A Computational Model and Classification Framework for Social Navigation

Mark O. Riedl
IMG Laboratory
Department of Computer Science
North Carolina State University
Raleigh, NC 27695-7534
919-515-6535
moriedl@unity.ncsu.edu

ABSTRACT
Social navigation is the process of making navigational decisions in real or virtual environments based on social and communicative interaction with others. A computational model for social navigation is presented as an extension to an existing framework for general navigation, reducing decision-making to the minimization of cognitive costs. Consideration for social navigation gives rise to a classification framework based on the synchronicity, directness, and social presence during social interaction, each of which has direct effect on the cognitive costs of navigational tasks. Finally, a new recommender system, TRAILGUIDE, is presented as a tool that facilitates social navigation by allowing authors to explicitly publish "trails" within and between World Wide Web pages.

Keywords
Social navigation model, social presence, embodied avatars, recommender systems, World Wide Web

1. INTRODUCTION
It has long been recognized that humans are fundamentally social animals. Virtually all activities that we engage in involve interaction with others or are influenced by the presence and opinions of others [10]. Beginning in the 1980s, computer science researchers began to recognize that influences such as social interaction affect the performance and the problem solving strategies of a single human using a single computer. Computer-supported cooperative work (CSCW) is the field of study that emerged to investigate how the computer can become a tool that will allow people to work together effectively. Work in computer-supported cooperative work has led to a variety of computer-mediated communication technologies. Some of the more prevalent computer-mediated communication technologies include Email, newsgroups, bulletin board systems, multi-user dialogs (MUDs) and collaborative virtual environments (CVEs), talk clients such as NetMeeting and Inter-relay Chat (IRC), recommender systems on the World Wide Web, and video conferencing capabilities. By allowing people to communicate and share ideas in new and more expressive ways, these technologies expand the ability for humans to communicate and help to create a wider sense of community between users.

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1.1 Navigation as a Socially Motivated Behavior
Navigation, in its most general sense, refers to the activity of following a route through an environment. An environment can be any domain in which one has a sense of location and locomotion and is not restricted to spatial or physical domains. Within the field of human-computer interaction (HCI), navigation is employed as a useful metaphor for interaction with information systems. Navigation is well understood in the context of the individual using a computer as a tool for navigation through virtual environments and information spaces such as the World Wide Web. Only recently has navigation been investigated within the context of collaborative work through computer-mediated channels. Computer users are motivated by social setting, the actions of other individuals, the actions of collective groups of other people, and the social nature of the work being performed [10]. Reasonably, user strategies for navigating through a virtual or simulated environment are also affected by social interaction. However, many computer-based navigation activities, such as browsing though the document structure of the World Wide Web, are still widely regarded as an individualistic activity [10].

1.2 Social Navigation
The term *social navigation* refers to the ways in which perceived social factors influence navigational behavior. Dourish and Chalmers define social navigation as moving towards a cluster of people or navigating to a particular place because someone else has been there or seen something [11]. The first definition of social navigation, movement towards a cluster of people, is most often investigated in terms CVEs. Typically a user is immersed in a 3D environment and often represented by a graphical avatar. Other avatars also inhabit this space and the goal is locate and interact with the other inhabitants of the virtual world. The second definition of social navigation, navigating to a place because someone else has been there or seen something, is most commonly addressed with recommender systems. Recommender systems attempt to assist the user by determining her interests and providing the most appropriate alternative [15].

The driving force behind social navigation research is the realization that the actions of a user at a computer do not occur in a vacuum. Users are motivated by perceived social setting, the actions of other individuals, the actions of collective groups of other people, and the social nature of the work being performed [10]. On the contrary, computer-based activities such as navigating through the document structure of the Web are still widely regarded as an individualistic activity [10]. Wexelblat and Maes point out that without access to others' problem-solving histories, each navigation task faced by an individual will require that individual to rediscover what may already be known [23]. Often, all that is needed to eliminate such redundant navigation is the realization that someone accessible (a friend, colleague, group member, etc.) has already made the effort to learn the same thing.

In the remainder of this paper is devoted to building a computational model of social navigation and how the model affects the design and use of certain computer-mediated communication technologies. In section 2 we will extend a framework for general navigation to take into consideration the impact of social navigation. Additionally, a new classification framework for social systems will be introduced as a means to compare the capabilities of different styles of social interaction. Finally, in section 3 a new system, TRAILGUIDE, will be presented as motivation for how the social navigation model and extended navigation framework can be used to the benefit the design of computer-mediated communication systems.

2. A FRAMEWORK FOR SOCIAL NAVIGATION

In the past, several frameworks for navigation in physical as well as virtual environments have been proposed (See [19] for a comprehensive review). These frameworks are built upon iterative cognitive processes involving identification of elements in the locale, mental modeling of the locale, formulation or refinement of navigation strategy, and then locomotion to a new locale. Spence [19] recognizes the potential for a general framework for navigation to be applied to socially motivated activity, but admits that social navigation may require a distinct, but inter-related, model.

2.1 A General Navigation Framework

In [19], Spence proposes a general framework for navigational models designed to be applicable to a wide range of environments, both physical and virtual. Figure 1 shows Spence's conceptual framework for general navigation. The framework consists of four stages:

- *Browse stage*. The navigator perceptually registers the environmental content around him. The environmental content is the information that can be elicited from the navigation space.
- *Modeling stage*. The registered environmental content is used to build an internal mental model of the environment on both the local scale and a more global scale, providing understanding of what is perceptually available as well as how it fits into the larger picture.
- *Interpretation stage*. The internal mental model is used to decide whether the goal has been reached or whether the browsing strategy should be revised.
- *Formulate browsing strategy stage*. The browsing strategy is revised and a new direction for movement is chosen.

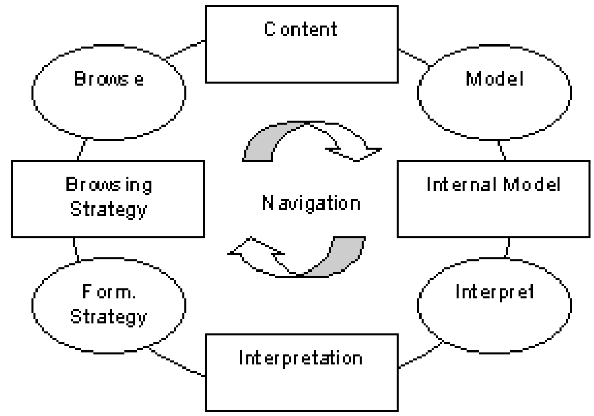

Figure 1. A general framework for navigation [19].

The process is iterative [19]. The *browse*, *model*, and *interpret* stages are involved with registering and understanding perceptual information. The results of these stages prepare for planning the next iteration of the navigation cycle. During the *formulate browse strategy* stage, the navigator opportunistically determines the best direction to move in order to achieve his goal [19].

The general framework proposed by Spence necessarily does not go into detail about how each stage of the navigation cycle is performed but merely suggests the outcomes of each stage. Social context will affect the planning stage of navigation since the social presence of others can provide decision-bearing information that cannot otherwise be gathered from the perception and interpretation of environmental content. We present a computational model of social interaction that will fill out the browse strategy formulation stage of the general navigation framework described above.

2.2 A Computational Model of Browsing Strategy Formulation

Our model for social navigation browsing strategy describes how one's browsing strategy, at the *formulate browse strategy* stage in the general navigation framework, is shaped by social as well as environmental context. The model extends Wegner's [22] notion of transactive memory. In the transactive memory model, humans are modeled as distributed processing units, each with their own local memory store. Figure 2 shows a transactive memory with extensions for navigation planning (in darker gray). Person A consists of a processor, P_A, and local memory store, M_A. Within the memory store are directories. D_A is a *local directory* that indexes all the knowledge known to A. D_B is a *remote directory* that indexes all the knowledge that Person B is believed to know. D_B is constructed from a history of interaction with Person B and from stereotypes. There is a remote directory for every other person with whom communication is possible. None of the directories are guaranteed to be accurate, least of all remote directories. The transactive memory is used to decide with whom to communicate to get the desired piece of information. Remote directories are the instruments through which this determination is made. When information is required, the local directory and all remote directories are queried simultaneously and the result either indicates that the desired information is resident in local

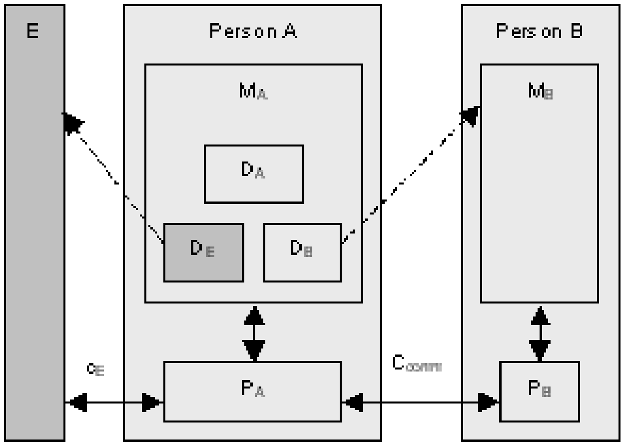

Figure 2. A transactive memory system (adapted from [22]). Persons A and B are modeled as a processor and memory store. E is the content available from the environment.

memory or that the information is resident in a remote memory, requiring a communicative act.

To this model, we add an *environmental directory*, D_E, in which an internal model of the environmental content (as constructed in the *modeling* stage of the general navigation framework), E, is located. The internal model contains understanding about the local environment, understanding about Person A's location in the global environment, and understanding about surrounding locales [19]. The transactive model is simplistic but is valuable to social navigation research because it is supported by social science research. In addition, since the model describes interaction with others and with the environment in terms of information exchange transactions, the model lends itself to formalization and simulation.

At each step of navigation, the organism must choose the next best direction to move and the information from which that decision is made is considered to be available in either local memory, some known remote memory, or in the environmental content. During the browse strategy formulation stage of navigation, local memory is queried for an answer to that decision. The local directory, remote directories, and environmental directory all operate simultaneously to produce the solution with the lowest operational cost. The possible solutions include

- Retrieval from the local memory store,
- Retrieval from a remote memory store requiring a communicative act, or
- Retrieval from the content available in the environment requiring interaction with the environment.

The navigational cost of any candidate solution involves many factors such as the time to perform communicative acts, the time to interact with content in the environment, perceived cognitive effort for local memory recall, desirability of a specific course of action, uncertainty, and so forth. Many of these cost factors are determined by individual preferences and cannot be modeled deterministically. Although there are many ways of measuring cost, our model will consider only three: time-cost, uncertainty cost and equivocality cost. Time-cost is proportional to the amount of time a communicative act is believed to complete. Uncertainty cost deals with the completeness of the communicated message [7]. If information is incomplete or omitted, uncertainty will be high. Equivocality cost deals with confusion due to the possibility of multiple interpretations [7]. Ambiguity of the intent of a message can lead to high equivocality cost. We will assume that the planning organism will always choose the solution with the lowest perceived cost. We will also assume that each interaction with the environment, c_E, requires a constant, non-zero time and that time to access the local memory store will always be minimal.

Social interaction occurs when the requested information is not present in the local memory store but is present in a remote memory store and when time to communicate with the remote memories owner, C_{comm}, is less than the constant c_E. Determining C_{comm} is not easy since different communication channels have different associated costs depending on their characteristics. Studies have shown that many people, when faced with uncertainty, prefer to receive guidance from personal, social contacts rather than seeking out static elements within the environment [17]. Ideally, if another person has already expended the effort to navigate a path to a common goal, then access, through interpersonal communication, to that person's past experiences can lead to drastically reduced time-cost and understanding costs.

2.3 A Classification Framework for Social Systems

The type of social system used for interpersonal communication has a direct effect on the cost of communication and thus the browse strategy chosen. Social systems share characteristics from which we can derive generalizations about the associated cost. A classification framework is presented below. There are three semi-independent axes on which social systems can be evaluated: *synchronicity*, *directness*, and *social presence*.

The first axis, *synchronicity*, addresses whether social interaction occurs synchronously or asynchronously. A synchronous system is real time where there is no delay in communication from either party. A face-to-face meetings, phone conversations, and real-time discussions in chat-rooms are examples of synchronous interaction. An asynchronous system involves delayed transmission of communicative messages. Email and postings on newsgroups are asynchronous systems because the message may not be read immediately. In general, asynchronous social systems have the potential for high associated time-costs due to the delay in transmission and reception.

The second axis for evaluating social systems is *directness*. Svensson [21] defines directness as the capacity for mutual communication. By this Svensson means the ability to reply – to reciprocate – to the initial message. Most social interaction is direct because messages are exchanged in sequences that are related contextually. Indirect interaction occurs when there is no mechanism for reciprocation such as when information is obtained through a collaborative filtering system or from a prerecorded message such as a TV commercial. Directness tends to reduce the equivocality and uncertainty costs because reciprocation can be used to refine and clarify the message. However, if the interaction is occurring through an asynchronous system, the time-costs for reciprocation can build up. Indirect systems have very low associated time-costs because the interaction is a one-time message. In cases of indirect communication, the format of the message itself has a strong affect on equivocality and uncertainty costs, as any ambiguity or incompleteness cannot be resolved without reciprocation.

The third axis is *social presence*. Social presence is degree of salience of another person in a social interaction. Social presence is strengthened by feelings of immediacy and intimacy during interpersonal communication [20] and is strongly correlated with effective learning [16] and persuasion [3]. Information can be exchanged in parallel across any number of channels such as eye contact, gestures, and voice inflection. Social systems that restrict the use of parallel channels tend to score low on social presence scales. Not surprisingly, email, newsgroups, and MUDs, which restrict communication to a textual channel, score low on social presence scales. Whether or not social presence is a desirable trait for a social system depends on the nature of the communicative task. High social presence systems have been found to reduce equivocality during tasks involving high equivocality [5]. Likewise, low social presence systems have been found to reduce uncertainty during tasks involving high levels of uncertainty [5].

Figure 3 demonstrates how different social systems map to the classification framework.

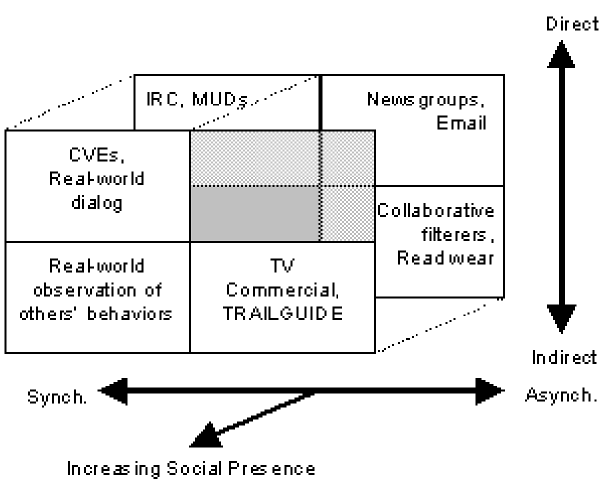

Figure 3. Examples of social interaction plotted against syncronicity, directness, and social presence axes.

3. A PRACTICAL IMPLEMENTATION OF A SOCIAL NAVIGATION SYSTEM FOR THE WORLD WIDE WEB

The World Wide Web is perhaps the most popular synthetic navigation space known at this time. However, despite the Web's popularity, web browsing is still considered and researched as an individualistic activity [10]. Aside from collaborative filtering systems and personal bookmark pages, any sort of interpersonal communication must be carried out over separate channels such as Email or phone. With regard to the anytime, anywhere nature of the Web, interpersonal communication is often restricted to asynchronous strategies resulting in large time-costs associated with that communication. As a result web-browsing strategies, as defined within the general framework for navigation, are restricted to personal knowledge and strict interaction with environmental content.

3.1 Strategies for Social Navigation on the Web

Even early in the development of the Web, people recognized the need for social navigational tools on the web and published bookmark pages as a way of informing others of the interesting things they had discovered [8][9]. As email and newsgroups become more ubiquitous, sending URL pointers in email messages and in bulletin postings became a way of informing others and becoming informed of relevant information on the web. Many news-related Web sites now offer to email articles to a friend on one's behalf along with a brief message attached. Bookmark pages, email, and newsgroup pointers are three techniques for social navigation. Recommender systems are the newest technique for creating a sense of community on the WWW [13]. On the World Wide Web, the most common recommender systems are of two flavors: collaborative filtering and "read wear." Collaborative filtering systems attempt to correlate a user's profile with that of a large number of other, anonymous profiles [15]. Read wear systems track the number of people as they read through a document and mark the most popular (heavily visited) parts visually by showing "wear and tear" [13].

3.2 The TrailGuide System

We present a system, TRAILGUIDE, which is designed to provide an alternative mode of asynchronous interpersonal interaction. The World Wide Web is an ideal choice of domain because navigational problems are common and often difficult to complete without assistance. An example of a navigational problem on the World Wide Web is asking, "How do I find useful information about a given subject?" Alternatively, one could wonder, "Where can I go to find something interesting?" Following from the model of social navigation proposed in this paper, a person solving a navigation task will choose a problem-solving strategy that will transfer the requisite knowledge to perform the task to one's own memory in the most cost-effective manner. If the way is not already known, this knowledge must come from the environment – the Web pages – or from other people through social interaction. TRAILGUIDE is designed to be a cost-reducing mechanism for social interaction in the case when the most likely source of task-related knowledge is not spatially or temporally available. TRAILGUIDE can assist navigation on the Web by providing guidance from domain experts at each decision-making (*formulate browse strategy*) step of the navigation task; social communication is offered by the system as a cost-saving alternative to making navigational decisions based on Web page content alone. Section 3.3 will further discuss how TRAILGUIDE uses a variety of techniques to reduce the costs of interacting with the environment and with other users.

TRAILGUIDE is a system designed to store and playback the recorded Web foraging experiences of users. To explain the concepts behind the design of TRAILGUIDE, I will evoke a metaphor of traveling on foot through a Forest Park. There are meandering trails through the Park, some of which I am familiar with and others that I am not familiar with. As I hike down a trail, I see tiny signs that indicate the species of certain plants along the trail. If I happen to be amateur botanist with no expertise, I can walk along a trail and read the signs and learn the names of plants and what they look like but little else. A better approach to learning about forest botany would be to ask a park ranger to speak in detail about some of the more interesting plants encountered in the forest. The advantages of interacting with an expert are clear. Unfortunately, an expert is not always immediately available and the cost of waiting might be too great. Now imagine that the forest is the World Wide Web and I am the same amateur botanist searching for information about strange and interesting plants. I find a copious number of sites about botany with a search engine, but it would take a long time to sift through all the results looking for information that meets my specific desires. Suppose a friend of mine is also a botanist with some experience who has already performed a similar search. He has foraged through the copious search results, found some of the more interesting factoids, recorded their locations and added commentary on why he thought his findings were so interesting. Even if this expert is not immediately available, his botany-related knowledge can be made available to all who are interested in his expertise.

TRAILGUIDE is a system developed to maintain a repository of the recorded experiences on the Web for oneself and for others. TRAILGUIDE consists of an authoring tool and a play back tool. The authoring tool records the movements of the user as he browses from one page to another; links that are selected for navigation are recorded as trail markers. Trail markers act as signposts pointing the way that the user chose to go as well as an optional annotation of the reason the link was chosen. When the user finds a Web page with interesting content, the content can be highlighted and another trail marker will be created to store an annotation typed in by the user. In this manner, TRAILGUIDE records a user's experiences within and between pages on the Web. Advanced authoring tools allow an author to write conditional statements into the trail markers. For example, the author finds a textual passage about a type of tree and annotates it, noting that this species of tree has recently become endangered. In addition to the annotation, the author specifies a conditional that would allow a future reader to "ask for more information." If the future reader indicates that she does want to know more, a second annotation will be displayed revealing where the largest existing grove of these trees can be found in New York State. If the reader were not interested, then the information would be suppressed. The author can also specify branch points at any point along the trail to refer the reader to tangentially or incidentally related trails that exist in the repository. The name of the author and a list of those who are allowed to access the trail (for security and privacy purposes) are encoded along with the trail in the TRAILGUIDE repository. The access list grants specific access, group access (for example, a botany club), or public access.

3.2.1 Avatars and Social Presence in TrailGuide

Before anyone can begin recording with TRAILGUIDE, that person must first register a 2D-avatar body to represent herself with. Preferably this avatar body should visually represent the user's character, personality, or role with respect to those who will view the users. When a user plays back a recorded trail, instead of getting a static list of trail markers, he is presented with the author's avatar, which proceeds to gesture, emote, and speak the recorded thoughts of the author. Figure 4 shows the TRAILGUIDE in use with a playback in progress.

Figure 4. TRAILGUIDE in use with playback in progress. An avatar has highlighted a segment of text from a Web page and is speaking in greater detail on the topic.

During playback, the avatar indicates the links that the author followed but the viewer does not need to select the links himself, the avatar can do it for him. Interaction with the avatar mainly involves indicating that the avatar should continue the presentation (or go back to a previous point); the avatar pauses after each trail marker is presented to allow the user to pursue her own thoughts or read through Web page material at her own pace. Additional interaction takes place if conditionals and branches are scripted into the trail, in which case the avatar can ask the user questions and receive limited feedback. If the viewer chooses to, she can navigate away from the pre-recorded trail. The viewer can return to the trail by asking the avatar to bring her back to the last played point or by navigating back on to the trail manually. If the viewer navigates on to part of the trail not yet viewed (or any other trail in the repository), TRAILGUIDE can pick up at that point or return the viewer to the last played point.

A wide repertoire of communicative behaviors is available to be authored into the trail and acted out by the avatar during playback. Possible behaviors include the more mundane pointing, moving, and glancing as well as more emotionally motivated behaviors such as expressing pleasure, satisfaction, excitement, or disappointment.

With the use of avatars, TRAILGUIDE hopes to elevate the perception of social presence above that of the traditional recommender system despite the fact that the true communicative act is both asynchronous and indirect. Despite the asynchronous and indirect nature of communication between author and reader through the TRAILGUIDE system, informal observations have indicated that readers become affectively engaged with the presenting avatar. Such phenomena have been observed in other domains [14].

3.3 TrailGuide Compared to Other Social Systems

Support for indirect, asynchronous, high social presence interaction sets TRAILGUIDE apart from other computer-mediated communication systems on the World Wide Web. TRAILGUIDE can be considered a recommender system under the most general of definitions [15] but is not a collaborative filterer.

Collaborative filterers and read wear systems support an asynchronous, indirect manner of interaction as well, but tend to score low on social presence because they must aggregate the opinions of a large population into a single message. Within the Forest Park metaphorical world, a collaborative filtering approach would be to stand at the entrance to the park and watch which way visitors in swimsuits went in order to find the lake. A read wear approach would be to look at the ground choose a trail that looks more traveled upon. Collaborative filterers and read wear systems have low time-costs due to their indirectness, however equivocality costs may be high because the circumstances through which the recommendation is made is not always clear.

Similarly, bookmark pages are asynchronous, indirect tools for social interaction. The social presence associated with bookmark pages can be higher than that of collaborative filterers and read wear systems due to the potential for personalization coded into the pages, but the social presence is still not considered as "high". Metaphorically, a bookmark page is a sign with directions at the entrance to the Park, but there cannot be any more direction signs once the Park is entered. Like collaborative filterers and read wear systems, time-cost is low. Associated equivocality and uncertainty costs depend on how the information is coded into the bookmark pages, but can be quite high due to the indirect nature of the interaction with the page's authors.

Email and newsgroups can be used as tools for social navigation, even though that is not their primary role. In such circumstances, Email and newsgroups are asynchronous, direct, low social presence systems. Social presence is low due to the inexpressibility of the text medium. Email and newsgroups do not suffer from high equivocality or uncertainty costs because of their direct nature. However, they do suffer from high time-costs since the time it takes to receive and reply to a message has no upper bound.

TRAILGUIDE differs from the traditional approaches to social navigation on the World Wide Web by offering higher levels of social presence. TRAILGUIDE already exhibits the low time-cost associated with most recommender systems. However, by increasing social presence with the use of animated avatars that stand in for the trail authors, any equivocality costs associated with a trail are reduced. By using avatars as surrogates for the trail authors, the focus of the social interaction is shifted from the author to the avatar, which can react to the user in real-time, further reducing equivocality and uncertainty costs in a fashion more consistent with direct interaction. In general, uncertainty is still strongly linked with the content of individual trails themselves and cannot be corrected for. With the ability to add branches to trails, a mechanism exists through which a trail's completeness can be augmented.

4. RELATED WORK

TRAILGUIDE derives most of its concepts from the MEMEX system proposed by Vannevar Bush [4]. With MEMEX, a user could store vast numbers of microfilm documents. The user can annotate documents stored within MEMEX. The novel aspect of the MEMEX system is that related documents could be tagged and associated together in "paths" and "branches" by the user. Such paths would create a contextual meta-organization that would be separate from any conventional hierarchical organization scheme. A fully annotated and cross-referenced Memex storage could be copied and passed down from mentor to apprentice; one could in this way share one's accumulated experiences and knowledge with others.

The FOOTPRINTS system, developed by Wexelblat & Maes [23], records a history of all users as they navigate on the Web. Any user of FOOTPRINTS can view a directed graph of any site they visit based on the foraging of her colleagues. All the user histories are anonymized and aggregated to protect user privacy although the popularity of any particular page is indicated by color. In this respect, FOOTPRINTS is similar to read wear in the way it filters through collaborative effort.

WALDEN'S PATHS [12] is a pedagogical application of social trail mapping. Students and teachers can associate web pages in a linear fashion in order to create a path through the information space of the Web. At the top of each page visited on the path there is an annotation revealing the relevance and navigational tools to allow a user to advance through the path or to return to the path if he decides to stray. WALDEN'S PATHS provides an accompanying authoring tool and allows readers of paths to contribute to the path by adding new pages to the path. Furuta and Shipman observed in classroom trials that WALDEN'S PATHS was well received and that teachers would use WALDEN'S PATHS in lieu of textbooks and slide shows [18].

André, Rist, and Müller developed the WEBPERSONA [1]. Given a set of presentation goals, media objects, and temporal constraints, WEBPERSONA uses an intelligent planner to lay out a presentation on the Web. The author provides the goals to be accomplished during the presentation and WEBPERSONA automatically generates and lays out the presentation. An animated life-like character stands to one side and points to relevant cues in each Web page as the presentation progresses. The life-like character is used primarily for playback; some parameters of the presentation can be adjusted by interacting with the character through pull-down menus and sliders. Most of the character's communicative behaviors (gesturing, moving, etc.) are planned out as part of the presentation.

DOCUMENT AVATARS [2][6] provides users with the ability to design a synthetic animated agent with ones own physical likeness. The avatar is attached to a personal Web page and is scripted to play recorded speech, pose, and point to elements within the Web page.

While all the afore mentioned systems can be considered systems that support Social Navigation, the authors are not aware of any other attempts to formalize social navigation or provide a computational framework for social navigation at the time this paper was written.

5. CURRENT STATUS AND FUTURE WORK

The current implementation of the TRAILGUIDE system is little more than a recording and playback system. During recording, the current page URL and any highlighted text is stored so that TRAILGUIDE can find the exact location within the document during playback, regardless of the browser window's dimensions. TRAILGUIDE is implemented in C++ and can monitor and affect the Microsoft Internet Explorer 5.0 Web Browser through its COM interface. The animated avatars are implemented using the Microsoft Agent technology.

No formal evaluations of TRAILGUIDE or the computational model presented in this paper have been performed to date, as work on both is still preliminary. However, we anticipate that studies will show that model reasonably approximates real social navigation strategies and that interaction through the TRAILGUIDE system produces better retention of Web content and better decision-making during browsing than when browsing is performed without. Furthermore, user trials with and without the presence of animated avatars will help us determine how strongly social presence can affect user navigation and user opinions.

Informal observations of people interacting with TRAILGUIDE in playback mode indicate that users expect more dynamic interaction with the animated avatars during their presentation. The next step for TRAILGUIDE is to investigate ways that the personality and background knowledge of the represented author can be captured within his avatar. Such an enhancement will allow the avatar to act more like the author it represents in order create an even stronger sense of social presence. The avatar could also be allowed to improvise and even augment the content of the trail, making social interaction more dynamic, believable, and direct. Providing the animated avatars with greater autonomy, however, runs the risk of overstepping the bounds of the author's original communicative intent so the subject of autonomy must be approached with extreme delicacy.

The social navigation model is also not complete. The use of perceived costs as a decision-making mechanism is currently limited, abstracting away much of personal preferences. The effect of communication medium on cognitive costs of social interaction also requires more in-depth investigation as the current media classification framework only weakly ties together attributes of social interaction and their effects on cognitive costs. Finally, the model of social navigation will be extended to account for behavioral considerations such as reactive planning, and the interleaving of navigational planning and the execution of incomplete browsing strategies.

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