Comparative Evaluation of Two Interface Tools in Performing Visual Analytics Tasks

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ABSTRACT

In this paper, we performed a comparative evaluation to show the effectiveness of two interface tools, one a floating text-based menu (Floating-Menu) and the other a more interactive iconic tool (Interactive-Icon). We evaluated the use and human performance of both tools within one highly interactive visual analytics system. During task performance we tracked completion times, task errors, and captured coarse-grained interactive behaviors.

1. INTRODUCTION

In visual analytics, human interaction and flow of cognition have been noted to be important for problem solving [1]. Specifically, this previous literature mentioned that traditional menus cause considerable interruptions to an analyst's flow, and argued that "visualization design should avoid, as much as possible, menus or other actions that take the user outside of the frame of the task. Interactions should be direct manipulation or closely attached (e.g., with buttons in or on the window). This would include pull-down menus, which require the human to sort through and think about menu items."

However, in surveying literature in the HCI community on the cost and benefits of pulldown menus vs. direct manipulation icons, we find that the distinction between the two is not nearly as clear. In fact, in a paper by Lim et al. [3], they reported the results of an evaluation that directly compares these two systems (menu vs. direct manipulation icons) and found no time difference on task performance. The claim by Green et al. and the findings of Lim et al. appear to be contradictory on surface. Since the primary concern in visual analytics is to help users solving analytical problems (tasks) efficiently, menu systems are commonly adopted as supporting tools. But, the contradictory statements between the two different menu systems make it difficult to follow for designers when designing a useful visual analytics system. The goal of this paper is therefore to perform a user study to examine the use of these two interface tools involving the use of a visual analytical tool and determine whether the claim of Green et al. is valid, or if the finding of Lim et al. could be extended to complex visual analytical tasks as well.

2. SYSTEM

Within a genomic visualization (called GVis [2]), we tested two different tools: a Floating-Menu tool and an Interactive-Icon tool. GVis is an expert visualization system that helps bioinformaticians to support the visual analysis of large-scale phylogeny hierarchies populated with the genomic data of various organisms. It uses a publicly available biological database (GenBank) hosted by the National Center for Biotechnology Information (http://www.ncbi.nlm.nih.gov/) to visualize the phylogeny hierarchies of organisms and allows the user to quickly browse the hierarchy from the highest-level (base categorization) down to the level of individual genome for the desired organism of interest.

Figure 1(a) shows a system overview; phylogenic hierarchies are represented in spheres, and each organism is directly mapped within that sphere. On top of GVis, two interface tools were designed: Floating-Menu (Figure 1(b)) and Interactive-Icon (Figure 1(c)). To represent 18,000 citations, an aggregation technique was utilized to make the visualization both complete and scalable. If an organism is located in the lower level of the phylogeny, the represented information is too small to be perceived; aggregation is then automatically applied to show such information within the organization of the higher categorizational level.

3. COMPARATIVE STUDY

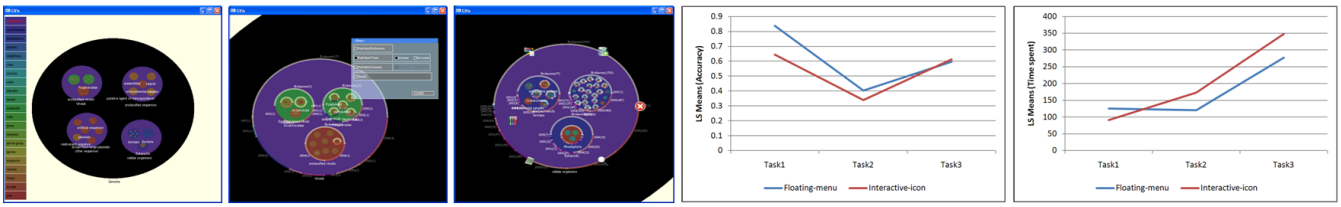
3.1 Procedure

We conducted a within-subject study to explore which interface was more effective. 31 participants (twelve males and nineteen females) performed a total six performance tasks, 3 with each interface. All participants were taking an introductory psychology course, and received course credit for participation. Most participants self-reported that they were unfamiliar with data visualizations.

3.2 Evaluation Results

We present the results of our evaluation based on accuracy, speed, difficulty and usefulness, effectiveness, and preference.

Accuracy: Approximately 54.84% (17.0 ± 7.9) of the participants answered correctly using Floating-Menu. On the other hand, when using Interactive-Icon, about 61% (14.3 ± 5.0) of them were able to answer correctly. Furthermore, there were two instances in which participants could not complete the task when using Floating-Menu and three instances when using Interactive-Icon. By looking at the answers and the captured log-file, some participants (9 participants in Floating-Menu and 12 participants in Interactive-Icon) got close to the goal, but they did not answer correctly. In such case, we provide a half-point. Based on the statistical analysis (Repeated Measures ANOVA), we found that the accuracy difference is not statistically signif-



(a) (b) (c) (d) (e)

Figure 1: The system overview (a) showing the biological taxonomy ranking information as a vertical bar having different color representations and each organism is located in a circular layout having the relevant color attribute. (b) and (c) show two different interfaces as Floating-Menu and Interactive-Icon. Based on user's selection within the interface, it shows a detail information related to each organism group. Least Square Means of Accuracy (d) and Time spent (e) when solving each task. In (d), the accuracy value close to 1 indicates the participant finds a correct answer.

icant across the two interfaces with ($p = 0.24$) and without ($p = 0.25$) a half point given. Interestingly, we found that the accuracy difference is statistically significant across the gender with ($F(1, 185) = 8.55, p = .0039$) and without ($F(1, 185) = 10.69, p = .0013$) a half point given. About 69.4% of male participants correctly solved the given tasks; whereas only about 50.4% of female participants provided correct answers.

Speed: We assume that the user might spend less time when solving the given tasks with an interactive interface tool. However, we found no statistically significant difference ($p < 0.25$) on time-spent.

By measuring least square means about the accuracy (Figure 1(d)) and the time spent (Figure 1(e)), participants spent more time when solving more difficult task questions (difficulty of each task: task 1 < task 2 < task 3). Based on Pearson's Correlation Coefficient measure, there is a trend between the time spent and the difficulty of the task ($r = .47, p < .0001$). Although it is not statistically significant, there is a negative correlation between the accuracy and the difficulty of the task ($r = -.12, p = 0.09$). The participants spent less time with Interactive-Icon for solving the easy task (task 1), the accuracy is lower than with Floating-Menu. However, when solving the difficult task (task 3), the accuracy was slightly, but not significantly higher with Interactive-Icon even if they spent significantly more time.

Easiness & helpfulness (post-task questionnaire): Participants are requested to report the easiness and helpfulness of the interface in solving the task. About 60% (18.6 ± 0.5 for each task) and 43% (13.3 ± 4.0 for each task) of the participants reported all 3 tasks to be "easy" or "very easy" when using Floating-Menu and Interactive-Icon, respectively. Also about 74% (23 ± 3.6 for each task) of the participants identified Floating-Menu to be "helpful" or "very helpful" in solving the tasks, and about 65% (20 ± 3.6 for each task) of the participants found Interactive-Icon to be "helpful" or "very helpful."

Learnability (post-application questionnaire): The post-application questionnaire conducted right after the evaluation of each interface tool. Of particular significance are the questions asking the participants how easy was the interface to use and how easy was the interface to learn. About 67% and 51% of the participants rated that Floating-Menu and Interactive-Icon were easy to use ("very easy" or "easy"), respectively. Since all participants were not familiar with interactive visual interface, they felt simple selection mechanism in Floating-Menu was much easier to learn than Interactive-Icon. These might be because user's familiarity is quite related to determining ease of learning and ease of use on each interface.

Preference (post-study questionnaire): In regards to the participants' preferences, there is no significant difference. Based on the description of the pros and cons, we found that several participants pointed out the strength of Interactive-Icon as being "interactive".

4. DISCUSSION AND FUTURE WORK

Our findings demonstrate that the two interface tools, Floating-Menu and Interactive-Icon, perform similarly both quantitatively and qualitatively.

In comparing Green et al.'s claim that menus cause considerable interruption to the analysis process, and Lim et al.'s reports that menus and direct manipulation icons are comparable in performance, our findings seem to support the latter claims. It would appear that although the evaluation conducted by Lim et al. uses only trivial tasks, their findings may be generalizable in some ways to complex analysis processes using visual analytical tools. However, there are other factors that need to be considered in evaluating these contradictory claims. These experiments, as well as the considerations and analysis they engendered in this paper have set the stage for significant new work. Based on this analysis, we and others can now undertake deeper and more careful experiments on the relationships between the use of interactive tools during engaged cognitive flow and reasoning processes. This is a central research issue for visual analytics.

5. REFERENCES

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