Spatial Layout versus List Layout: A Comparative Study

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Abstract. Information retrieval systems support users in finding relevant information in data sets. List layouts are wide-spread, but spatial layouts are catching up. User studies that systematically show their benefits for users are missing. We report on a comparative between-subject study with 43 participants comparing a spatial layout with a list layout. One group performed a task with a system providing semantic visualization, and the other group performed the same task with a system without semantic visualization. The results show that the users of the spatial layout had significantly more interaction with the system in shorter time, with a slightly higher outcome and higher satisfaction.

Keywords: spatial hypertext · spatial layout · list layout · user study.

1 Motivation

Spatial hypertext promises to discover "the missing link" [5], bridging the gap between human beings' associative thinking and machines explicit structures. On a 2D screen, spatial context can be derived, e.g. by interpreting size, shape, hue or spatial arrangement of nodes. Interpretation of the spatial context happens naturally for humans, but need specialized algorithms when done by machines. So-called *spatial parsers* [7] analyze the visual cues mentioned above and produce a weighted graph of the human organized layout. The resulting graph may be utilized in various cases, e.g. supporting hierarchical selection [1] or user interaction in general [4]. This process of parsing human generated layouts to an explicit structure can be inverted as well, often with the goal of making complex information structures visually accessible. Such *meaningful layout* generation "works well in iterative systems, in which the collection of elements is not defined a priori" [2]. An example of such a layout generation is explained in [6], where authors argue that the positioning and dynamic behavior support users' browsing and understanding of the spatial hypertext. Klouche et al. [3] identified "a lack of understanding on the end-user benefits of interactive visualization in multi-aspect search scenarios", especially in comparison to conventional search interfaces with a ranked result list. Effects of interactive, spatial visualizations in such information retrieval scenarios are still not well studied. For this purpose we conducted a user study with 43 computer science students and discuss the first results in the following sections.

2 Experiment

We had an experimental design with a spatial variant (Mother) and a list variant (List). Both were tested remotely, with the same knowledge base, offering the same suggestions. 43 students in computer science (26 % female, two not specified) with a mean age of 22.6 (ranging from 19 to 30) were asked to participate in a voluntary user study. Participants should imagine the following situation: "Close to your residence, it is planned to build new wind turbines. Find as many potential advantages, disadvantages and other personally relevant topics you want to ask questions about at a soon to be held citizens' meeting, as possible."

The task is completed, when participants think, they have gathered enough information for the citizens' meeting. Right after, they should write down the topics, which they will ask questions about. The experiment used two systems, one based on a spatial suggestion visualization and a reference system which shows results in a ranked list. Participants got randomly assigned to one of the systems. The underlying data (weighted graph of keywords) is German and the participants were native speakers. In both cases the system shows an initial keyword, suitable for an open search task given to the users. In turn, they get suggestions based on this keyword and all other selected suggestions.

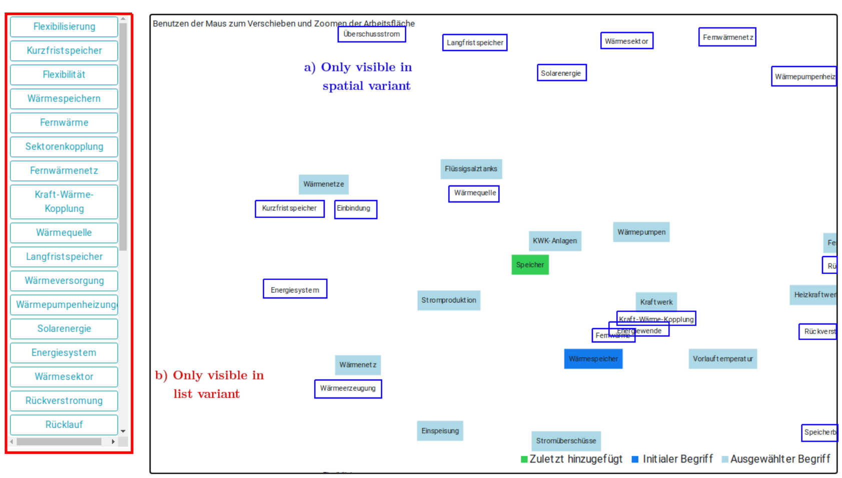

Fig. 1. Comparison of spatial layout (a) and ranked list (b); suggestions are identical

The knowledge base is a weighted graph with keywords, formed around the topics of sustainability and renewable energy. All keywords are extracted nouns of ten Wikipedia pages, like "Windenergie" (wind power), "Passivhaus" (passive house) or "Fernwärmespeicher" (steam accumulator). Weight calculation is done by accumulating how often these keywords appear in the same context.

To make results comparable with a list-based variant, the spatial one does not allow users to alter position and size of nodes. Focus is given on how suggestions are represented, not how users interact with already selected nodes. An example is shown in Fig. 1a. Colorized keywords are nodes selected by the user, with *green* denoting the initial (given) keyword, which cannot be deselected. *Light Blue* marks selected keywords, that can be deselected and *dark blue* highlights the last selected keyword. Suggestions do not have any colorization and are positioned with the algorithm in [6]. In short, the authors describe a physics based approach, utilizing a simulated, annealing spring network to represent parts of a weighted graph.

Selected keywords appear at the position where they were suggested to be. The number of suggestions grows with the number of selected nodes in a linear manner. Panning and zooming the viewport helps look into details or gaining an overview. Both actions are triggered by the computer mouse, the latter with the mouse wheel. The baseline system is very similar to the spatial one, as can be seen in Fig. 1b, and is inspired by the baseline system of [3], where results are shown in a ranked list. Suggestions are not visible in the space until they get selected from the ranked list on the left. With selecting an entry from the list, the keyword appears in the space, positioned as in the spatial variant.

During the test, any interaction with the system is recorded, such that a detailed replay of a session could be created. For the analyses we examined those which are relevant to the effectiveness, efficiency, and satisfaction of the users. In this study effectiveness is defined as the outcome in the number of chosen topics, written down right after task completion, and efficiency as the task duration in seconds. Satisfaction is the subjective assessment of how helpful the system was, on a scale from 0 to 10. Additionally, we want to characterize the respective interaction of the participants with either variant. For this purpose we measured the number of pans and zooms as well as the number of de-/selections.

3 Results and Future Work

The results for both test scenarios are summarized in Tab. 1. Overall, the collected data shows a higher efficiency for the spatial variant, as participants did finish in less time, while the rating of the helpfulness is equal for both test variants. The quantity and quality (the latter estimated by authors) of chosen topics suggest, that both groups performed similar, thus the variants were equally effective. While not statistically significant, both the effectiveness and satisfaction measure tend to be better for the spatial variant.

Adding and deleting nodes are the necessary actions to browse the knowledge graph. Participants with the spatial visualization seem to interact less, but the differences are not significant (Wilcoxon: $p = 0.089$). Yet, due to the faster task completion, there are significantly more interactions per time frame. As expected, spatial variant participants used the 2D space considerably more to explore the knowledge base, measured by the amount of pans and zooms.

Table 1. Summarized results for list and spatial variants; bold values indicate $p < 0.05$

	Baseline (B)		Mother (M)		B vs. M	
	M	SD	M	SD	Test	
Chosen topics	2.5	1.5	3.3	2.8	$p = 0.2465$	(t-test)
Task Duration (seconds)	251.6	147.2	162.5	133.4	$\boldsymbol{p = 0.02265}$	(Wilcoxon)
Helpful rating (0–10)	5.7	2	6.2	1.9	$p = 0.2504$	(t-test)
Navigation (pan+zoom)	21.8	27.1	50.2	37.6	$\boldsymbol{p = 0.000741}$	(Wilcoxon)
Interactions (de-/selections)	25.3	12.4	20.3	14.8	$p = 0.08811$	(Wilcoxon)

In the end, this and comparable studies suggest advantages of spatial visualizations in information retrieval scenarios, compared to typical list-based interfaces. We plan to investigate the data into more detail: Did the interaction rate change during the test? How does another layout algorithm influence the result? *How* do users browse the 2D space? Furthermore, this study utilized a reduced feature set of the positioning algorithm. Especially the possibility to move nodes, while suggestions re-position themselves may influence the results, as there are more opportunities to interact with the system.

References

1. Francisco-Revilla, L., Shipman, F.: Parsing and interpreting ambiguous structures in spatial hypermedia. In: HT 2005 - 16th ACM Conference on Hypertext and Hypermedia. pp. 107–116. ACM Press (2005)
2. Kerne, A., Koh, E., Sundaram, V., Mistrot, J.M.: Generative semantic clustering in spatial hypertext. In: Proceedings of the 2005 ACM Symposium on Document Engineering. pp. 84–93. ACM Press (2005)
3. Klouche, K., Ruotsalo, T., Micallef, L., Andolina, S., Jacucci, G.: Visual Re-Ranking for Multi-Aspect Information Retrieval. In: Proceedings of the 2017 Conference on Conference Human Information Interaction and Retrieval. pp. 57–66. CHIIR '17, ACM (2017)
4. Lyon, K., Nürnberg, P.J.: Applying Information Visualisation Techniques to Spatial Hypertext Tools. In: Wiil, U.K. (ed.) Metainformatics. pp. 85–93. Springer Berlin Heidelberg (2005)
5. Marshall, C., Shipman III, F.: Searching for the missing link: discovering implicit structure in spatial hypertext. Proceedings of the fifth ACM conference on Hypertext (November), 217–230 (1993)
6. Roßner, D., Atzenbeck, C., Gross, T.: Visualization of the relevance: Using physics simulations for encoding context. In: HT 2019 - Proceedings of the 30th ACM Conference on Hypertext and Social Media. pp. 67–76. ACM Press (2019)
7. Shipman, F., Moore, J.M., Maloor, P., Hsieh, H., Akkapeddi, R.: Semantics happen: Knowledge building in spatial hypertext. In: Proceedings of the ACM Conference on Hypertext. pp. 25–34. ACM Press (2002)