Proximity Based Tools that Make Us Smart

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Abstract
The physicalisation of the information landscape, the fact that people are being more and more mobile in the sense of having constant closeness to the digital information world, and an increased information pressure on people in their everyday life form the starting point for the work that this paper presents. This development concerns the society, both at a technical and a social level. A theoretical platform for studying how people use the environment to become smarter, with its basis in distributed cognition is presented. The paper presents a toolbox with tools aimed to helping people to cope with the increased information pressure. With this toolbox a design space with five dimensions is introduced: access, anchor, proximity, affect, and abstraction.
Keywords
Cognitive Tools, Distributed Cognition, Mobility, Information Overload, Semantic Positioning

I. INTRODUCTION

The information society of today is characterized by high complexity, fast information flows, and a situation where the amount of information increases rapidly. In addition to that, there is an ongoing *physicalisation* of the digital information space that implies a tighter connection between the digital/ virtual world and the physical world. GeoUrl is an example of this, as well as GeoNotes[1–3]. This development increases the risk of *information overload*[4].

The focus of this paper is on how we humans can amplify our ability to cope with and overview the information complexity in everyday life by means of tools that utilize our physical environment and our ability of spatial thinking. One of the goals with this paper is to give an overview of a theoretical platform for studying and understanding how we utilize space and tools to make us smart. Another goal is to introduce a technical platform that makes it possible to answer questions about the consequences of the technical and social changes in our society for our everyday life.

This paper is dived into six sections. Section one is this introduction. The second section gives the background to our work. Section three introduces a theoretical platform. Section four takes a technical perspective and introduces a toolbox with five tools. The fifth section discusses the research issues that we focus on in our work, exemplified with three projects. The last section summarizes and concludes the paper.

II. BACKGROUND

Places have an ability to remind us, and to set us into a mood. Places have meanings that guide our behavior. These meanings can be private or shared with a larger group or the whole society. Humans communicate asynchronously by leaving messages in the public space. We associate places with information and messages, timetables, shop-windows, etc. Locations and places have meaning for the learning process. We use many spatial-based techniques to amplify our cognitive capacity. For example, we put things in front of the outer door in order to remember to take them with us next time we leave the house. We use landmarks to navigate and to orientate. In short, we think with help of our environment.

We have developed a broad spectrum of tools that seem to increase or amplify the cognitive capacity. For example, we use maps to navigate and orientate, we use paper and pen to remember things and to communicate. We have a calendar or diary to remember time-based events. We use a calculator to perform complicated calculations. We use computers to perform more complicated calculations or process data or information. Those cognitive tools can be logical/mental such as principles or rules, physical such as Post-It notes, or virtual such as database systems.

We humans are social beings where the collective plays a central role for how we act and behave[5]. We utilize our conception of the collective and individuals and our self-conception when we make decisions. Knowledge is a social construction, where we collectively unify around a conception of the truth, and this "truth" rules our behavior. Learning in this context is a social process, where we as individuals interact with the environment to create our own conception.

We humans constantly moving between places. Historically, the moving was to a high degree ruled by the supply of food. This foraging behavior has a less central role in today's information society. It is more relevant today to talk about an information foraging behavior[6], when the fact is that information and knowledge rule our behavior. However, we

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are still to a high degree nomadic. We are moving quite easily across the globe. We travel almost every day between the home and the work. Many of us live in suburbs, and we still move between places (across the town) to find cheap and easy food supply. In that perspective, very much in our daily life is about navigation, orientation, avoiding obstacles, etc. Spatial cognition is important to us.

Mobile phones and the Internet are two technical innovations from the 20th century, with a very high impact on the society. The mobile phones made us independent of our location for communication, and the Internet opened up an enormous world of information. However, the access to that world has to a high degree been bound to special locations. What happens now is that these two techniques are merging to a mobile Internet, setting free us from that dependency of special location for accessing the digital information world. This is the next technical revolution that we are in the middle.

From a technical point of view people become more and more mobile, i.e. less bound to specific places for their communication and access to information. From a user point of view, the distance to information shrinks. Positioning people and objects are natural components in this, and it is becoming quite cheap and easy to keep track of people and objects[1] .

The technical and social development in this scenario gives us the possibility and motives to develop location based memory aids, virtual beacons, virtual footprints, asynchronous location-based communication, visual interpretations of social behavior and other systems with a shared feedback loop, etc.

What impact will this development have on our behavior? How can we utilize constant access and closeness to the information space? What consequences may these technical and social changes have on our every day life? In order to answer such questions we need to study such tools and the experience from using them. That also implies a need for: a stable theoretical platform; a technical platform; and techniques and algorithms.

III. THEORETICAL PLATFORM

The aim with this section is to give an overview of a theoretical platform based on contributions from areas that we consider as important when trying to understand how people make cognitive use of the spatial layout of their environment. Hence, theories about human cognition such as distributed cognition and theories dealing with the meaning of location and space are natural components in this platform. This new era of information technology implies that we all more or less will act as knowledge workers in our everyday life. Therefore, it is necessary that the platform includes theories about knowledge work and the need for tools that this new way of live implies.

[1]The penetration of GPS via the 3G mobile phones will be an important factor in this process.

We believe that positioning humans and objects, etc in terms of physical positions, semantics and time is central for the kind of services and tools that need to be developed. Hence, theories and concepts from the area of user modeling such as semantic positioning and matching algorithms are central. Computers and Internet have given us totally new conditions for the way we communicate and interact. For example, it is possible to interact with huge numbers of people over distances in time and space, direct or indirect. UseNet and E-mail exemplifies direct interaction, as well as the Amazon.com with its way of recommending products based on customers' buying behavior, is an example on indirect interaction. We believe that theories concerning this new phenomenon of mass interaction are necessary to include in the platform.

A. Distributed cognition

Distributed cognition was first conceptualized by Hutchins and his co-workers at University of California in 1985. An important difference between Hutchins's study and the traditional study of cognition is that it was done "in the wild", which means in a real environment, not a laboratory environment in which focus is on the mind of one single agent [7].

Distributed cognition is a way of looking at cognition as a distributed phenomenon [8]. It is a system approach to cognition. It emphasizes the distribution of cognitive phenomena over man, machine and environment [9]. It ranges from processes in the brain of a single individual to the interaction in a work team. It can also be applied to a single human interacting with artifacts, a simple example is maybe writing memos on paper.

Most research in the area of distributed cognition has been focused on how tasks are solved in work environments such as cockpits, air traffic control and naval navigation. Lately some focus has been put on how we can study distributed cognition in our everyday life, how we use tools, our environment and space to "become smarter" [10]. All distributed cognition is not distributed between people.

According to Perry [11] recent research has suggested that distributed cognition can be divided into two groups: individually distributed cognition and socially distributed cognition. Perry identifies important differences between socially distributed cognition and individually distributed (Table 1).

B. The meaning of space and location

Space can take many different forms; a room, a country or even the universe are spaces, all of different sizes and contents. How do people normally conceptualize space? What attributes are used to differentiate some spaces from other? Freundschuh and Egenhofer [12] provide a list of different types of space derived from analyzing lots of previous research on the topic of categorizing space. The different categories are based on three attributes:

Table 1. Major differences between IDC and SDC [11]

Features	IDC	SDC
Control	Centralized in the individual's mind	Emergent, arising out of the interaction of multiple actors - no central executive
Tool use	Artifacts are used as cognitive resources	Artifacts are cognitive resources as well as mechanisms for coordinating distributed cognitive resources (i.e. meta-resources)
Cognitive approach	Serial cognitive process	Parallel, distributed process
Investigation and analysis	Quantitative/Experimental or Functional analysis	Qualitative/Interpretative analysis
Focus	Show where representations reside and where rules or processes can be externalized in environmental constraints.	Shows the co-ordination of collaborative activities through an examination of the representations passing between actors.

Manipulation: Is the space amenable to manipulations by a human being?
Requirement of locomotion: Is it necessary to move around to experience the space or can the whole of it be viewed from a fixed position?
Size: The size of the space compared to a well-known thing, such as a house or an ant.

From these three attributes, space can be classified into six different categories, providing, as Freundschuh and Egenhofer claims [12], a framework for how people look at and define different kinds of spaces.
Manipulable object space: spaces smaller than the human body that do not require locomotion to experience them. For example, a small table or a wastebasket.
Non-manipulable object space: spaces that do require locomotion to experience them. These spaces are typically bigger than the human body and smaller than a house. For example, a bed or a car.
Environmental space: Non-manipulable spaces that require locomotion to experience them. The size ranges from inside of houses to cities.
Geographic space: Non-manipulable spaces that cannot be experienced by locomotion since they are too huge. Size ranges from larger-than-cities, such as counties, to the universe.
Panoramic space: Non-manipulable spaces that do not require locomotion to experience them. Small or large. For example, a view in a room, a scenic overlook or a field.
Map space: Non-manipulable spaces that do not require locomotion to experience them. Small or large symbolic representations used to bring a reduced version of spatial information.

Such a categorization is needed to understand how people normally conceptualize space. It also provides, as Freundschuh and Egenhofer [12] further claim, "a theoretical basis for how different spaces might shape and mold the spatial cognitive representations that we create".

C. Cognitive tools

The cognitive artifacts that Norman discusses in *Cognitive Artifacts* [13], are artifacts for operating upon information. To remember how to perform a process, the order of the actions, etc., is an example of a task where cognitive efforts are involved. What is the typical support one would use in a situation like this? We believe that a checklist or a to-do list is the kind of support that most of us would use. The checklist makes it easier to determine which operations to perform. It looks as if the checklist enhances memory.

The question is, does the person perform the same task, with or without the checklist? In some respects it is the same, but in others it is not. The task is changed with respect to the performer of the task: Instead of trying to recall the next operation in the sequence, the person will now focus on finding, reading, and ticking off the next item on the checklist. Some of the performer's abilities are released for other tasks. Norman refers to this way to look at the task as the *personal view*. For someone looking at the task from afar, however, it may look as if the performer performs the same task in both cases, the same job gets done – Norman refers to this way to look at the task as the *system view*. From this point of view, the task is unchanged but in some respects, the use of an artifact affects the outside view, too. Cognitive artifacts can in many cases release cognitive resources, so that the task may be performed faster, with less error, and/or with less anxiety, or the released resources may be utilized for other cognitive tasks.

Norman's concepts of personal and system view of a task identify important aspects of artifacts and cognitive tools – how they work and affect the task and the environment. With the use of artifacts, the character of the task changes (in the personal view), and the changes depend on the artifacts used for the task (using a different artifact to make the task easier would have affected the task in a different way). This is not unique for cognitive artifacts – e.g. a drill changes (the personal view of) the task of making a hole ([14] page 11 discusses more of these aspects).

There are at least two things that distinguish cognitive tools from physical ones. *First*, the character of the objects they are used on. Cognitive tools are used on abstract objects such as data, information, and knowledge. Traditional tools are used on physical objects such as boards and stones. *Second*, the design space for cognitive tools with respect to the medium for implementation is broader than the design space for physical tools. A cognitive tool can be implemented physically (a checklist), mentally (strategies for memorization), and as a computer artifact (a spelling checker), but it is hard to see how a physical tool, could be implemented mentally or be

(completely) computerized.

To conclude, tools in general are artifacts that make our work easier; cognitive tools can be understood as artifacts that in some sense make cognitive work easier. Both Norman's more general definition of cognitive artifacts and Derry's definition of cognitive tools as mental and computational devices that support, guide, and extend the thinking processes of their users [15] – strengthen this view.

D. Mass interaction systems

A mass interaction system consists of an environment in which a number of individual actors share some experience/ phenomenon [16, 17]. Data originating from the actors and their behavior is collected, transformed and fed back into the environment. The defining requirement of mass interaction is that this feedback has some noticeable and interesting effect on the behavior of the individuals and the collective – that something 'emerges' in the interactions between the individuals, the collective, and the shared phenomenon as a result of introducing the feedback mechanism.

The immediate effect may be enhancement of the individual experience – with resulting effects on the individual's behavior, choice of action, and so on. The immediate effect can also be some kind of change in the observed, shared phenomenon. In particular the feedback might effect or establish some kind of collective control. The effect could also involve some kind of organizing and controlling of the collective. 'Organization', in this case, need not imply uniformity and regularity, it could just as well be to diversify or even randomize behaviors.

Systems in which people interact in a shared feedback loop already exist. What is new with this mass interaction approach is a unified view on such systems, or an agenda that seriously addresses the task of *designing* mass interaction. This is made possible and necessary by the new information technology. Computer, communication, and interface technologies crucially change the conditions and possibilities. First, the amount and variety of data that is possible to collect, and the speed of collection increase radically. Second, the new information technology offers completely new possibilities to design and control the feedback function and thus ultimately the behavior of such systems. Third, the feedback loops can be speeded up many orders of magnitude to match the 'natural' time scales of individual and collective behavior, thus also making the existence and importance of such systems more easily recognizable. Fourth, in this new time scale, with these new capabilities, there are great opportunities as well as possible hazards that we so far only can guess.

E. Semantic positioning

Semantic positioning concerns the task of extracting and categorizing the content of information objects in order to create applications aimed to match users' interests and information objects, e.g. filtering tools, guiding tools, decision support etc. For that kind of applications able to reflect the user's way of categorizing information, we must create models that describe the individuals' interest, experience and values. An individual's interest or personal profile is many-faceted, and a model must catch this. An individual can be described with demographic information (gender, age, ethnicity, home address, etc). This gives a rather poor view of a person, and it is very hard to say anything about the person's interests. On the other hand the books in a person's bookshelf and the documents in the bookmark list in a person's web browser can give a lot of information about interests and values. In the same way, personal documents, notes, diaries, bloggs etc are in some sense an externalization of the individual's views and values, and can be used to model personal values, experience, etc.

There are costs to build and administrate user models; much of these costs are related to the quality of the model. There is also a relation between the quality of the model and what kind of application that it allows, and vice versa. The quality is very much a matter of covering and depth in the model [18]. There are many techniques to collect data about persons and their interests: interviews, questionnaires, explicit or implicit logging or sharing of information, etc. There are pros and cons with all these techniques. E.g. questionnaires are rather static and it is hard to change categories in the questionnaire once the form is used. On the other hand, corpus-based techniques are fuzzy and do not suit demographic data [19, 20].

IV. THE TOOLBOX

Umeå Centre for Interaction Technology (UCIT) at Umeå University and especially the Cognitive Computing Lab (CCL) [14, 21–25] has a tradition in the field of cognitive tools with both theoretical work as well as empirical work with field studies and software development. Much of this work has been focused on learning tools and knowledge work. When we move the focus to everyday life in the new era of information technology that we are entering, we are all more or less becoming knowledge workers, and we have the need for same kind of tools as learners or professionals. Managing and overviewing situations with a high degree of complexity in the information flow are basic needs. The tools in our toolbox can be divided into two groups: *dynamic maps* (Overview and K-map) and *proximity-based tools* (Information Radar, Virtual Scribble Boards, and Notifier).

The aim with this section is to discuss the toolbox in terms of how they give access to the information space, the way they make abstractions, the way they affect the information space, how they anchor actions/events/information in the environment, and if they are proximity-based.

Overview is a system that supports the users to make logistic decision in complex environments, and the users affect the environment indirectly in the way they act. The idea is to

capture, analyze and display how people act, move and where people are, i.e. to serve the users with an abstraction of the current situation in the form of maps. The historical perspective is central in this kind of application. For example, the long-term patterns how people move, where the bottlenecks are, where people stop, etc. We work both with anonymous and discernible data. *Overview* gives access to status[2] information of the environment. Both public (large wall-mounted displays, see Figure 1) and private displays (PDAs) are used. The idea is to connect multiple data streams (individuals' position, personal profile, etc). The input for the analysis in the first version developed for the NOLIA fair 2003, was a video stream from a camera mounted under the ceiling.

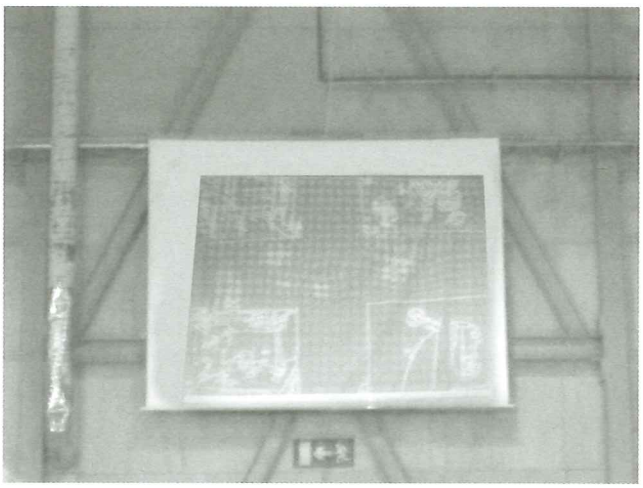

Figure 1. A wall-mounted display, showing density and flow on a fair floor

K-Map is a client that makes a personal visualization of the information landscape (located information objects). The visualization is based on a user's interests and how relevant information objects are. That means that it constructs abstract maps over the information landscape as overlays on ordinary geographical maps. The tool gives a user access to an overview of the information landscape in the vicinity. The *K-Map* client is implemented on a PDA platform. We work with transparency of objects to express the relevance, and color schemes to express different fields of interests. In the same sense that the *Overview* tool affects the information landscape indirectly from the way users act, a *K-Map* user can also do that (by adding, deleting, or modifying objects).

Information radar is a personal tool scanning the information landscape in the vicinity for relevant information objects, like the radar searches a physical area to find objects. The client reports the objects that it discovers and their relevance to an individual's profiles, in a list. This list gives a very abstract view of the information landscape that can be used to access the objects. The client gives another way to access the information object, via its alert function where sound and/or vibration signals are used to make the user aware of interesting objects in the near [26].

Virtual Scribble Boards (VSB) is an asynchronous communication channel where the virtual messages are associated with places like rock carvings, scribble on walls, advertising pillars, etc or objects such as a certain individual, another information object, cars, etc. The client makes it possible to anchor messages at places, on people and information objects; the information landscape is affected in a very direct way. Users have access to their own messages but also messages that the producer are willing to share with others [26].

Notifier is an agenda-based tool, which extends the possibility for the users to anchor activities to persons and kinds of persons, and places and kinds of places. The purpose is to support the user with reminders based on the situation (the objects, information, persons, etc that are nearby in a wide meaning). There is a close relation between *Notifier* and *VSB*. Both tools affect the information landscape directly by putting notes anchored in the environment. Both tools give the user an abstract view of parts of the information landscape in form of lists.

V. DISCUSSIONS

The overall question that we have for our research is: what are the consequences and possibilities of the ongoing technical and social changes in our western society on everyday life? What impact has it on our behavior? How can we utilize constant access and closeness to the information space? We have designed and implemented a technical platform that gives us possibilities to study these questions, as well as the very techniques that make this development possible.

Most of our efforts up to today have been on design and development of the technical platform. Part of this platform is the toolbox spanning a five-dimensional design space that we are exploring (Table 2). We have conducted some field studies: Find-Them, Overview, and Located at the NOLIA fair 2003 [27], and a mobile blogging project at the Jokkmokk winter market [28].

Table 2. The basic characteristics of the toolbox

Characteristics	Tool				
	Overview	K-map	Info-Radar	VSB	Notifier
Abstraction	Map	Map	List	List	To-do list
Access	Status	Overview	Direct	Direct	Direct
Proximity	-	-	Relevance	Identity	Situation
Affect	Indirect	Indirect	Indirect	Direct	Direct
Anchor	-	-	-	Location Object Person	Location Object Person Situation

Find-Them is a system for directed information streams over an SMS-channel. Find-Them is a broker system on a fair, where

[2]Depending of the data/input

we utilize a database, with user profiles to direct offers from the exhibitors to small groups of visitors. There were about 2000 test pilots (visitors) in the database and about forty exhibitors were involved in the test[3]. *Overview* is a demonstrator of an emergent interaction system, (see the description of the system above). *Located* – the aim with this project was to test and demonstrate some of the basic concepts (the physicalisation of the digital world) we are working with at a big fair in Umeå. We made demonstrations of location-based applications (with some early prototypes of Information Radar and VSB). *Jokkmokk blogg* – we ran a mobile blogg project[4] during the 399th Sámi winter market in Jokkmokk, February 2004. The focus for the project was on the shared feedback loop that is in a blogg, and how this concept can be used to give a feeling of presence over distance. During the market days we had approximately 700 distance visitors to the market each day mainly from Sweden but also from Australia, England, USA, etc.

Our research has now turned into a more empirical phase, and the aim with this section is to introduce the research issues and activities that we are currently working with. Very much of the activities are focused on exploring the design space in Table 1. *Access* is about who should have access to the information and how it can be customized to a personal view of the information landscape. Hence, traditional filtering and retrieving, where modeling and matching users' interests are central issues. *Abstraction* is a matter of presenting understandable views of the information landscape; views useful to make decisions regarding, e.g. navigation, orientation, etc. We believe that the historical perspective, where you can see trends, and a relevance perspective, are important components, as well as the personalization of the view. Another issue is the minimalization of the user interface where we must focus on situation and modality. *Anchor* concerns how to connect the mental, the virtual, and the physical. Methods for describing, modeling and matching entities such as activities, intentions, situations, etc. Another line of research is how humans use the environment to anchor information, and what it is that rules our everyday logistics, i.e. why one is at a specific location at a specific time. *Affect* is about how one can affect the environment, directly or indirectly. The direct way is very much a technical issue, where system design must be in focus. For the indirect way of affecting the information space, group behavior, privacy, integrity, etc. are central issues to study. *Proximity* is about distance and how we measure distance in different situations. Proximity concepts other than physical distance, e.g. how relevant an information object is, how close in a semantic sense objects, situations, activities, etc are depend on the way one models interest and the information space.

VI. CONCLUSION AND FUTURE WORK

The basic purpose in this early phase of the empirical studies with relevance for all five prototypes is to explore the potential for this kind of social information systems, and what kinds of applications are acceptable and not. It is too early to have any real results from this research, but we have knowledge and experience from this early phase to report.

First of all, the kind of tools that we foresee a need for is possible to build. The basic techniques (PDAs, GPS, Wireless datacommunication, etc.) that make this possible are here. Of course, there are many problems to overcome at a technical level. The accuracy in the positioning system can be a problem. The delay in the positioning system when moving from indoor to outdoors, it can take long time to get contact with the GPS-satellites. The lack of a positioning system for indoors use that covers more than small isolated areas. The weather conditions, is too cold, too sunny, or does it rain? The mobile platforms (PDAs, tablet PCs or mobile phones) are very sensitive for outdoor use. To test the use of the kind of applications for everyday use where proximity, anchoring and notifying are central demands quite large group of users, which can be hard to find.

Even if there are many problems to overcome there are many indications from our demonstrations and tests that support our vision and approach. Both sides of the FIND-THEM application, customers and exhibitioners have positive reactions on the potential with the concept of directed offerings [27]. The mobile bloggers at the Sámi winter market in Jokkmokk had the same positive reactions, despite the hard weather conditions. Even the first test with *physical web browsing* at the Nolia fair collected many positive reactions that point out the potential for the Information Radar application.

[3]There are about 130000 visitors during the nine days that the fair lasts, and about 950 exhibitors.

[4]This was a joint project between UCIT and Humlab at Umeå University.

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