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Thesis Overview

Interactions in Visualization

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Abstract: The overall goal of this thesis is to define the interactions and a classification of interactions in visualization valid in different application domains. The defined interactions will be applied to the states and transformations of the visualization process. In this context, it is necessary to define a representation for the data sets involved in the process. This representation must be sufficiently flexible to support the different classifications of data, attributes, data sets and visual mappings present in the visualization literature.

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Nowadays, the vertiginous growth of information generates volumes of data that are increasingly larger and difficult to understand and analyze. The contribution of visualization to the exploration and understanding of these large data sets is highly significant [1, 2, 3, 4, 5]. Usually, different application domains require different visual representations, however, several of them share intermediate states of data, transformations, and/or require similar manipulations. These common denominators suggest the need for a visualization model that is consistent for all visualization areas and valid for different application domains. In this context, the Unified Visualization Model (UVM) is defined [6].

The UVM is a model of states and transformations that represents the flow of the data throughout the visualization process. The properties of the visualization process determine that the user should be able to interact with the data and its intermediate representations, control the transformations and manipulate the visualizations. In this context, the definition of a taxonomy of the interactions in the visualization area is extremely necessary to achieve a better understanding of the interactions' design space.

The overall goal of this thesis is to define the interactions and a classification of interactions in visualization valid in different application domains. The defined interactions will be applied to the states and transformations of the visualization process. In this context, it is necessary to define a representation for the data sets involved in the process. This representation must be sufficiently flexible to support the different classifications of data, attributes, data sets and visual mappings present in the visualization literature.

The main contributions of this thesis are:

- A specification of a classification for data, attributes and data sets in the visualization context. We introduce a classification and a representation schema for the data, the data sets and the attributes involved in the visualization process. The representation presented includes the definitions proposed by the most relevant authors in the area [7, 8, 9], achieving in this way an integration that lays the foundation for the definition of a visualization process independent of the application field and the visualization area. The obtained representations serve as the basis to define the interactions that take place in each state and transformation of the UVM.

- A specification of a representation for visual mapping. The specification for the visual mapping contemplates both the storage of the data set to be represented, and the visual structure to represent that data on the screen.
- A multi-level taxonomy of interactions for visualization in the context of the UVM. The presented taxonomy is composed of two main classes, depending on the user to which they are intended: the interactions for the programmer and the interactions for the (visualization) user. The interactions for the programmer, in turn, are classified into two groups: the low-level programmer interactions and the high-level programmer interaction. Low-level programmer interactions are defined based on our representations for the data sets and the visual mapping. High-level programmer interactions are defined based on the low-level ones. User interactions are classified into 4 main classes depending on the stage of the visualization process that they affect (the data sets, the visual mapping, the view and compositions of these three). User interactions are defined based on the programmer interactions. For each user interaction we specify in which state or transformation of the visualization process is resolved.
- The design and implementation of two geological data visualization prototypes and its associated interactions. We designed and implemented SpinelViz [10] and Spinel Explorer [11, 12, 13], two prototypes of geological data visualization that served as the basis for the study and exploration of the concepts introduced in this thesis. For each prototype, a set of interactions was designed and implemented in terms of the introduced taxonomy of interactions. The interactions implemented for both prototypes directly contributed to significant advances in the workflow of expert geologists. In SpinelViz, the interactions to manipulate the 3D view allowed to integrate, for the first time, the three-dimensional representation of the Spinel Prism with the projections in two dimensions that users are accustomed to employ, as well as enriched the exploration process by incorporating semantic zoom directly into the prismatic space. In Spinel Explorer, the designed interactions greatly improve the process of classifying mineral samples. In this system, brushing and linking, specific classification interactions and

novel interactions for contour generation and manipulation considerably reduce the time employed to the classification process in the traditional workflow.

Thanks to the obtained results, we managed to define a valid interaction scheme for the Unified Visualization Model, which establishes the available interactions in each state and/or transformation of the visualization process. In this way, both the user and the programmer know, all the time, what they can do, how to do it and the consequences of their actions, both on the visual representation and its underlying data, controlling, in this way, their data exploration processes.

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