Seven Directions for Spatial Hypertext Research

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Introduction

The emergence of spatial hypertext out of node-and-link hypertext was driven by observations of how people naturally used and authored structure among documents. Specialized map interfaces in node-and-link hypertext systems like NoteCards [Halasz, Moran, Trigg 1987] proved to be popular among users working in a hypertext. They provided authors/readers/browsers an overview of the graph of navigational links, presenting more context to the user. This led to hypertext systems like Aquanet [Marshall et al. 1991] in which the map view was the central interface and the document reading/presentation interface became more peripheral. When given Aquanet, instead of continuing to create explicit links between nodes, authors constructed their map spaces to imply these relationships. This observed use of implicit rather than explicit structure led to VIKI, a system designed to support expression and manipulation through implicit relations [Marshall, Shipman, Coombs 1994]. VIKI provided this support through the easy access and unconstrained use of visual cues and a spatial parser that could recognize spatial structures that users would commonly create.

With systems like CHAOS [Reinert et al. 1999], HyperMap [Verhoeven, Warendorf 1999], and the Visual Knowledge Builder (VKB) [Shipman et al. 2001b] following in the footsteps of VIKI, spatial hypertext has emerged as a sustained area of research. This position paper points to seven areas for future research within the spatial hypertext community. These include lower-level system issues of distribution over wide-area networks and real-time synchronous access and authoring. Also, there are issues of making use of inter-document structure expressed in a spatial hypertext, such as exporting the contents of a spatial hypertext and embedding computation in and over spatial hypertexts. User-level directions include exploring the cognitive characteristics of different topologies and the rhetoric, design theory and guidelines of spatial hypertexts. Finally, there is the question of how to evaluate the success of spatial hypertexts. This brings up issues of the role of spatial cognition and spatial intelligence in the use of these systems and more general computer-human interaction issues including choosing appropriate evaluation methodologies and points of comparison. These research directions are not independent but foci representing areas of activity within the space of spatial hypertext research.

Direction 1: Synchronous Collaboration in Spatial Hypertexts

Spatial hypertext is a medium of expression and communication appropriate for collaborators to collect and share information. Reports of VIKI use describe a research group sharing ideas and notes about related projects and some of the social solutions generated due to the system's lack of direct support for multiple users [Marshall, Shipman 1995]. CHAOS demonstrated the possibility of real-time synchronous use but never matured to the point where such use could be observed and reported. VKB emphasizes asynchronous collaboration with the inclusion of a navigable history and observations of long-term project spaces and collaborative writing tasks [Shipman et al. 2001c].

Spatial hypertext raises some unique questions for synchronous collaboration. The use of space makes it possible to explore locking and notification strategies based on the location and composition of relevant components in the spatial hypertext. For example, in a spatial hypertext system that supports a large number of separable spaces, like collections in VIKI or VKB, collaboration protocols could be based around these spaces. For single space spatial hypertexts like CAOS or HyperMap, locking and notification might be on regions within a space, particularly if (as was seen with Aquanet) users create regions of activity in that space.

Direction 2: Wide-Area Distributed Spatial Hypertexts

Spatial hypertext emerged as a research area based on observed use of node-and-link and map-based hypertext. With the growth of node-and-link hypertext use on the Web, there is the potential for spatial hypertext to provide some of the same advantages in the wide-area use as were observed in local use. But wide-area distributed spatial hypertexts generate a number of new technical and usability issues. VKB and HyperMap enable links within a spatial hypertext and VKB's VRLs allow links between spatial hypertexts. The use of these systems has not yet been able to ascertain how people will make use of links and other connections between spatial hypertexts.

For system designers, distributed spatial hypertext raises issues surrounding naming, access, linking, and editing rights. For hypertext authors, it raises issues of how much information should be in a spatial hypertext and when to use links. A node in a traditional hypertext is generally a smaller entity (more focused and containing less information) than a spatial hypertext. Finally, alternative methods of connecting spatial hypertexts need to be explored. In a system like VIKI or VKB that supports a hierarchy of spaces, would graphical inclusion of remote spaces be a more natural mode of accessing distributed spatial hypertext than traditional links.

Direction 3: Integrating Spatial Hypertext into the Information Environment

One of spatial hypertext's main advantages is that it allows more ambiguous, implicit, and non-verbal expression than other hypermedia. Users of spatial hypertexts are likely to be authoring their spatial hypertext as part of a larger task. This implies that information in other applications needs to be included in the spatial hypertext and that the information in the spatial hypertext needs to be shared with other applications. VIKI allowed nodes in the spatial hypertext to point to information on the Web. VKB nodes can be images and may point to any information available via users' file system and local-area network. VITE maps the contents of a relational database table into a spatial workspace and reflects the graphical manipulation of those contents within the semantics of the database [Hsieh, Shipman 2000]. But these only support the inclusion of external information in the spatial hypertext. What happens when information in a spatial hypertext is exported for use in some other application?

Computational interpretation of spatial hypertext expression has been investigated in VIKI's spatial parser and type suggestion, CAOS's exploration of incremental parsing, VKB's implicit type recognizer, and Gronbaek's three-dimensional pattern recognition. Applications like hierarchic click-selection and formalization suggestions have been designed acknowledging the heuristic nature of this automatic interpretation. Research is needed to determine what types of expression can be convertible/exportable.

Direction 4: Computation In and Over Spatial Hypertexts

This is the one direction listed for spatial hypertext that was also on Halasz's list of issues for hypertext systems [Halasz 1988]. Spatial hypertexts, like normal hypertexts, can be designed to adapt to users, their tasks, and the environment of their use. Dynamic generation of Web-based materials and structure occurs through various scripting and programming languages and communication protocols. Generating and making use of content and structure in a spatial hypertext could also be done through programs that generate layouts and programs that make use of recognized structure in the spatial hypertext.

HyperMap is an example of an educational use of spatial hypertext where a user (student) must demonstrate proficiency in a topic before areas of the information space become accessible [Verhoeven, Warendorf 1999]. Questions of how to map user actions and information layout into user, task, and environment models requires an understanding of how the basic operations available in the spatial hypertext system are used and combined into domain-level activity. Such an understanding will emerge through observing use within particular domains and generating domain-specific dynamic or adaptive spatial hypertexts.

Direction 5: Impact of Topology and Expressiveness on Usability and Usefulness

One question for spatial hypertext system designers is the impact of the topology of the space on expression and use. VIKI and VKB enable constructing hierarchies of two-dimensional spaces. VKB

additionally allows navigational links between these spaces. CAOS and HyperMap support a single space but HyperMap controls access to different parts of the space based on user models. How do these differences affect ease of expression and common use of the medium? Does the choice of visual properties made easily editable impact what is expressed as well as how it is expressed? Similarly, do visualization features of the spatial hypertext system, like VIKI's multi-focus non-linear views [Shipman, Marshall, LeMere 1999] alter its use?

While some of these questions can be informed by work in graphical and information design, the interactive nature of spatial hypertext means that real use is required to more fully answer these questions. Examples of this line of research include studies of how materials and topology impacted "information triage" in VIKI [Marshall, Shipman 1997] and how the media affected collaboration and process in writing "magnetic poetry" in VKB [Shipman et al. 2001a]. With a broader range of such comparative studies, lessons generalizable across spatial hypertext systems and applications may emerge.

Direction 6: Writing & Designing Spatial Hypertexts

Spatial hypertext systems are most often used for tasks where the authors and readers of the spatial hypertext are the same group of people. In these cases, difficulty in comprehending the implicit and ambiguous nature of the resulting information is offset by the ease of authoring and reduced by the readers' understanding of the other authors' goals and predispositions. Presentation-oriented spatial hypertext cannot rely on such an understanding. For this reason, research is needed to determine good design practices for spatial hypertext. As is apparent from the variety of guidelines for "good" Web design, rules for authoring spatial hypertext will also depend on the particular situation and audience. Guidelines should help authors determine how much information a node or spatial hypertext should include, how to use visual and spatial layout to communicate interpretations of and relations between nodes, and when to use navigational links or other explicit representations rather than implied relations.

Most design guidelines assume efficiency and accuracy of communication are of primary importance. This is not true in more literary uses of any medium, including spatial hypertext. Within these contexts, there is need to determine if common rhetorical practices will emerge for particular effects. Traditional links have come to serve functions varying from creating tension much like television commercials to providing opportunities to move between threads in multiform stories. How will authors use a hierarchy of spaces found in VIKI or VKB, the conditional links of HyperMap, and VKB's navigable history?

Direction 7: Evaluation Methods and Practices

Impact-oriented and design-oriented spatial hypertext issues, including many associated with the six research directions listed above, require observations of use or comparative studies to inform further efforts. A number of challenges exist to evaluating spatial hypertext. Foremost has been the "proof of concept" nature of many of the systems (CAOS) or the specialized hardware they required (VIKI.) Now that systems are being developed for use on common computational settings, there is need to consider how evaluation practices can be selected to investigate the issues surrounding spatial hypertext.

Among the questions that must be considered are how to measure the expressive and communicative power of various designs and how to compare applications of spatial hypertext to those of traditional hypertext. Additionally, determining the applicability of spatial hypertext raises questions about whether it is just for "visual thinkers" or people with high "visual intelligence". While more of a supporting research direction than the other six, work on tailoring evaluation methods and practices to the idiosyncrasies of spatial hypertext will greatly aid the field as a whole.

Conclusions

The field of spatial hypertext emerged from observations of node-and-link hypertext use. With the subsequent popularization of this traditional model of hypertext, the ideas and techniques of spatial hypertext are more important and applicable today than ever. There are a wide variety of directions open to spatial hypertext researchers. This position statement discusses prior work and open issues in seven of

these directions that will have the greatest impact on future spatial hypertext research and the application of spatial hypertext in real-world settings.

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