Chapter 2

On Spaces and Navigation In and Out of the Computer

Nils Dahlbäck
SICS

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Nils Dahlbäck
SICS, Box 163, S164 28 Kista, Sweden[1]
nilsd@sics.se
http://www.sics.se/humle

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Introduction

We are 'lost in hyperspace' when 'navigating electronic worlds'. And many workers in HCI are working on remedies for this. Many issues of relevance for this task were addressed at a workshop on navigation in electronic worlds at the CHI'97 conference in Atlanta. As pointed out by Jul and Furnas (1997) in their summary of the workshop, "no definitive solutions were reached, [but] much of the problem space was laid out." Our aim with this paper is to contribute further to the task of clarifying the problem space.

As pointed out by Lakoff and Johnson (1980), each metaphor hides more than it highlights. The risk of being blinded by an inappropriate use of a metaphor makes it is therefore important to also assess the pros and cons of the metaphors used. In the present case, it seems especially important to clarify what is distinct and unique to navigation, in contradistinction to other tasks performed by users, as well as the similarities and differences between geographic space and different kinds of electronic spaces.

The Navigation Metaphor

The navigation in electronic worlds-metaphor rests on some important assumptions. First and foremost that geographic worlds and electronic worlds are similar enough to make it possible to make use of results obtained by researchers on navigation and wayfinding in geographic space. "One approach to the problem, which we have found to be beneficial, is to compare navigation in the physical world with navigation in electronic worlds" (Hirtle, 1997, p. 1). Another, and less obvious underlying assumption, is that the *activities* of wayfinding and navigation are similar to the information seeking activities of users of information spaces.

A corollary of these basic assumptions is that it is assumed that navigation in geographic space is similar enough to navigation in electronic worlds to make it possible to use results obtained by geographers, spatial psychologists, architects and others in designing computer systems that can be navigated with ease. But all electronic worlds are not created equal. And there are possibilities for more than one kind of activity in these spaces. Since it is not obvious that navigation support will look the same in all these cases, it seems important to attempt to clarify which the important dimensions distinguishing the different categories are. Without

[1] Also with the Department of Computer and Information Science, Linköping University

doing so, it will be more or less impossible to be able to generalize from particular design solutions or results from empirical studies to the relevant group or class of similar instances.

Definitions of navigation and wayfinding

The Marriam-Webster dictionary defines ‘navigation’ and ‘navigate’ as follows (abridged).

1. NAVIGATION

1: the act or practice of navigating

2: the science of getting ships, aircraft, or spacecraft from place to place; especially: the method of determining position, course, and distance traveled

3: ship traffic or commerce

- nav·i·ga·tion·al /-shn&l, -sh&-n&l/ adjective

- nav·i·ga·tion·al·ly adverb

2. NAVIGATE

Etymology: Latin navigatus, past participle of navigare, from navis ship

+ -igare (from agere to drive) -- more at AGENT

Intransitive senses

1: to travel by water: SAIL

2: to steer a course through a medium; specifically: to operate an airplane

3: GET AROUND, MOVE

Transitive senses

1 a: to sail over, on, or through b: to make one's way over or through: TRAVERSE

2 a: to steer or manage (a boat) in sailing b: to operate or control the course of (as an airplane)

In recent work on navigation in electronic spaces, navigation has been used as a synonym for ‘wayfinding’, a term used in architecture. Wayfinding has been defined by Passini (1984, p 154) as “a person’s ability, both cognitive and behavioral, to reach spatial destinations“, which is only one, but perhaps the most central, of the aspects of navigation described in the dictionary. This activity is composed of a number of analytically distinct but in actual acting intertwined sub-parts. Downs and Stea (1973) claim wayfinding to be composed of four steps: *orienting* oneself in the environment, *choosing* the correct route, *monitoring* this route, and *recognizing* that the destination has been reached.

At a recent workshop on Navigation in Electronic Worlds (Jul and Furnas, 1997) a number of leading workers in the field presented their definitions of navigation. In some cases these definitions are clearly about, or at least heavily influenced by, activities in geographic space, e.g. Leventhal “Navigation is the cognitive process of acquiring knowledge about a space, strategies for moving through space, and changing one’s metaknowledge about a space“. Others, e.g. Spence, focus on activities in hypermedia spaces only; “I have suggested that navigation broadly comprises four activities: browsing, context modeling, gradient perception and movement.“ A similar view is put forth by Dourish and Chalmers (1994), who define navigation as “the means by which a user can describe movement between pieces of information“.

For some workers in the field, ‘navigation’ seems to have acquired a meaning synonymous with ‘seeking information’, as illustrated in the following quotation (Wexelblat,1997) “Imagine that you borrow a book or paper reprint from a colleague. It comes to you not as it would from a store, but rather with pages folded, with notes in the margins, possibly with tabs or tags attached to mark interesting pages. These additional features allow you to *navigate* the book in a different way that if it were untouched“ (italics added). Such a wide definition of ’navigation’, making it more or less synonymous with information retrieval, is not what is aimed for here. To be able to e.g. provide guidelines on navigational aspects of design we need to make clear what sets navigation apart from other tasks of users. If not, these guidelines will be co-extensive with general guidelines for good HCI design. On the other hand, the state of the art in the field today is not developed enough to make it meaningful or even possible, to define the concept on navigation in electronic worlds or information spaces in a universally accepted way. Further theoretical and empirical work is needed to reach this goal

We need both to consider to which extent geographic space is similar to different kinds of electronic spaces, and to consider to which extent the activities pursued in electronic spaces are similar to navigation. We will begin with the issue of different kinds of spaces, and return later to the issue of the different kinds of activities.

Geographic and electronic spaces

While most workers in the field stress the similarities between geographic and electronic worlds, it is as important to also stress the differences. One important such difference is that geographic space has a stable Euclidean geometry, making spatial relations between objects stable and permanent. Gothenburg will always be between Stockholm and Edinburgh. To a large extent this is true for VR systems, and especially immersive VR systems. This is not, however, true in a hypertext or hypermedia system, where new links can arbitrarily be created, making previously distant nodes adjacent to each other. This difference is emphasized also by Kent Wittenburg, who claims “The concept of navigation in cyberspace has a completely different physics from navigation in the physical world. The cartographers and engineers of cyberspace must not only create the maps and the instruments but also the world itself. In such a plastic medium, it is not clear that navigation and search should be thought of as contrasting approaches, but rather as part and parcel of the same activity“ (1997, p 1).

But, as pointed out above, cyberspace is not one but many. Today’s common classification distinguish between hypertext and hypermedia, and immersive and non immersive Virtual Reality (VR). It seems clear that different design solutions are required for all these kinds of electronic worlds. 3D Virtual Reality (VR) systems, and especially so-called immersive ones, preserve most properties of the geographic worlds, hereby making the mapping from work in the geographic world to the electronic world rather straightforward. But, as pointed out by Wittenberg above, for hypertext and hypermedia, the mapping is less perfect, and more caution should be exercised when trying to make use of results obtained by workers on navigation in the physical world, as well as when trying to port successful design solutions from one kind of electronic space to another.

The standard classification is, however, primarily technical, and does not consider the *contents* of the information space, nor the *tasks* performed in it. Leaving the task aspect aside for the moment, it seems clear that there are different levels of structure in most systems of this kind, and this is especially true for hypertext and hypermedia systems. We can at least distinguish between three levels that need to be kept distinct; the *inherent structure* of the content domain, the *structure imposed* by the system designers, and finally the *cognitive map* that the user has of these two structures and their interrelationships. When it comes to the structure of the system, it is probably necessary to distinguish between the underlying structure and the presented structure. In an ideal world, and at least for simple enough systems, these will be co-extensive.

When developing designs or evaluating or comparing existing designs, the kind of mapping between the structure of the information presented and the structure of the information presentation need to be considered. At least the following cases of hypertext information content-structure mappings can be distinguished.

- Information about geographic and similar information, e.g. tourist information about the hotels at a summer resort. Here there exists a real spatial structure that can be used by the users for structuring the information, and furthermore some of the information is inherently spatial in nature, e.g. the distance from the hotel to the beach.
- Information about domains which are not real physical spaces, but which have some commonly agreed upon internal structure. Examples of this would be biological classification systems or educational systems (which often are described in terms of 'higher' and 'lower' education etc.).
- Information about domains that do not have any commonly agreed upon internal structure. Examples of this are classification of different kinds of musical styles or classification of art.

It should be noted that for the last category there might exist consistent conceptual structures for sub-groups of users. And many competing such structures or worldviews can co-exist and even compete at the same time. In fact, the difference between the second and third category is very relative to a particular cultural perspective. All people that have received traditional Western schooling would probably agree upon at least the crude outlines of a biological classificatory system, but the Kaluli people on Papua New Guinea would probably not share this view. So in some sense we have not three but two distinct types. But the distinction between the latter two has an heuristic value when designing hypermedia systems for specific purposes, in making the designer forced to consider whether there exist a structure common to all the intended users, or if many different such structures need to be catered for in the design.

For the first and second category, the users will probably have some shared cognitive map of the inherent structure, which system designers should stay close to when designing the interface and the underlying structure of the system. The third category requires extra caution, since there will be no mutually shared cognitive map of the inherent structure, probably requiring a very clear mapping between the system's underlying structure and the structure presented by the interface.

Another interesting classification is the one by Dourish and Chalmers' (1994) of three major modes of navigation, namely *spatial*, *social*, and *semantic*. Leaving the social navigation aside here, spatial organization, the prime example being immersive VR systems, is obviously closely related to our ability to navigate in geographic space. The class called 'semantic' (CD-ROMs, help systems, etc), which has a structure organized by semantic connections, is argued by Persson (this volume) to rely on the user's semantic and not spatial ability. The distinction is obviously important, but some data (also reviewed by Persson) suggest that further clarification of what characterizes the different classes might be needed here. It has been shown that hypermedia, databases, and hierarchical file systems are of a spatial character (Dahlbäck et al, 1996, Benyon & Murray, 1993, Vicente & Villeges, 1988). But these systems are not spatial in the same sense as an immersive VR system. They seem rather to belong to the non-spatial or non-geographical system in the tripartite classification presented above. They have, in a sense, a spatial structure but not spatial content. The concept of time seems to be a prime example of this (Clark, 1973, see also Dahlbäck 1992). There are a number of different conceptual structures of time, in different cultures or for different purposes (linear, circular, and sub-types of these), but they all seem to have in common the use of a spatial structure to conceptualize something inherently non-spatial.

In this context, it is interesting to note the results from a study by Stanney and Salvendy (1995). It has been previously shown that users with high spatial ability outperform users with low spatial ability (Dahlbäck et al, 1996, Benyon & Murray, 1993, Vicente & Villeges, 1988). Stanney and Salvendy showed that it was possible to build interfaces that compensated for the differences between high and low spatial users, but that the differences between the two groups remained when the task required the construction of a mental model of the information.

Some observations by Dahlbäck et al (1996) in fact suggest that different human spatial abilities are correlated with navigation in geographic space and navigation in a large help system, but more work is clearly needed here. It is important in further work to clarify whether these two kinds of spatiality share enough properties to make similar solutions work in both cases, or whether they should be treated differently, despite both being of spatial nature. I would like to suggest here that a distinction need to be made here between *relational* knowledge and *object* knowledge need to be upheld here. This is similar to Piaget's (e.g. Piaget & Inhelder, 1973) distinction between *operational* (i.e. structural), and *figurative* knowledge, and to Shum's (1990) distinction between *locational* and *attributional* information (though Shum claim both of these to be sub-categories of spatial information, making the much too common mistake of conflating 'visual' and 'spatial').

Electronic spaces usually lack one important feature of geographic space, namely the explicit or implicit information that we are progressing in the right direction. This is not only given us by route signs telling us that we have less distance left to our final destination. When walking in the forest in search for a good place to stay the night, preferably by some lake or river, we are presented with an abundance of cues possible to use for monitoring our task; the slope of the hill and whether we are walking up or down, but also the changes in the kinds of flowers growing on the ground, the kind of soil we are walking on etc., help the experienced hiker to find a way towards a suitable place for staying over night. Both Furnas (1997) in his work on *navigational residue* and Pirolli in his work on *scent* (1997) have addressed this problem (though the work of Pirolli and his co-workers is concerned with the task of summarizing and communicating the structure of very large collections of information). Both approaches have shown initial promising results, but much further work is clearly needed here. Another way of managing the lack of environmental awareness, is to incorporate features in the interface that makes it easier for the user to connect the different snap-shots provided into a coherent real or virtual space (c.f. the chapter by Persson (this volume) on cinematic space).

Unfortunately, many design solutions for alleviating the navigation difficulties encountered by users are limited to *moderated* spaces only (i.e. databases, help systems, and similar designed systems). For *non-moderated* spaces (the prime example being WWW), it is not possible to through design create a uniform perspective or a tailored navigational instrument like a map. In these cases metadata needs to be derived, making the navigational support task a much larger challenge.

Navigation and other activities

The most obvious conclusion possible to draw from staying close to he navigation metaphor is that the major stumbling block for the user is finding the site or location of the relevant information. In the vast majority of cases, our main concern is finding the place we are looking for. Once we have found it, the navigation task is solved. But perhaps this is taking the navigation metaphor too literal? Sometimes this is not the task the user is engaged in. Höök and Benyon (1997) point out that not all activities of computer users are navigation or wayfinding in the strict sense of the word. They make a distinction between *wayfinding* and *exploration*. The former refers to the situation where the navigator has a clear and precise goal or task, the latter refers to situations where such a clearly defined goal does not exist, or where the user only wants to obtain a general overview of the spaces. There is a difference, then, between *learning* the space and *using* the space. In actual practice, these two activities are of course always intertwined. The reason for making a distinction between them in the present case is that it seems plausible that the obstacles encountered by the user when engaged in two activities are different, and that therefore different kinds of user support might be needed.

Furthermore, in those cases where the user is not engaged in exploration of the space, but in using it to solve a particular task, the major problem seems not always to be finding the specific locations in the information space. In their work on the design of a database for research geneticists, Doerry and co-workers have found that, while users have little trouble finding specific data, they frequently become distorted during multi-step data manipulations (Doerry et al 1977). So, at least in this case, the problem is not finding particular pieces of information, but rather the structuring of the information found. Staying with the navigation terminology, the problem is not finding the route to the goal, but construing the survey map of the domain.

Doerry et al also points out that the structure of the interaction with the information system is rarely related to the user's actual task. (C.f. below in the section on spaces). Another interesting observation by Doerry et al is that users often switch between different tasks, making it very difficult to infer the appropriate task structure from the interactions with the system

Kinds of navigation in information spaces

As pointed out above, Benyon and Höök (1997) have argued for making a distinction between wayfinding and exploration. Furnas (in Furnas & Jul 1997) takes this one step further. He distinguishes between two tasks, *searching* and *browsing*, and two tactics, *querying* and *navigation*. These are defined as follows (abridged here). Searching; looking for a known target, Browsing; looking to see what is available, Querying; submitting a description of the object sought to a search engine, Navigation; moving around sequentially in an environment, basing the next step on the task and current information about the environment.

Navigation and problem solving

In some cases, the models of navigation used in the HCI community, (e.g. the one developed by Spence (1997) (see fig 1)) show large similarities to general models of problem solving developed within the AI community. This seems somewhat problematic. Not only is this model in many, perhaps most, cases not a correct characterization of problem solving activities as pointed out by Suchman 1987). What is more important in the present context, is to make clear what the characteristics unique to navigation are, that makes this task separate from problem solving in general. The *situatedness* seems to be one such important factor (c.f. Furnas above). Navigation in the full sense of the word is never an armchair activity; it always involves the locomotion through space. Because of this, there is always the possibility of revising the activities planned during the task (the *monitoring* aspect of the Downs and Stea classification). An important consequence of this, is that error recovery and other forms of adaptation become an intrinsic part of the activity. For us as designers it becomes important to look at navigation design with this in mind. Perhaps support for error recovery, and more general, for monitoring the progress during locomotion, is more important than providing the electronic world analogues of maps and compasses? It is clear that present day interface design gives little support for this.

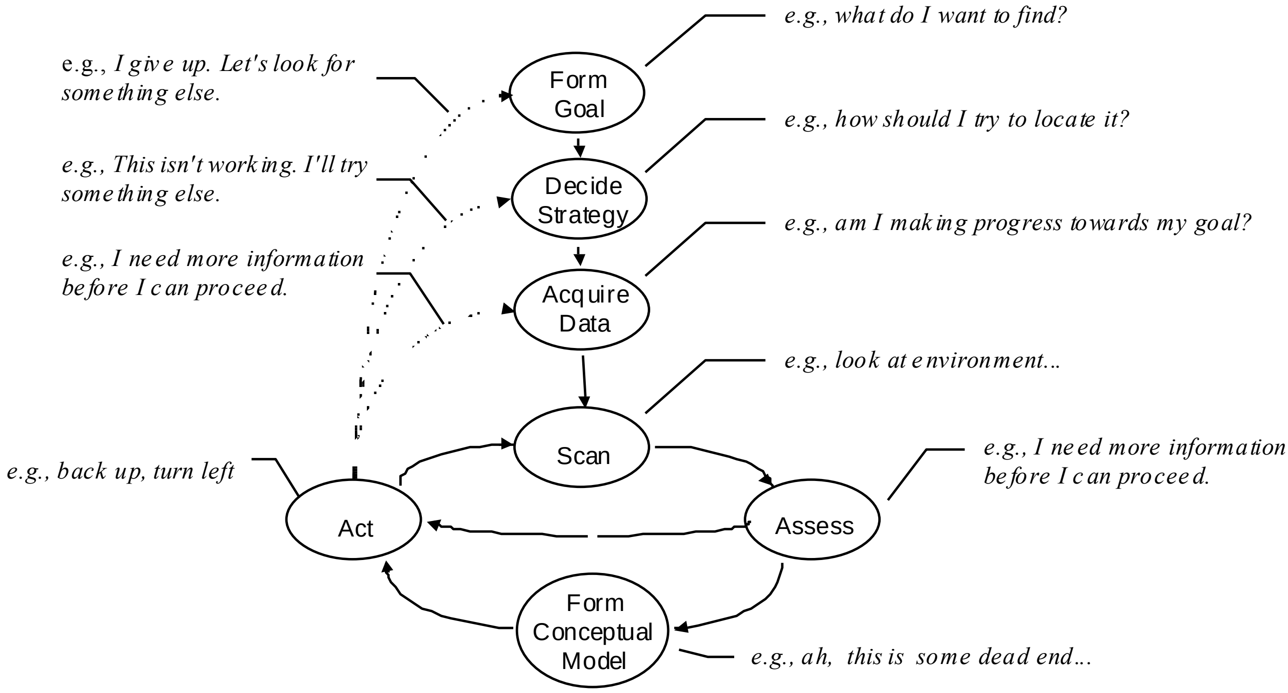

Figure 1 A General Framework for the Navigation Process. From Jul and Furnas (1977)

Another aspect important to navigation addressed both by Persson and Svensson (this volume) is that navigation is a cognitively active process. They distinguish navigation from *transportation*, where the subject either knows the path extremely well, or when the subject is just following a path that he knows will take him to the destination, but whiteout knowing, or caring to know, how the start and end points are situated in relation to each other, or which places he will pass during the locomotion through space. From a psychological point of view, the two kinds of transportation are probably different. In many cases of e.g. routine commuting by car the driver often have a good survey knowledge of the space, and can switch to another mode should the need arise, e.g. in the case of a traffic accident blocking the normal route. This is true for many other highly trained or automated tasks, which makes them very different from the passive transportation of the passenger in the bus, who presumably cannot take over the drivers task should the need arise.

At the CHI'97 workshop on navigation a similar characterization was made. In their report from the workshop, Furnas & Jul (1997) describes it as follows:

> After some discussion of the individual definitions, there were four basic aspects upon which everyone could readily agree. While they do not constitute a definition, they will likely be essential to one:
>
> *Locomotion*
> Something moves—either the navigator or an object that is the focus of the navigator's attention. This assumes a concept of *location*, in particular, a *here* and a *there* (or not-here). The movement is *directed*, i.e., deliberate decisions are made in choosing among locations. The movement is *purposeful* in that it is undertaken in service of meaningful goal.
>
> *Decision-making*

> In being a directed and purposeful activity, decisions must be made continually regarding strategies for reaching the goal and determining whether the goal has been reached. These decisions sometimes follow a plan and sometimes respond to the environment. They depend on both declarative and procedural knowledge and frequently require coordination of knowledge in different forms (orientation).
>
> *Process*
> Navigation is an incremental real-time process that integrates these two components (locomotion and decision-making).
>
> *Context*
> Each navigation process takes place in a particular information environment (set of locations) and is inextricably tied to that environment.

For those scholars that wish to see navigation as something more specific than problem solving in general, there seem to be a consensus on a view with the following properties: The navigator is an active agent. (A passenger in a bus with darkened windows is no more navigating than the body in a hearse.) There is a movement through a space, and this movement is monitored and adapted during the process. There is a goal for the process, and once the goal is reached the process is finished. If this, then, is what constitutes navigation, the question that emerges is to which extent this is a reasonable description of the activities in electronic worlds?

Learning to navigate in a space[2]

It is common to distinguish between three kinds of knowledge of a space. Following Siegel and White (1975) these are called *landmark*, *route*, and *survey* knowledge, often acquired in that order. Landmarks are conceptually and perceptually distinct locations. Route knowledge is understanding of the environment in terms of paths between locations. Survey knowledge describes the relationships between locations, often likened to map like memory representations. Results from Tversky (1991) and others indicate these survey representations often show a hierarchical structure.

The fact that humans often naturally create hierarchical survey knowledge structures, is of course very relevant for the designers of hypertext and hypermedia systems, which by definition have this structure. It is, however, important to note some complications here. First, that there probably has to be a close mapping between the structure of the system and of the user's knowledge structure. Second, that the mental map of a domain will vary depending on the viewer's perspective. The latter studies can, however, be interpreted as indicating that it is the metric and not the topological aspects of the mental maps that vary view viewer perspective. Since hypertext and hypermedia system do not have a stable Euclidean geometry, it is possible to entertain the hypothesis that designers need not take these fluid perspective changes into account when designing their systems. But this is, of course, only a hypothesis, in need of further investigation.

Acquisition of spatial knowledge can be either primary or secondary, where primary denotes knowledge acquired through navigation in the world and other kinds of primary experience, and secondary denotes knowledge acquired through symbolically transmitted information, e.g. maps (Schachter and Nadel, 1991).

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[2] This field is reviewed in depth by Sjölinder (this volume). The text here owes much to her work and my discussions with her on this and related topics.

There are three different ways of describing an environment to a listener; taking the listener on an imagined *tour* through the environment, providing a *survey* description, or taking the listener on a so-called *gaze tour* (Tversky, 1991). The difference between the two latter is that in the first case a map like overview is given, whereas in the latter, the listener is placed on an imagined viewing point, and the locations of the different objects in the world is given with reference to the viewer's position (e.g. the Hoover Tower is to the left of Jordan Hall, the Gates building to the right, and the Tresidder behind it).

It has been shown by Tversky and others, that the knowledge acquired through studying a map is in some senses different from the knowledge of the same space acquired from actually being there. The best-documented difference is that primary spatial memory is more robust to various manipulations of orientation at the time of retention. On the other hand, a series of studies by Taylor and Tversky (1992a, b) have shown that subjects acquire the same spatial mental models from survey and route descriptions, as well as from maps.

The interesting question that then emerges from these findings is what kind of knowledge that is acquired through navigating in a hypermedia space. This activity is in some sense similar to being in the space. But what distinguishes it from the actual locomotion through geographic space, is that no cues, or at the best very abstract and map like cues, are given showing how one particular location is related to the others in the space. So in this respect it is more like map reading.

Linde and Labov (1975) and Taylor and Tversky (1996) have shown that there are typical preferences for different kinds of relations for different kinds of environments. When describing an apartment, most people prefer a route description, whereas for describing rooms that can be seen from one viewpoint, most people prefer gaze descriptions. But there are also individual differences here; e.g. some people use survey descriptions to describe their apartments. To this author, this suggests that navigational aids should be able to adapt to the user's individual preferences in environmental description format.

Navigation tools supporting the user

Much of present day research is devoted to designing tools that will help the user navigate to space, by e.g. giving her a map of the domain. But once again, we can ask ourselves whether we are staying too close to the navigation metaphor, and a particular interpretation of that metaphor, namely the professional navigator in a ship or a plane. Is it really tools we need? Designing maps and similar devices to help the user see where he is in the space, could be likened to having a person drive a window less car through the help of a sophisticated map and navigation system, where a simpler and probably more efficient solution should be to give her a window to look out through?

But looking out through a window is of no help, if everything you see look the same no matter where you are. The suggestions put forth by Persson (this volume) and MacAulaylay, Benyon, and Crerar (this volume) all suggest ways of giving locational cues to the user, without interfering with her primary task. Note, however, that these suggestions in many cases will be in conflict with commonly accepted design guidelines, which advocate a uniform design of each window or section of a large system. This is most likely a contradiction that can be resolved through a careful design, but more work is clearly needed before these design solutions can be formulated as general design guidelines.

In summary; there are two ways of supporting navigation, at least in moderated spaces. One can make the space more navigable, by incorporating in the design features that makes orientation easier, or one can develop tools to support the navigation task, by e.g. presenting map-like overviews of the space.

Social navigation (no user is an island)

Taking one step back, and looking at present day research on navigation, it becomes obvious that the implicit picture of the navigator or information system user, is in most cases that of some kind of lonely ’walker in the woods’. It takes only a moment of reflection to realize that this is a very distorted picture of human activities. We are in constant interaction with other persons through most or all steps in the tasks and activities pursued.

As a reaction to this, a number of different scholars have recently introduced the concept of ‘social navigation’ (e.g. Dourish and Chalmers 1994, Erickson 1996, Dieberger 1997). As pointed out by Svensson (this volume) the definitions differ between different scholars. The common denominator seems to be an attempt to introduce social aspects into the task of navigating in information spaces. No attempt will be made here to recapture Svensson’s review and analysis; the interested reader is referred to Svensson’s chapter here. Instead we will discuss the relationship between different interpretations of the navigation metaphor and different views of social navigation. We will also discuss how to delimit the ‘social’ in social navigation from other kinds of navigation.

Social navigation in the different metaphor interpretations

Analytically, we can distinguish between two ways that social aspects can be incorporated in the activities of users of information spaces. First, the social activities can be likened to getting help from other people in finding the way to the desired goal, e.g. asking people in the street for the way to the library. In this case we preserve the goal of the activities in the metaphor’s mapping between the domains, making the important goal the finding of a particular place in hyperspace. Second, the social activities can be likened to asking for information from other people, instead of finding out from written and other sources, e.g. asking people for information, instead of going to the library to find the information there. In the latter case, we are in a sense substituting social interaction for navigation activities.

For the first interpretation, supporting social navigation in electronic worlds implies developing agents and other software devices that the user can use for finding the way to the desired goal. For the second interpretation, supporting social navigation would more likely imply creating software information providers that the user can access through some kind of interactive dialogue, without having to find the way to the information sources, and perhaps in many cases not even having to learn the location of these sources. Another approach would be to support the social interaction and dissemination of information on the Web and in other similar electronic worlds (c.f. Dieberger 1997). Svensson places himself squarely in the first camp “social navigation is navigation. In fact (...) the only thing that separates navigation and social navigation are the tools.“

One could, however, argue that this is not an either or situation; that we have to decide which of these two interpretations that is the correct one. We have previously pointed out that there are kinds of activities that users of information spaces pursue that are different from the prototypical navigation task. Also these tasks are always done within a social context, and the social aspects need consequently to be considered in successful design supporting these tasks too.

One should also be aware that the distinction made above is not a dichotomy. We are never individuals interacting with either the social or the physical world. We are all the time doing both, also when we are alone. A good example of this is given by Wexelblat (1997), who points out that following the paths in a forest is actually using information given by other persons; they have walked here because it lead to some interesting or in other respects valuable destination. (The Footprints system currently under development at the MIT Media Lab tries to provide this kind of information for users of the WWW.) Svensson addresses similar issues under the heading of 'indirect social navigation'. One problem here is that is seems difficult to delimit indirect social navigation from navigation in general, since all the electronic and other information spaces that exist are created by people, they are in a sense vehicles of socially transmitted information. This is especially true if we also include so-called history enriched environments. The World Wide Web is, as pointed out by Svensson, essentially a social structure. But it is a strange social structure; created by people, but (with a few exceptions, like the Footprints system) inhibited only by individual users.

Social and non-social navigation

Is there then no way of delimiting social navigation from other forms of navigation? Following Dahlbäck (1998) we could argue that there are two fundamentally different ways of being in the world, *action* and *interaction*. Action is what we are doing when manipulating the physical world; walking, moving or changing objects etc, interaction is always with humans and other agents, i.e. dialogue[3]. Interaction is always with another agent, to whom we can ascribe intentional states (c.f. Dennett, 1987). Interaction is always social, action is never social per se, but can of course take place in a social context, and the environment in which most people spend most of their time is to a large extent created by human activities.

We can then use this distinction to make a difference between social and non-social navigation. Social navigation is in essence navigation which at least to some part is done through interaction with other agents, human or artificial. It is what Svensson call 'socially enhanced navigation'.

The basic argument for distinguishing between these two classes is that we as humans carry with us different expectations concerning action and interaction; most of us would be greatly surprised if our car would engage in a dialogue trying to convince us that we shouldn't turn right at the next intersection.

The hypothesis advanced here is, that since we can both act and interact with computers, it becomes important to make clear to the user which state the system is at a particular time. Furthermore, that designs that place themselves on some middle ground between action and interaction should be avoided, especially for computer novices.

Summary: Dimensions we might need to consider

We have surveyed and discussed a number of different dimensions pertaining to spaces and activities in spaces. Let us try to summarize here what we have found. The basic distinction was between geographic and electronic spaces. Among the latter, we discussed a number of different issues.

[3] It is of course unfortunate that the computer industry has used the words 'dialogue' and 'interaction' for aspects of human's computer usage that in fact are more like analogues of physical manipulation, e.g. graphical user interfaces. But that does not invalidate the distinction, it only makes it more difficult to communicate it to that community. Moving a chair by hand, or asking a person to move *are* after all very different kinds of actions.

Electronic spaces
- Hypertext, Hypermedia, Virtual Reality, Immersive Virtual Reality
- Moderated Vs non-moderated spaces

Levels of structure in hypertext and hypermedia systems
- Inherent structure, imposed structure, presented structure, cognitive structure

Kinds of structural/spatial information
- Spatial (geographic), structured but non-spatial; non-structured
- Spatial Vs visual information

Tasks in electronic spaces
- Searching and browsing; querying and navigation
- Finding a piece of information Vs (finding and) structuring many pieces of navigation
- Using a space Vs learning a space

Kinds of learning of a space
- Primary (experiential) Vs secondary (symbolic)

Social dimensions
- Non-populated Vs populated spaces (social traces in the world)
- Social Vs non-social navigation
- Acting Vs interacting

While not all of these dimensions will be important in all cases, we would like to argue that in both design and evaluation we need to make clear where in this multi-dimensional space we currently are working. If not we risk importing successful design features from other systems that are less useful in our present case, or we risk making overgeneralizations of the results obtained from evaluation studies. No claim is being made here that the dimensions we have considered here constitute an exhaustive list. But we hope that we have provided a useful starting point for further work in this area.

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References

Clark (1973) Space, time semantics and the child. In T. Moore (Ed.) *Cognitive Development and the Acquisition of Language*. New York: Academic Press.

Benyon and Höök (1997) Navigation in Information Spaces: supporting the individual. In *Proceedings from Interact'97*. Australia, July 1997.

Benyon and Murray (1993) Adaptive Systems; From Intelligent Tutoring to Autonomous Agents. *Knowledge Based Systems*. 6(3).

Dahlbäck, Nils (1992) Representations of Discourse; Cognitive and Computational Aspects. Ph.D. Thesis. Linköping University.

Dahlbäck, Nils (1998) The Navigation Metaphor, How far will it Take us? Manuscript in preparation.

Dahlbäck, Nils, Höök, Kristina, and Sjölinder, Marie (1996) Spatial Cognition in the Mind and in the World; The Case of Hypermedia Navigation. In *Proceedings from the Eighteenth Annual Meeting of the Cognitive Science Society*. San Diego, Ca, July 1996.

Dennet, Daniel C. (1987) *The Intentional Stance*. A Bradford Book, The MIT Press.

Diebergber, Andreas (1997) Supporting Social Navigation on the World Wide Web. *International Journal of Human-Computer Studies.* 46, 805-825.

Doerry, E., Douglas, S., Kirkpatrick, T., and Westerfield, M. (1997) Task-centered Navigation in a Web-accessible Dataspace. In *Proceedings from the AACE/WebNet97 Conference* Toronto, Canada, November 1, 1997
http:/zfish.uoregon.edu/ZFIN/PAPERS

Dourish, Paul and Chalmers, Matthew (1994) Running Out of Space: Models of Information Support. In *Proceedings from HCI'94*. Glasgow, August 1994.

Downs, R and Stea, D (1973) Cognitive Representations. In R.Downs and D. Stea (Eds.) *Image and the Environment*. Chicago: Aldine, pp 79-86.

Erickson, Thomas (1996) The World Wide Web as Social Hypertext. *Communications of the ACM*, January, 1996.

Furnas, George (1997). Effective View Navigation. In *Proceedings from CHI'97*. Atlanta, Ga, 22-27 March 1997, 367-374.

Hirtle, Stephen (1997). Spatial knowledge and navigation in real and virtual environments. Position paper for the CHI'97 workshop on Navigation in Electronic Worlds.
http://www.pitt.edu.~hirtle/navig.html

Jul, S., Furnas, G. (1997). Navigation in Electronic Worlds. SIGCHIBulletin, 29, 4 (Oct). New York: ACM Press.

Lakoff, George and Johnson, Mark (1980), *Metaphors we live by*. Chicago: The University of Chicago Press

Linde, C and Labov, W. (1975). Spatial Networks as a Site for the Study of Language and Thought. *Language*, 51: 924-939.

MacAulay, Benyon and Crerar (1998). Voices in the Forest: Sounds, Soundscapes and Interface Design. *This Volume*.

Passini (1984). *Wayfinding in Architecture.*

Persson (1998a). A Comparative Study of Digital and Cinematic Space with a Special Focus on Navigational Issues. *This Volume*.

Persson (1998b). Supporting Navigation in Digital Environments: A Narrative Approach. *This Volume*.

Piaget, Jean, and Inhelder, Bärbel (1973). *Memory and Intelligence.* London: Routledge and Kegan Paul.

Pirolli, Peter. (1997) Computational Models of Information Scent-Following in a Very Large Browsable Text Collection. In *Proceedings from CHI'97.* 3- 10.

Schachter, D.L. and Nadel, L. (1991). Varieties of Spatial Memory: A Problem for Cognitive Neuroscience. In R.G. Lister andH.J. Weingarter (Eds.) *Perspectives on Cognitive Neuroscience.* Oxford: Oxford University Press.

Shum, S. (1990). Real and Virtual Spaces: Mapping from Spatial Cognition to Hypertext. *Hypermedia*, 2(2): 133-158.

Spence, (1997) cited in Jul and Furnas (1997)

Stanney, K.M. and Salvendy, G. (1995). Information Visualization: Assisting Low Spatial Indivituals with Information Access Tasks through the Use of Visual Mediators.*Ergonomics*. 38(6): 1184-1198.

Suchman, Lucy (1987) Plans and Situated Action: The Problem of Human-Machine Interaction. Cambridge, MA: Cambridge University Press..

Svensson (1998) Social Navigation. *This Volume.*

Taylor, Holly and Tversky, Barbara (1992a). Spatial Mental Models Derived from Survey and Route Descriptions. *Journal of Memory and Language*. 31: 261-292.

Taylor, Holly and Tversky, Barbara (1992b). Descriptions and Depictions of Environments. *Memory and Cognition*. 20(5): 483-496.

Taylor, Holly and Tversky, Barbara (1996). Perspectives in Spatial Descriptions. *Journal of Memory and Language*. 35: 371-391.

Tversky, Barbara. (1981) Distortions in memory for maps. *Cognitive Psychology*, **13**, 407-433.

Tversky, Barbara (1991) Spatial Mental Models. *The Psychology of Learning and Motivation*. 27.

Wexelblat, Alan (1997). Navigation by Trail-following. Position paper for the CHI'97 workshop on Navigation in Electronic Worlds.
http://wex.www.media.mit.edu/people/wex/CHI97-wkshp-pos.html

Vicente and Villeges (1988). Visual Momentum as a Means of Accomodating Individual Differences Among Users of a Hierarchical File System. In J. Rasmussen and P. Sunde (Eds.) *Proc 5th Symposium EFISS,* Risö National Laboratory, Denmark, November 1987. New York: Plenum Publishing.

Wittenburg, Kent (1997). Navigation and Search – What's the difference? Position paper for the CHI'97 workshop on Navigation in Electronic Worlds.
http://www-personal.engin.umich.edu/~sjul/nav97/wittenburg.html.