usage patterns by inferring the visual task and by creating a visual "short-cut" to perform this task. With regard to the guidance context, the user requires knowledge about the goal, but not about the (best) path to get there. Its guidance domain are visualizations, while the guidance target can be considered indirect, with users being not necessarily aware that their actions are used to specify the target.

Wehrend and Lewis [4] pioneered one of the earliest approaches to guide the selection of visualization techniques. Based on task-operations and object type taxonomies, they provide a classification of useful visualizations. In contrast to Gotz' and Wen's approach it is based on prior expert knowledge and can be used as a guide for users without prior knowledge in a very direct way.

May et al. [2] propose a guidance support for the navigation and browsing of graphs that are too large to be displayed in detail. The visualization provides signposts to name and point to invisible portions of the search space. The user is not required to have full knowledge about any goals from the start. However, at least a coarse knowledge about the topology of the guidance domain is required for effective use. Because the signposts refer to properties or clusters of the graph's nodes, the guidance target is indirect.

The previous examples are rather unobtrusive approaches, where the user is free to accept the guidance offered by the system or pursue unguided means of interaction. Streit et al. [3] propose a concept for the authoring and the guided use of an analytical workflow. The knowledge required to guide a user is gathered and formalized in the authoring phase. The resulting workflow provides concise support for inexperienced users or for analytical processes mandating a high degree of reproducibility. The knowledge about the guidance goal and the navigation to it is embedded in the authoring process and the application, but the user being guided is not required to have that knowledge.

In contrast to resorting to a-priori knowledge, Yang et al. [5] propose a concept utilizing all findings collected during data analysis. These findings can subsequently be used to streamline further exploration – either to pinpoint promising spots for closer investigation or to avoid redundant searches. Hence, this is an example for indirect and inverse indirect guidance targets. In this case, the guidance domain is the data (specifically, the set of possible patterns), with only minimal knowledge required from the user.

4 Conclusion

In this work, we proposed a first draft of a characterization scheme for guidance in visualization. The aspects governing guidance approaches are the guidance context, the guidance domain, the guidance target, and the guidance degree. We illustrated by a few examples how existing approaches are characterized.

In future work, we plan to extend the categorization of guidance approaches and establish a more comprehensive list of examples. This will enable us to identify which aspects of guidance in visualization are well-investigated and which are still underrepresented and deserve more in-depth studies.

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