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# Conclusions and Future Works

Although the separation of the conceptual model of user operations from the interface details is a widely accepted principle in HCI design, it has hitherto not been properly applied in the context of information exploration tools. Consequently, it is difficult to assess and compare the adequacy of these tools for information exploration tasks. Given this scenario, this research work proposed a novel framework of exploration operations expressive enough to describe the majority of state-of-the-art environments and tasks.

In order to build a framework with good coverage, we analyzed more than 20 exploration environments and models published in the literature, such as faceted search tools and models, set-oriented browsers, tabular data processors, and visualization tools and models. The analysis process was guided by the principle of separation of concerns and Norman's gulf traversal theory, which allowed us to search for an abstract set of actions, and their respective variations, separately from interface and interaction details. From the analyses we derived a collated list of features that were generalized and formalized as abstract data processing operators.

The framework allows both the formal description of explorations strategies and a more precise assessment of the functional aspects of exploration environments, independently of how the operations are articulated thorough the interface. Therefore, we can compare the extent of the exploration support of different tools using the same set of operations, as we demonstrated in chapter 6. Moreover, the framework also allowed a new approach to the design space of exploration tools, where its formal concepts guided the definition of design issues and solution alternatives both of the data access and the interaction/interface concerns, as we demonstrated in chapter 7.

The present work establishes a theoretical base for future researches on both the design of exploration environments and user studies. With regards to the design of exploration tools, we presented a discussion of the design space with

special emphasis on interaction issues. However, the interface design also comprises a layer of abstract widgets that may lead to an abstract interface model. As an example, each operator has an interaction scene associated, which can be initiated by a starter widget. Within the scene, the parameters for the operation are defined in terms of interface elements. Therefore, each parameter is associated to a range of interface elements. Moreover, the operation is associated to a trigger widget that fires its execution. Finally, the operation causes a state transition on the interface, which is associated to a change of contextual information, such as the exploration trail, and layout reconfigurations. These are some abstract interface elements identified along the research.

Using an abstract interface layer between the functional and the concrete interface layers can leverage the operationalization of user studies, where different interaction dialogues and interface configurations can be tested without loosing sufficient expressivity for a given task. On the other hand, expressivity studies can also be carried out isolated from interface concerns in order to discover, for example, popular operations/compositions that may require differentiated interface designs.

Despite all advances in the visualization field, rapid prototyping applications for research purposes is still a shortcoming for the research community (DOWNIE *et al.*, 2011). This is mostly caused by the lack of development environments specifically designed for this purpose. In the exploration field, such environment is of a great value due to the diversity of possible interface/interaction models and visualizations that can be tested for a given task/user profile. Therefore, as a future work we plan to evolve XPlain into a development environment for rapid prototyping of exploration interfaces and visualizations on top of the proposed DSL, preferably leveraged by an abstract interface model. For visualization prototypes, we plan to investigate the possibility of integration with the Field environment (DOWNIE *et al.*, 2011).

Another future research, also related to user studies, is investigating how exploration patterns emerge within a community of information consumers and how to efficiently support the generalization and reuse of exploration strategies. One obstacle for such user study is its long-term nature, which depends on the continuous use of the environment among a specific community of users. Moreover, there is also a space for research on a proper language to communicate

exploration patterns to end-users, since the DSL targets developers and may not be appropriate for this issue. Visual representations, seems to be a better option for communicating those patterns and allowing further manipulations.

Finally, the formal description of exploration actions also opens a range of possibilities for research on intelligent computational assistance to exploration tasks, where machine-learning agents can be trained to recommend exploration actions and strategies based on previously recorded explorations.