Proceedings of the First Danish Human-Computer Interaction Research Symposium

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Edited by

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Preface

The First Danish Human-Computer Interaction Research Symposium has been realised as a joint effort between sigchi.dk and Centre for Human-Machine Interaction. The primary motivation for this effort has been to stimulate networking and to create an overview of recent Danish HCI research. It is the hope that the symposium will become a recurring event

The present proceedings consist of the 25 extended abstracts accepted for the symposium, presenting a very broad range of work, characteristic for Danish HCI research. In addition, participants in the doctoral colloquium held the day before the symposium have been given the opportunity to have their thesis (in progress) summaries published in these proceedings. Three of them have done so. We would like to thank the contributors.

The symposium has been organised by Olav W. Bertelsen, Susanne Bødker, Torkil Clemmensen, Klaus Marius Hansen, Marianne Dammand Iversen, Christina Nielsen and Michael Thomsen.

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Aarhus, November 2001

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User requirements for personalized virtual agents in e-commerce

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Abstract

Interactive Internet services grows very rapidly. This growth has led to both a constantly increasing number of modern Web sites, and to an increase in their functionality, which, in turn, makes them more complicated to use. Thus, any attempt to enhance the consumer-supplier relationship in e-commerce has to meet the challenge of coping with two almost contradictory goals: A useful e-commerce application should not only mimic traditional catalogues, order forms and other printed material which used to be the basis of communication between consumers and suppliers, instead, the inherent potential for interactive data processing and human-machine dialogue should be used by e-commerce applications to meet the user's need for immediate situation-specific response, instantly available problem-specific advice, and better ways to access and inspect the supplier's offer. The solution suggested in the COGITO (e-commerce with guiding agents based on personalized interaction tools) project is based on "personalized agents" which represent virtual assistants or advisors (also visually) by modeling their ability to support customers.

The role of Risø in the COGITO project has been to establish a set of user requirements for the development of such an agent (Andersen et al 2001). The methodological approach applied in our exploratory study has mainly followed the principles and concepts offered by the Cognitive Systems Engineering (CSE) approach developed at Risø National Laboratory (Rasmussen et al, 1994). It allows the analyst to analyze a system in terms of means-ends relationships. We have analyzed the user requirements in three levels: strategic, procedural and operational. The data collection was carried out in "interviewing while doing" sessions, where we exposed respondents to agents on the Internet. In these sessions we focused on eliciting general e-commerce problems and agent use requirements.

Eight subjects took part in these sessions. We first gave them an introduction to the test and then we tried interviewing while doing to let them get familiar with this approach. We then went on to the actual tests giving the subjects a number tasks to solve on three web-sites (two of these contained virtual chatterbot like agents). Finally, we gave them a short questionnaire. The length of the sessions varied from 1-2 hours. Two weeks later we met with the eight subjects again this time for a focus group discussion. Here we discussed general e-commerce problems, the agent appearance and in particular the agent use problems and requirements. We also carried through a word association test related to the visual appearance of virtual agents. During the analysis we transcribed the video tapes and categorized user requirements in terms of means-ends relationships.

Based on the word association test we analyzed the subject's expression in three categories - positive, negative and neutral. On the basis of the analyses mentioned we have established a list of operational, procedural and strategical user requirements and a set of recommendations for the visual appearance of a virtual personalized agent. Below is a very brief discussion of the most important strategic requirement.

Trustworthiness. The most important requirement for a customer/supplier relation - be it via a web-site or in any other form - is trust. Trust that information given by the customer will be treated in a confidential and decent way and not be misused in any way, trust about fulfillment of agreements and about the quality of purchased products, and trust concerning treatment of information related to credit cards and accounts.

Mediation. A very important point related to mediation is the confidence the customer feels in the agent. This confidence reflects as well the direct appearance of the agent, how the agent conforms to the context in which he/she is placed, as the functionality of the agent concerning a natural conversation and the professional knowledge.

Seriousness/reliability. The respondents expressed very explicitly that the agent should be serious and reliable if he should prove useful to them. The seriousness applies to both the form of the agent represented by his appearance and the contents of the agent represented by the agent's abilities and knowledge.

Flexibility/tailorability. The respondents stressed the need for flexibility of the abilities of the agent. This means that the agent must be able to support various search strategies allowing users to seek and retrieve information in several ways. The agent should also provide conventional navigation and search alternatives for instance by providing access to menus or by assuming the function of a search machine allowing the users to search in single words or phrases, use truncation, similarity search etc. according to their preferences

Value added services/surprise me. The respondents all expressed a wish for value added services on the web-site. Value added means services or products that provide an extra, possibly not foreseen value or experience to the user, something that surprise the user in a positive way and thereby enhance the quality of the site.

Entertainment by the agent was discussed among the participants and this topic seems to be a very delicate problem. On one side entertainment could be valuable for increasing the interest in the site, intensify the communication, and even increase impulsive purchase. On the other hand the risk of tiring or offending people may be very high.

The word association test showed that the agents that received the most negative response were judged to be very weird, artificial, and silly. These were based on computer generated visualizations. If we look at the number of words expressed and the positive value of the words attached to each agent there was a preference for a of a photo of a human being.

Acknowledgements

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Maritime Instruments as Media: a Theme in the Elastic Systems Project, Center for Human Machine Interaction

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In safety critical domains, such as the maritime domain, maintenance of *situation awareness* is important. This can be achieved by enforcing *verbalization*: the crew must say what they are doing. The two examples below illustrate how the norm of verbalization is enforced in practice.

D	Nu på nul nine nul
C	Nul nine nul ja det siger han ikke noget om
D	Nej, det kan være vi skal bede ham om det
C	ja
	(P)
D	When you infor... when you changed the course (...), inform (...) just tell me which course you go to please ()
L	Okay
D	Thank you very much

C	og så synger du lige ud K, når du er på den nye nye kurs ikke, (...) når den er der over, så siger du one one five, når den er der, så ved vi, så ved vi at den er der
K	Det sagde jeg også sidste gang
C	Nå, jeg hørte det bare ikke

This means that maritime instruments are not only tools for controlling the ship; together with verbal communication, they must also contribute to maintaining the situation awareness of the crew. In short: they must also be able to function as media.

Introduction of integrated computerized bridges presents problems for maintenance of situation awareness since the same signal is used by many instruments: “How can we know what is left if the GPS falls out?”.

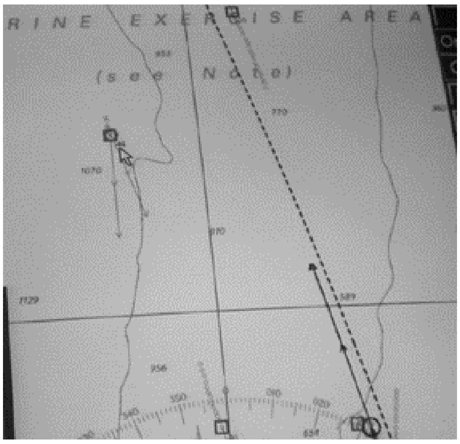
A main reason for this is the tradition of information-hiding or encapsulation. It is assumed that the user needs not know most of the processes taking place inside the system. This assumption is perfectly reasonable in “safe” applications, such as office applications, but needs revision in safety-critical areas.

In such areas, it is important that users can understand what goes on in the system, if they are to maintain situation awareness, e.g. in fault situations.

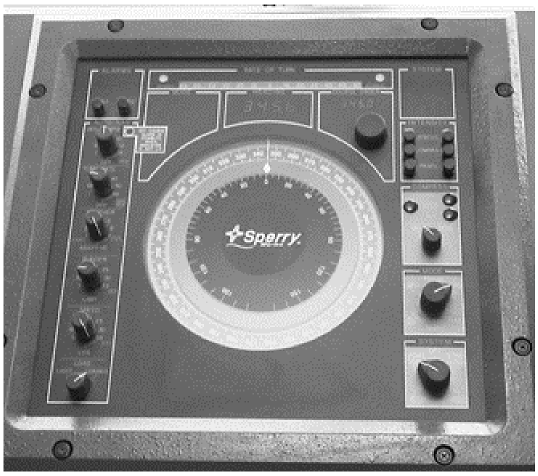
It is therefore interesting to look for principles that will enhance the users’ opportunities to understand what goes on under the “hood” of complex machinery. One such principle could be to principle of “peeking”:

Peeking: the user should have access to the way higher level components act upon lower level components.

The VMS system and the autopilot exemplify this principle. The course orders sent from the higher level VMS system to the autopilot are of the same kind as those which the officer himself can enter into the autopilot, and they are displayed in the same place.



VMS system



Autopilot

This enables the officer to understand and evaluate the performance of the VMS system in relation to his own performance when using the autopilot alone. This again enables him to discover errors and sub-optimal performance in the VMS system.

Common information spaces

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Common information spaces are often, implicitly or explicitly, viewed as something that can be accessed *in toto* from one (of many) location. During the past years we have been engaged in two fieldstudies, one of a wastewater treatment plant, and one of a usability design group. We have conducted workplace studies, and we apply an interventionist approach through the construction of prototypes for new computer support.

Our empirical studies show how such massively distributed spaces challenge many of the ways that CSCW view common information spaces. The studies fundamentally challenge the idea that common information spaces are about access to everything, everywhere. Both studies look at information spaces that are embedded in a dispersed physical spaces, not detached from this, and the studies point out that people zoom with their feet, that by moving around e.g. a wastewater plant, they know where they are and what information they need there. Furthermore the studies looks at learning as deeply intertwined with the action radius in the physical and information space.

At the same time as the studies challenge the idea that user interfaces for small or large devises are plainly shrunken or enlarged copies of PC interfaces and the studies show how alternative post-WIMP interaction styles are more suited for accessing common information spaces and for augmenting the physical space with such information spaces. We have worked with both small, mobile interfaces on palmtops, and with ubiquetous technologies and large screens, and with combinations of such. The emphasis on the intertwined physical and information space is maintained through our focus on augmented reality, where the technology is primarily developed to augment the capabilities of objects and environments.

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Using the Concept of Augmented Reality as a Vehicle for Transcending the Desktop Tarpit

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Established concepts in desktop computing generally do not scale to interaction with small mobile interfaces and trying to use them indiscriminately of the fact that these interface paradigms were in fact developed for a different technology with very different properties will very likely result in design that does not take advantage of the possibilities of in the mobile device/technology. In particular, the concept of direct manipulation that historically has served as the main vehicle for understanding the graphical workstation seems problematic due to the tight coupling to the desktop metaphor, the workstation concept, and a strong focus on information access.

We explore novel interface principles for small mobile devices derived from the concept of augmented reality interfaces.

Augmented reality is an approach to information systems design augmenting physical objects instead of replacing or representing them by purely computer based systems. The argument is that non-computer based artefacts in the workplace often mediate work in subtle ways that are impossible to transfer to new computer based artefacts. Mackay (1998) introduces augmented reality as a classification of three technical approaches to design of interactive devices, spanning a continuum of technical substrates for mixed environments: augmenting the user, the physical object and the environment. These strategies describe the technical locus of the interface assuming the analytical separation of function and interaction in the computer artefact.

However, the way we have employed the concept of augmented reality is as a tool for divergent thinking, a kind of metaphor or springboard. By definition, the concept of augmented reality cannot be applied to small mobile devices; thus we have abstracted defining features from the three directions in augmented reality interfaces and applied them in the different technical setting. Subsequently, the principles have been further investigated through future scenarios of PDA support for wastewater treatment work built on the augmented reality classification transformed to small mobile interfaces.

We developed future scenarios for wastewater treatment work with PDA applications developed by using the technical classification of augmented reality interfaces as a thinking tool. The applications in these scenarios were designed for a standard PDA extended with a bar code reader and a modem for a cellular telephone. Thus, we emphasised solutions that could be implemented with limited resources today. Our future scenarios address some of the specifics of wastewater treatment work: the distributedness, the number of different component the workers have to deal with, the wired wilderness enabling most of the designs.

Using the concept of augmentation and the classification of augmented reality interfaces as a thinking tool has given us several advantages. Using the augmented reality principles as thinking tools sparked our imagination and at the same time steered us clear of pure science fiction.

Initially, the concept "augmented reality" seemed to be impossible to apply in PDA design; it seemed that a PDA application would always end up being based on the "augmenting the user" class of interfaces. This apparent impossibility turned out to be an important source of creativity. This technique is generally applicable. That is, when established design principles impose tunnel vision on designers, proceed by selecting technical concepts that obviously not fit the design problem, and then structuring the new solutions according to the misfit concepts.

Focussing on interaction with physical objects in the work setting has provided us with specific boundaries to work within and thus became an effective guide in deciding what to include in each of the PDA applications. Thus, the concepts of augmented reality worked as a tool for handling the context problem. Most of the information and control made accessible with the suggested PDA applications is present in the existing process control system. The strong focus on interaction with physical objects around the plant, however, helped in specifying actual physical and situational context for the applications in the future scenarios.

Through the construction of future work scenarios, the three different strategies of augmenting the user the object and the environment enabled us to transcend the image of interaction with a PDA as the users introvert fiddling with his little pen on his personal four square inch pad. A broader range of physical postures in interaction with a PDA emerged: hand waving, writing, walking around, etc. In this way we change the concept of augmented reality from being a classification of interface technology into an interaction style concept independent of the concrete technical substrate of implementation.

Direct manipulation as a general user interface principle falls short in relation to mobile devices. In particular the lack of screen space inhibits detailed representation of the object of work at the screen. Basing PDA design on concepts of augmented reality interfaces forced us to think beyond direct manipulation; requirement to representations of the object of work on the screen is very different when it is also present physically in the situation of work. However, the more general principles underlying direct manipulation interfaces, e.g. directness and transparency, apply nicely for mobile devices just as well as for full-fledged augmented reality systems.

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Creating and Styling Fluid Annotations on Third-Party Web Pages

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Introduction

Since the introduction of the Web, several annotation systems have been developed, i.e. systems that allow the user to comment on a (subset of a) Web page and possibly share this annotation with other users. One problem with these systems is that the annotations themselves will either permanently disrupt the layout of the page (by inserting text) or obscure part of the page (by using e.g. popup windows). The work described herein attempts to address this by dynamically displaying and hiding annotations using fluid typographical animations; the system thus provides availability of the annotations without sacrificing appearance of the original document. A complication introduced with this technology is distinguishing between primary (the original Web page) and secondary (the annotation) material, which the reader preferably should be able to do reliably.

Figure 1 - Fluid annotations in use. In this example, a story on a newspaper Web site has been annotated with information about a Danish politician. The annotation is visually differentiated from ordinary links. Upon activation, the annotation appears in a smooth animation, pushing the remaining text on the page down. The annotation can be left open or closed (smoothly animated) according to the user's wishes.

Fluid Annotations on the Web

Fluid annotations 5 use animated typographical changes to provide a novel and appealing user experience for hypertext browsing and for viewing document annotations in context. Hitherto, fluid annotations have been restricted to monolithic hypermedia research prototypes 4. Recently, the Arakne Environment 1, a collaborative open hypermedia system, has been extended to provide fluid annotations on Web pages 3. This is achieved through the integration with a Web browser, so that links, fluid annotations, and other hypermedia structures are inserted into Web pages, as they are displayed on a user's screen. These links and annotations can be collaboratively authored or shared among users through interchange files.

Authoring and Styling Fluid Annotations

The basic authoring of a fluid annotation is quite simple. The user makes a text selection on a Web page as an anchor, presses a button in the Arakne Environment and starts writing. The systems featuring fluid annotations have been very presentation oriented, and this implementation is no exception. Fluid annotations are behaviourally quite different from ordinary links, so users of the system should be able to clearly differentiate between fluid annotations and other kinds of content on a Web page. Furthermore, Web pages vary tremendously in layout, and the presentation of a fluid annotation must also address this. To accommodate this differentiation, the creator of an annotation can specify the type of annotation animation, the typographical appearance of the anchor and the annotation text, as well as how or when the annotation should be actuated. Once defined, a style (or 'presentation specification') can be applied to other annotations. One of the ongoing UI challenges of the system is balancing simplicity with the ability to specify sophisticated typographical changes. The work by Weinreich *et al.* 2 illustrates the plethora of styling possibilities, and fitting variety of choice in an interface is difficult. An example of a fluid annotation can be seen in Figure 1, which illustrates how an annotation may be differentiated from ordinary links.

Conclusions

The Arakne Environment demonstrates the viability of fluid animated annotations on the Web. By integrating themselves onto the Web page and only appearing on demand, annotations are discreet while easily accessible. Future work will explore the presentation of many annotations by multiple authors, and more closely integrate the authoring into the Web browser.

Acknowledgements

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An Activity Theory Approach to Affordance

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In 1966 Gibson introduced the term "affordance" to denote the relation between the organism and its environment in a pragmatic sense. Somewhat later Norman (1988) introduced the term and the concept to the HCI community in order to focus attention of designers on certain necessary aspects of interfaces. The term has since become a buzzword used by almost anybody to describe anything ... and is in risk of losing contents altogether.

We would like to present an analysis of the concept of affordance as it was originally introduces by Gibson, and elaborate on this concept, acknowledging, that the general theoretical landscape in psychology is in fundamental ways different from the situation in which Gibson found himself. Specifically we will suggest the inclusion of the ecological theory of perception in the paradigm of activity theory and cultural historical psychology developed in the former Soviet Union by figures like most notably Lev Vygotsky, A. N. Leont'ev, N. A. Bernstein and others. It will be suggested, that much of the confusion in HCI concerning the concept of affordance is a consequence of the attempt of using it inside a theoretical paradigm that is unable to capture and encompass one of the most essential aspect of Gibsons concept of affordance, that is its foundation in activity. Current mainstream cognitive psychology as it is used in much of the HCI literature is - often implicitly - still subject to the abstractions stemming from behaviorism, which precludes a correct understanding of the concept of affordance.

The Concept of Affordance

Affordance was introduces by Gibson in the following manner: "The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. The verb to afford is found in the dictionary, but the noun affordance is not. I have made it up. I mean by it something that refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment." (G. 1986, p. 127).

Thus the complementarity and interaction of organism and environment is a very important characteristic of Gibsons theory, that differentiates ecological psychology from main stream cognitivist thinking. Dualism is out from the beginning.

"An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behavior. It is both physical and psychical, yet neither. An affordance points both ways, to the environment, and to the observer." (G. 1986, p. 129).

It is evident form these citations, that affordances are in the interaction between organism and objects in the environment. It is equally an important fact of the ecological approach, that the basis for perception of affordances is the temporally extended perceptual activity, that affordances are signaled by invariants in the various ambient arrays of stimulus information across transformations, and consequently that perception is not based on the momentary sensory input, but on the continuous activity of the perceptual systems.

The conclusion is that the use of ecological theory of perception can only be productive if the step is taken from Stimulus -> Response theory to Subject - Activity - Object theory where activity is the basis and the fundamental unity of analysis. Perception must be understood as perceptual activity.

The main obstacle to extended application of the principles of ecological approach to perception arise from an undifferentiated concept of activity. This factor makes it difficult and nontrivial to address areas of research like HCI that have substantial cultural, symbolic and technological components of a cultural - historical origin. This makes it impossible to understand direct perception as having an evolutionary biological explanation.

Natural and cultural historical activity

In natural objects the affordances are unintended functional consequences of the physical properties of objects, substances and processes in the environment. The evolution of species are the evolution of specific adaptations to properties of econiches. The ontogenetic development of individuals adapt functional systems to specific details in species specific econiches (habitats) -parameter justification.

In artifacts the affordances are produced intentionally and are specifically designed for inclusion in cultural-historical forms of practice. The cultural - historical forms of practice are artificial habitats. The ontogenetic development of individuals adapt functional systems to specific details in these artificial habitats.

The fundamental difference is the nature of the "econiches" in which the adaptation takes place. The ability to adapt to historically changing environments is dependent on specific details of human activity and the human brain.

Learning to perceive affordances of artefacts (cultural-historical products) is a process proceeding in principally the same way as the learning of perception of natural objects, apart from two details

- it takes place in a cullturally-historically modified environment and specifically includes man-made objects (incl. symbols) with intentionally specified affordances in the activity process
- the synthetic component plays the dominant role in the development of functional brain organs

Consequences for user interfaces, hci, mmi etc.

The application of the concept of affordances to problems in HCI will only succeed, if artefacts, technologies, and their knowledgeable users are seen in their actual interdependency and co-existence in processes of activity, ultimately as abstract moments in societal forms of praxis. This necessitates an integration of insights from activity theory and cultural historical psychology with ecological psychology.

Consequently, the concept of affordances can be used appropriately in HCI design only provided the design is based on a proper knowledge of the particular activities and "econiches" in which the affordances originates and functions.

Computer applications as mediators of design and use - a developmental perspective

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I present an understanding of computers as the materials that we shape in design, on the one hand, and the artifacts that we use, in work and other everyday activities on the other. My work is primarily methodological and design-oriented, i.e. it is concerned with changing computer applications, and with understanding them as changing and as part of change.

I base my work on the ideas that human use of technology develops, and that we cannot design the future totally – use as well as design is an ongoing learning process. I have chosen as an overriding perspective that of learning or development in and of use. Seen from the perspective of the clay of computing, the materials of computer scientists, this is an understanding of computer applications in their ongoing transformation in human activity, i.e. in use, in design, and between the two. Learning, I take to mean more than just adaptation to technology. It is a matter of development, change, or even expansion of practice of communities in cooperation between participants, struggling with the particular material and cultural conditions of the activity.

With this conceptual framework we get at better understanding of how development in design and use can be supported by the computer artifact. The framework further points out how the mediational role of the computer application is multi-layered and pertaining to all activities in the web of design and use of a particular technology. The work shows, through a number of specific empirical cases, how use and design transform or develop the computer artifact, at the same time as the artifact constrains or disciplines use as well as design. It develops a theoretical framing of our understanding of these processes, and consequently a methodological basis for the development of computer applications, for transforming computer artifacts as materials into computer artifacts as instruments of use. The framework as well as the large number of design techniques are themselves design artifacts.

Listen, Kids - A Sound Lab for Children

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A Sound Lab concept has been developed to provide children with an intuitive and tangible way of working with digital sound. The Sound Lab consists of three elements: A ``Sound Microscope'', ``Sound Manipulators'' and a ``Sound-producing Carpet''.

The ``Sound Microscope'' isolates, amplifies and records sounds created by scratching a hand, stiring LEGO bricks or beating on pots and pans.

The ``Sound Manipulators'' control transformations of a digital sound. Sound Manipulators are different physical objects that interface to sound transformation algorithms. Through shape, texture and material each Sound Manipulator expresses the kind of sound transformation it controls. Actions like squeezing, touching or pushing a Sound Manipulator transform a particular digital sound in real time. The transformation may change, for example, a sound of running water from a continuous flow into a granular, rhythmic pattern; from the original water sound to a melodic sound where the 'notes' of the water sound are enhanced; or from a distant, airy water to a close underwater sound.

On the ``Sound-producing Carpet'' rolling, walking or dancing starts and stops sounds mapped to different sensitive areas of a carpet.

The three elements of the Sound Lab can be used by children to create a soundscape that surrounds them when they move on the carpet, for example a soundscape of underwater sounds or traffic sounds. Sounds can be mapped to a labyrinthine layout on the carpet and the sound sequences activated when they move in different directions on the carpet may tell different stories of fear, joy or relief. A group of children can use musical sounds mapped to the carpet to improvise and experience musical composition.

The goal of the Sound Lab development has been to make children use all their skills when they work with digital sound. With their perceptual-motor skills they can perceive sounds with their ears and eyes when they act with their hands on the materials in the Sound Microscope; when they handle the physical Sound Manipulators; and when they move around on the Sound-producing Carpet.

They can use their cognitive skills to put descriptive labels on the sounds they discover, the manipulated sounds and the sound composition they create.

Through a playing exploration of digital sound children may have an emotional experience of fun, involvement and beauty.

Sound Lab as Prototypes and Mock-ups.

The prototype Sound Microscope is a Plexiglas box containing a microphone connected to speakers through a computer.

Mock-ups of Sound Manipulators. The corresponding sound transformations have been implemented in the sound tool MAX-MSP on a Power Mac.

The prototype Sound-producing Carpet is a rectangular carpet with eight consecutive touch sensitive areas.

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Textile designer who graduated from Kolding Designskole. After graduation she has concentrated on the production of textiles and scenography, costumes and textile art using three-dimensional surfaces, and on designing multimedia installations.

Rasmus B. Lunding (ras.blund@get2.net.dk)

Has many years of experience working with music and sound. Has played as a soloist and in groups, has published two solo CDs as well as touring and presenting compositions at an international level. Rasmus B. Lunding has worked on the development of educational projects on IT and children and has developed scenarios of sound to research projects.

Ole Caprani (ocaprani@daimi.au.dk)

Computer Scientist. Has used LEGO robots in teaching at all levels from school children to university students, has designed and programmed a sound synthesizer for LEGO robots controlled by LEGO MindStorms RCX so that they can use sound effects or play melodies when they move or dance.

HCI fællesskabets viden – rapport fra en igangværende undersøgelse af HCI praksis i DK

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I denne præsentation rapporter vi fra en igangværende undersøgelse af HCI praksis i Danmark, hvor medlemmer af et dansk HCI-fællesskab af praktikere og forskere (sigchi.dk) har besvaret spørgsmål om deres uddannelse, interesse for teori samt kendskab til metoder. Motivationen for undersøgelsen er at internationalt set synes HCI fællesskabets viden at være fragmenteret, idet der højst findes en to-tre artikler om hvert emne [1], samt oversvømmet af importerede teorier og metoder fra andre discipliner i et omfang, der forhindrer en naturlig integration af forskningens produkter i praksis [2]. Samtidig har det vist sig at anvendelsen af velkendte metoder - såsom tænke-højt test og kognitiv gennemgang - er betydelig mere problematisk end tidligere antaget, måske fordi der sjældent foreligger tilstrækkelige beskrivelser af brugerne ved brug af metoderne [3].

Problemet med den manglende teoretiske fokusering er flersidigt. Dels er det svært for forskere at bygge videre på andres arbejde og dels er det svært for praktikere at anvende de indsigter som forskningen producerer. Sidstnævnte kan forstås som et teknologi-overførsels problem: hvordan bringes indsigter, teori, metoder etc. fra forskningen til anvendelse i HCI praksis? En løsning er at udvikle et fælles sprog for forskere og designere, der for eksempel kan tænkes som en omskrivning af en teori-ramme til et design redskab [2]. En anden løsning er at fokusere på ”reference opgaver”, d.v.s. typiske bruger opgaver, som forskningen så kan opbygge en viden om og derudfra give råd til praktikere [1]. Begrundelsen for begge løsningsforslag kan kritiseres, dels for en manglende analytisk og empirisk afgrænsning af hvad der udgør HCI fællesskabet, dels for en tilsvarende manglende forankring af påstanden om at praktikere ikke med fordel anvender forskningens produkter. Derfor forholder vi os i dette projekt undersøgende og analyserende til hvordan HCI fællesskabet (i Danmark) afgrænses og hvordan praktikere indenfor dette fællesskab anvender forskningens produkter.

Vores tilgang kan ses som et forsøg på at bidrage til det område indenfor HCI/CSCW der p.t. kaldes Community Knowledge [4] og hvor konstruktion og håndtering af viden studeres med henblik på at understøtte udvikling af konkrete fællesskabers viden. Fra et mere praktisk synspunkt vil vi gerne bidrage til videreudviklingen af et dansk HCI fællesskab, der kan tjene som en vidensmæssig ressource ved anvendelsen af usability tests m.v. i danske virksomheder.

I første omgang er det hensigten at skabe et rimeligt overblik over hvem i DK der arbejder med HCI, ved at gennemføre en spørgeskemaundersøgelse blandt medlemmerne af en dansk forening for alle HCI interesserede. Skemaet indeholder 16 hovedspørgsmål, der består af likert scale lignende, multiple choice og åbne spørgsmål. Spørgsmålene falder indholdsmæssigt i fire grupper: demografiske oplysninger, identifikation af eget HCI arbejde og aftagerne af det, interesse for og engagement i teori og metode, samt holdninger til HCI specialist rollen. I spørgsmålene om interesse for teori og metode tager vi udgangspunkt i en historisk analyse af udviklingen af HCI teori [2], samt i vores egen gennemgang af hvad HCI kurser på danske universiteter består i. Målgruppen for undersøgelsen udgøres i første omgang af de mennesker, der, qua deres medlemskab af HCI fællesskabet sigchi.dk, kan antages at arbejde med praktiske HCI problemer i en del af deres arbejdstid. Fra tilsvarende undersøgelser ved vi at en besvarelsesprocent på 10-15% er almindelig. Undersøgelsen er ikke repræsentativ; vi vil anvende svarene til at karakterisere respondenterne kvalitativt og i øvrigt inddrage andet materiale der belyser rekrutteringsgrundlaget for HCI specialister i DK. For at få begrundelserne for interessen for teori og metode frem vil vi analysere svarene på de åbne spørgsmål ved brug af grounded theory metoden. Dette er tidligere blevet gjort med succes på spørgsmålet om hvorfor metoder lært på universitet ikke bliver anvendt i praksis. Et typisk resultat af en kvalitativ analyse af denne slags er en eller flere ”kernekategorier”, altså begreber der står centralt i respondenternes forståelse af emnet.

Vi ved at det formentlig bliver nødvendigt at arbejde med mere end en ”kernekategori” i vores analyse, da det næppe er muligt at identificere HCI specialister som en homogen gruppe. Vi forventer at undersøgelsen kan belyse om HCI fællesskabet i DK har et akademisk præg, og om en prototypisk dansk HCI specialist har en teknisk/naturvidenskabelig uddannelse som sin første uddannelse. Også holdningen til egen rolle er muligvis under forandring; der er formentlig en del, der opfatter sig selv mere som ”interaktionsdesignere” end som traditionelle ”usability” folk, ligesom de, der arbejder med meget med web udvikling måske også udvikler en mere designorienteret faglig identitet.

For forståelsen af hvilken rolle teori spiller for den enkelte HCI specialists identifikation og løsning af design problemer er det måske især af interesse hvornår i karriereforløbet en bestemt type af teori læres, fx om det har indflydelse på problemidentifikationen om specialisten er en erfaren systemudvikler der også har lært noget om psykologisk/social teori, eller en erfaren psykolog der har lært noget om systemudvikling. Også spørgsmålet om hvor ofte specialisten møder et givent problem kan være interessant; måske arbejder nogle specialister mere teori-drevet end andre, fordi de ser de samme problemer hyppigere. Endelig er der spørgsmålet om hvad det betyder for vores opfattelse af andre, hvis vi betjener os af bestemte værktøjer til at beskrive brugerne. Ikke alle disse spørgsmål kan besvares indenfor rammerne af en spørgeskema undersøgelse, men der er brug for svar når vi vil bidrage til udviklingen af et dansk HCI fællesskab.

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The Next Generation of Tool Support for Coloured Petri Nets

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We have just announced the first release of the next generation of tool support for Coloured Petri Nets, CPN Tools, developed by the CPN Group in co-operation with researchers from the Centre for Human-Machine Interaction, University of Aarhus, Denmark. The CPN Tools are intended to replace Design/CPN, which is the most widespread software package for modelling and analysis by means of Coloured Petri Nets. Design/CPN is used by 750 organisations in 50 countries, including 200 commercial enterprises.

The CPN Tools are available free of charge for all kinds of users, including commercial companies. The development of the CPN Tools started three years ago and a total of 15 man-years have been used. The development will continue over the next years with an expected total effort of five man-years per year. The first version of the CPN Tools is available on the Windows platform. Later we may also support other platforms.

The present version of the CPN Tools supports construction of CPN models and analysis by means of simulation. Later versions will include support for formal analysis by means of state apace analysis.

The user interface includes a number of novel interaction mechanisms such as the use of two-handed input by means of a mouse and a trackball.

There are three key principles that we use in the design of the overall graphical interface:
Reification: The process of turning interaction patterns into first class objects. Thus, commands can be made accessible as instruments, combinations of properties can be turned into styles and the selection of multiple objects can be tagged and accessed as groups.
Polymorphism: Similar operations may be applied to different objects. Thus, various objects can be cut, copied or pasted, any operation can be undone, and operations that apply to a single object can be applied to groups of objects.
Reuse: Previous commands and the responses by the system can be reused. Thus, input may be reused as the "redo" command and macros, output may be reused as input to other commands, and new commands may be created out of existing commands and a partial list of pre-defined arguments.

The reification principle has strongly influenced the design of the new tool. For example, in the old tool a set of objects are aligned by applying a “vertically align center” command, but additional objects cannot be added without reselecting the aligned objects. In the new tool, this alignment command is reified into a magnetic guideline, a visible first-class object that is continuously accessible and modifiable. New objects can be attached to the guideline, and moving the guideline also move all the objects attached to it.

The interaction techniques of most traditional graphical interfaces use a combination of Windows, Icons, Menus, and Pointing (WIMP). Although these have a number of strengths, e.g., when well designed they are self-revealing to a novice user, their interaction is often limited to indirect manipulation techniques. This type of interaction forces users to divert their focus from the objects they are working with to commands embedded in menus and dialog boxes. In the context of a graphical editor, this separation between object and action is inefficient and slow. Contextual menus and floating palettes are improvements, but are still indirect manipulation techniques.

In contrast, direct manipulation techniques follow three principles: continuous representation of the objects and actions of interest with meaningful visual metaphors, physical actions or presses of labelled buttons, instead of complex syntax, and rapid incremental reversible operations whose effect on the object of interest is visible immediately.

We are working with the concept of Instrumental Interaction, which encompasses the range of techniques between direct and indirect manipulation. In this model, instruments mediate the interaction between a user and the objects in the interface.

Toolglasses, for example, are floating, semi-transparent instruments for direct, two-handed manipulation. They are positioned with the non-dominant hand and applied with the dominant hand. A toolglass similar to a colour palette would allow a user to apply a colour to or absorb a colour from an underlying object directly. The non-dominant hand moves the desired colour over the object of interest, and then applies the colour by clicking through the toolglass on the underlying object with the dominant hand. This allows the user to specify both the object and the action with a single mouse click, in context.

Another advanced technique applied in CPN Tools is layers, which create graphical sets of objects whose visibility and depth can be controlled like overlapping layers of transparencies. Layers are an effective way of separating structural objects from informational objects. This allows the user to manage the complexity of the view by adjusting the visibility of a layer based on its relevance to the current activity. For example, comments could be placed into one layer and simulation feedback in another, allowing the user to fade or hide items when they are not the focus of attention.

Standard architectures for graphical interfaces do not support these “Post-WIMP” interaction techniques and they are not trivial to add to existing interface toolkits. We have, therefore, completely redesigned the user interface architecture to support these new types of interaction. This new framework, Octopus, will be available as a part of the standard development environment of the BETA/Mjølner system.

The development has been supported by the Danish National Centre for IT-Research, Hewlett-Packard, Nokia Research Center, and Microsoft Research Limited.

For more information about CPN Tools, please see:
http://www.daimi.au.dk/CPNtools/

For more information about the BETA/Mjølner framework:
http://www.mjolner.dk/mjolner-system/

Contextual Design som Fælles Grundlag for Systemudviklings- og HCI-Undervisning

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Målsætninger og erfaringer vedrørende et nyudviklet introducerende universitetskursus med titlen Interaktive Systemer og Projektledelse ved Datalogisk Afdeling på Roskilde Universitetscenter (RUC) fremlægges til diskussion. En væsentlig erfaring har været, at Hugh Beyer og Karen Holtzblatt's Contextual Design (1998) har fungeret godt som de studerendes første og primære introduktion til udvikling af interaktive systemer.

I kurset, der blev gennemført første gang i foråret 2001, er behandlet emnerne interaktive systemer, systemudvikling og projektledelse. Fokus var at opbygge en forståelse og indledende tilegnelse af metoder, teknikker og værktøjer, som erfaringsmæssigt kan bidrage effektivt til systematisk udviklingsarbejde. Kompleksitet heri forudsætter studier af brugskonteksten, kreativt design, evaluering og iteration. Yderligere indgår evne til samarbejde i en projektgruppe, målrettet ledelse samt konstruktiv dialog med eksterne kunder/brugere. Effektiv og bekvem indretning af menneske-datamaskine interaktion har ofte vist sig at indebære særlig vanskelige udfordringer. Derfor blev udvikling af systemernes brugerflader tillagt stor opmærksomhed og støttet med lærebogsstof fra Ben Shneiderman's Designing the User Interface (1998) samt ca. 20 videoklip, primært af designdemonstrationer fra ACM's CHI- eller CSCW-konferencer.

Kurset har sigtet på at give de studerende en overordnet og samtidig så vidt muligt en konkret og personlig forståelse af udvikling af interaktive systemer og projektledelse heraf. Som led i kurset indgik derfor et gennemgående udviklingsprojekt, hvor de studerende i grupper har skullet problemformulere, kravanalysere og designe et mindre, interaktivt system i samarbejde med brugere. Gruppernes arbejde med disse projekter fik en særdeles fremtrædende plads i undervisningen, hvor grupperne ved de ugentlige øvelser modtog råd og vejledning fra lærergruppen. Som eksempler på projekter kan nævnes World Online's Support Log til kundebetjening, undersøgelse af Dannerstiftelsens arkiv, den fælles opslagstavle for aktiviteter på RUC, DFDS Seaways ordning for håndtering af kundeklager og en web-portal til inspiration for gaveideer. Projekterne har i et efterfølgende kursusmodul kunnet tjene som udgangspunkt for ca. 15-20 studerendes arbejde med en afgrænset programmeringsopgave.

Gruppernes gennemgående udviklingsprojekter blev rapporteret ved to delopgaver. Første delopgave kan beskrives som en problemstillende kravbeskrivelse for et udviklingsprojekt og havde følgende indhold: (1) Brugerne og deres arbejde. (2) Arbejdsgangen eller strukturen i brugernes arbejde. (3) Problemer i brugernes arbejde. (4) Problemer med brugernes værktøjer, herunder edb-værktøjerne. (5) Kort omtale af eventuelle foreløbige, men vigtige design-ideer som allerede trængte sig på ved de studerende undersøgelser af brugernes arbejde. (6) Oversigt over eventuelle udestående spørgsmål til supplerende/undersøgelse, dvs. vigtige usikkerheder og tvivlsspørgsmål.

Anden delopgave skulle give en koncis redegørelse for gruppens forslag til redesign af brugernes/kundernes arbejde med henblik på innovation/forbedring. Herunder skulle udarbejdes et sammenhængende forslag til systemmodel i form af det såkaldte "User Environment Design" ligesom ideerne bag og udformninger af gruppens forskellige prototyper skulle beskrives og illustreres. Som et særligt punkt skulle redegøres for resultaterne af gruppens evalueringer af prototyperne. Endvidere skulle konkret redegøres for erfaringerne med bruger-/kundekontakterne - hvad der her havde været særlig vellykket, og hvad der havde været mindre vellykket. Anden delopgave skulle tillige via udvalgte, særlig vigtige eksempler indeholde en beskrivelse af, hvordan erfaringerne havde været med at benytte de teknikker og begreber, som er fremhævet i lærebogen Contextual Design. I eksamensopgaven, der skulle besvares individuelt som en ugeopgave, krævedes redegørelser for og diskussioner af de vigtigste erfaringer indhøstet under det projektarbejde, som allerede var foreløbig dokumenteret for hver gruppe i form af de ovennævnte to delopgaver.

Erfaringerne fra forårets kursus 2001 kan resumeres sådan: (1) Hovedparten af de knap 70 studerende har bestået kurset med gode besvarelser; ca. 5 studerende har bestået kurset med udmærkede besvarelser; én studerende klarede ikke eksamenskravene og måtte dumpe, mens 5-8 studerende leverede usikre, men dog acceptable besvarelser. Hertil kan nævnes, at der har været et ukendt frafald af studerende, som har undladt at gå til eksamen; det drejer sig dog højst om ca. 10 studerende. Her i efteråret synes det konstateret, at kurset har kunnet fungere som indgang til videregående kurser i HCI, objektorienteret analyse og programmering, samt informationssystemer og projektledelse på RUC og IT-højskolen i København.

Hvad angår de mere specifikke erfaringer med Contextual Design kan nævnes, at mange studerende giver udtryk for at tilegnelsen har været vanskelig; men faktisk oplever de at være kommet igennem til nyttige erfaringer og ny indsigt. Mange fremhæver som særlig udbytterigt: (1) Contextual Inquiry der var svært og forskelligt fra almindelige interview. (2) Affinitetsdiagrammet der var nyttigt; men svært og dårligt fremstillet i lærebogen - bedre eksempler skal udvikles. (3) User Environment Design der var særlig nyttigt; men igen svært at tilegne sig. (4) Papir-prototyper i design hvor mange grupper har arbejdet kreativt med brug af skitser af skærmdialoger, især kombineret med post-it for fleksible demonstrationer , pop-up vinduer o.a..

Contextual Design fik højest prioritet og blev læst i sin helhed - og erfaringerne hermed har været nogenlunde vellykket. HCI-lærestoffet fik formelt mindre opmærksomhed; men de ca. 20 videoindslag fordelt gennem hele kursusforløbet synes at have givet i hvert fald nogle af de studerende uvurderlige indtryk og nye forestillinger, som de ikke har kunnet læse sig til. Projektledelsesdelen blev primært repræsenteret ved den projektudviklingsmodel, som indgår i Contextual Design, nogle beretninger ved forelæsningerne om faktiske projektforløb, bl.a. AMANDA-projektet, visse supplerende tekster og de studerendes egne erfaringer fra deres gennemgående udviklingsprojekt.

Særlig spændende har det for mig været at give denne introduktion i udvikling af interaktive systemer til studerende der ikke forinden har nogen programmerings- eller systemudviklingserfaringer. Uddannelse er i høj grad et spørgsmål om at udvikle effektive vaner; og de første erfaringer på et nyt område er altid mønsterdannende på en særlig dybtgående måde.

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Fluid Interfaces
Supporting Specific, General, and Minimal Interaction

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Abstract

Fluid interaction, interaction by the user with the system that causes few breakdowns, is essential to many user interfaces. We present two concrete software systems that try to support fluid interaction for different work practices. Furthermore, we present specificity, generality, and minimality as design goals for fluid interfaces.

What is Fluid Interaction?

Fluid interaction is interaction with *fluid interfaces.* An interface is fluid if it allows users to focus on their primary activities while interacting through it. This definition is in line with [4] that defines "fluid interaction" as interaction that "allows unhindered expression of ideas" and [1] that defines "transparent interaction" from an activity theory perspective as "handling the computer through operations". Breakdowns and focus shifts are signs of broken fluidity [5].

Fluidity cannot be a feature that in general can be built into software systems: activities change both through their development and the users learning processes. Thus, fluid interfaces will need to adapt to changing activities, users, and contexts.

Supporting Fluid Interaction

The Knight tool [2] (Figure 1) support object-oriented modelling on a variety of input devices ranging from electronic whiteboards to tablet PCs.

Figure 1. The Knight tool for collaborative modelling

Pens are used to draw gestures that resemble the object-oriented modelling symbol that the user needs. Thus, the interaction resembles very much what we saw was being drawn in informal modelling sessions using traditional whiteboards during our user studies. Also, the Knight tool supports the frequent transitions between working at whiteboard and desktop computers by providing an interface that is adapted to both kinds of uses.

The Kimura system [3] aims at supporting multitasking and background awareness using peripheral display (figure 2).

Figure 2. The Kimura augmented office environment

The user works at his or her ordinary desktop that is being monitored together with the user's working context in order to provide summaries of activities in the form of visual *montages* and cues to events of interest on the peripheral displays. If the user sends an e-mail to a colleague and that user happens to be in the coffee room, the system will provide salient, visual cues of that in connection to the activity in which the e-mail was sent. Furthermore, the user may manipulate activities using gestures on the interactive peripheral displays.

Issues

In order for an interface to be fluid it has to at least support:

- *Specificity*. For different types of activities, different types of interfaces supports fluid interaction. In collaborative object-oriented software design, the whiteboard is an effective metaphor for a fluid interfaces, in industrial design, physical artefacts may provide such an interface.
- *Generality*. A fluid interface needs to adapt to its context: when transitioning from use on large displays for collaboration to smaller displays for personal use, the interface needs to be able to adapt to the changing displays. This is especially important in the context of mobile computing.
- *Minimality*. Fluid interfaces need to support the activities that it should support but preferably not more.

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Studies of Systems Development and Evaluation: Collaboration – Information Seeking – Usability

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Abstract

Systems development is an example of a loosely structured domain with few accredited best practices, fairly self-organising groups, and a disturbing number of unsuccessful projects. To devise tools that more effectively support system developers in successfully accomplishing their work it is necessary to identify and scrutinise the prime constituents of this work. Based on both field studies and experimental work three such constituents are being studied: collaboration, information seeking, and usability.

Collaboration. System developers are responsible for the accomplishment of a task that requires close cooperation within the project group and frequent interactions with external actors to exchange information, negotiate commitments, and so forth. Colleagues often assist each other in providing hitherto unknown sources with an initial face and a trusted opinion about the credibility of the source (Hertzum, in press). It is, for example, a normal conversational practice to accompany the mentioning of information sources that may be unknown to some project participants by information that puts them in context. Systems for managing knowledge and sharing expertise must provide equally rich means of forming a perception about the trustworthiness of documents and other pieces of information. In working with system requirements, developers also need tools for generating and managing an inclusive set of system requirements. The multi-board concept (Robotham & Hertzum, 2000) sketches a low-tech, scenario-based tool for doing this. Aspects of the concept include construction of a common working environment where multiple display boards depict scenarios of the product life cycle and, thereby, support the creation of a shared mindset amongst the system developers.

Information seeking. Information seeking is a crucial aspect of cooperative work. Several studies provide evidence that engineers spend 40%-66% of their time communicating in order to get input to their work and to output results from their work. Developers of systems and products search for documents to find people, search for people to get documents, and interact socially to get information without engaging in explicit searches (Hertzum & Pejtersen, 2000). The intricate interplay between document and people sources arises from the nature of the design task. Many possible solutions are normally available to the developer and in choosing one over the others the developer must consider a complex set of issues involving both the product as such and its context. However, design documentation seems to be biased toward technical aspects of the chosen solution, whereas information about the context of the design process is typically not available. Hence, people become a critical source of information because they can explain and argue about why specific decisions were made and what purpose is served by individual parts of a design. This suggests that people finding is an important activity and that it should be analysed whether/how systems can support searches for people (Hertzum, 2000).

Usability. Although the importance of usability is gaining widespread recognition, considerable confusion exists over the actual meaning of the term. Sometimes usability is defined quite narrowly and distinguished from, for example, utility. On other occasions usability is defined as a broad concept synonymous to quality in use. While it is tempting

to assume simple, general relations between effectiveness, efficiency, and satisfaction – the three aspects in ISO's definition of usability – this does not seem to be the case (Frøkjær et al., 2000). This suggests that, at least for complex systems, it is necessary to measure all three usability aspects independently to be able to make statements about system usability. In addition to the conceptual ambiguity, it has been found that current methods for usability evaluation – such as thinking-aloud studies – suffer from a substantial evaluator effect (Hertzum & Jacobsen, in press). That is, multiple evaluators evaluating the same system with the same evaluation method detect markedly different sets of problems. The evaluator effect exists for both novice and experienced evaluators, for both cosmetic and severe problems, for both problem detection and severity assessment, and for evaluations of both simple and complex systems. System developers need more robust methods to systematically improve the usability of computer artefacts. The simplest way to achieve some of the needed robustness is to involve at least two evaluators in usability evaluations.

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Information visualizations of Electronic Documents: Usability and Reading Patterns

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Erik Frøkjær and I have recently been investigating if information visualizations support reading of electronic documents. Reading of such documents is becoming increasingly widespread, for example in digital libraries and on the World Wide Web. However, readers experience various difficulties with electronic documents compared to paper: electronic documents take longer time to read, it is difficult to get an overview of the structure of the document, navigation is hard, and fatigue is likely to occur if reading for extended periods of time.

It has been suggested that information visualizations of electronic documents may support reading and ease the difficulties mentioned above. One kind of information visualization shows an overview of the entire document together with a detailed view of the contents of that document. These so-called overview+detail interfaces have been used in for example Adobe Acrobat Reader. Another kind of information visualization shows only the important parts of the document. George Furnas's fisheye interface is one example of this. However, few empirical studies have investigated the usability of information visualizations for electronic documents. The studies we know of have failed to find an advantage of information visualizations over common, linear interfaces. In addition, no studies have investigated how information visualizations change users' reading patterns.

In an experiment, we compared the usability of a baseline, linear interface with an overview+detail and a fisheye interface. Twenty subjects answered questions and wrote essays about scientific documents discussing object-oriented systems development. In all, the experiment resulted in more than 100 hours of logged interaction with the interfaces.

The experiment revealed several differences in usability between the interfaces. The subjects preferred the overview+detail interface, stating that they liked the overview of the structure of the document and that navigation using the overview was pleasant. When subjects wrote essays after having read a document with the overview+detail interface, they got higher grades than subjects who had used the other interfaces. Subjects who used the fisheye interface were faster. However, they answered fewer incidental-learning questions correctly, suggesting that they had a shallow understanding of the document. When answering questions, subjects using the overview+detail interface were approximately 20% slower than subjects using the linear interface. We found no difference between interfaces in the quality of subjects' answers to questions.

Recently, we have worked on visualizing reading patterns from the logged interaction data. To explain the differences in usability, we created two visualizations of reading

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patterns. Progression maps show how reading progresses, visibility maps show for how long different parts of the document are visible. The progression map helped identify three phases in the subjects' reading activity. Some subjects started with an initial orientation phase, in which they navigated non-linearly through the document and read the abstract, the introduction, and the conclusion. In the linear read-through phase, subject read through the documents from the beginning to the end, making occasional jumps forwards and backwards. In the review phase, subjects apparently reviewed what they found to be the main points of the document. The duration of these phases differed between interfaces. In the fisheye interface, subjects used longer time on initially orienting themselves and less time on reading linearly through the document. With this interface, subjects used an overview oriented reading style, first getting an overview of the document, later reading the details. The visualizations of how reading progress also give an explanation of why the overview+detail interface was slow for answering questions. When subjects had located an area in a document that contain the answer to the question we gave them, they often continued to explore the document. These further explorations happened because the overview appears as an easy way to navigate. Perhaps the overview also created associations for subjects about what to explore next. A negative way to put this is to say that the overview distracted subjects.

For designers, our studies suggest that overview+detail interfaces support reading, and should be used more in systems for information access and use. Fisheye interfaces support quick, overview-oriented reading, but subjects do not get a deep understanding of the document read. Consequently, fisheye interfaces should mainly be used for time-critical tasks. The most common interface in practical use we found to be inferior in usability compared to the information visualizations. It should be avoided whenever possible.

Three areas of further research are needed. First, visualization of reading is a useful technique for studying reading activity that gives more fine-grained information than simple usability measures. In addition, progressions maps are more manageable than data from eye-tracking studies. Such visualizations will be useful in further studying reading activities. Second, our study show that overviews may be made more content-rich, and that algorithms for fisheye interfaces may be further improved. Third, attention in information visualizations needs to be better understood, especially how the overview distracts/creates associations.

Further details may be found in K. Hornbæk & E. Frøkjær, (2001), 'Reading of Electronic Documents: The Usability of Linear, Fisheye, and Overview+Detail Interfaces', Proceedings of ACM Conference on Human Factors in Computing Systems (CHI'2001), Seattle, WA, 31st March-5th April 2001, p. 293-300, and in my PhD thesis 'Usability of Information Visualizations: Reading and Interaction Processes' (2001), e-mail me at kash@diku.dk for a copy.

Playing games to understand design collaboration

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Seeing design as a game

Within HCI literature it is now widely accepted, that design is a communicative and social process involving a variety of different competencies throughout the design process. Hence design competence is not only the skilful development of technology for future use, but also the ability to communicate and interact with other design team members. Taking departure in Harbraken & Gross's (1987) 'Concept Design Games', we have explored the potential in using board games as a metaphor in design team training. With game elements such as game board, rules, pieces and turn taking, we deployed game thinking as a metaphor for negotiating and interacting in collaborative design processes. This poster introduces findings from our experiments with game playing in design educational settings.

The Silent Game: Establishing a game vocabulary

A Concept Design Game in the sense of Harbraken is a board game that models certain aspects of the design process. It has bricks and board, roles and rules, but differs from ordinary games by having no elements of competition. The game is not about winning, but rather a frame for exploring design moves and strategies in a reflective setting. In student design training we start out with the Silent Game (Harbraken & Gross, 1987) to establish a vocabulary for talking about collaborative design practice.

The Silent Game is played with two players (e.g. chief designer and assistant) and an observer. No speech is allowed during the game. Player 1 starts the game by placing one or two pieces on the game board according to a personal design idea. Interpreting player 1's move, player 2 makes her move by placing a piece on the game board, somehow relating to player 1's move. If player 2 gets the idea, player 1 can expand the idea, if not, she can emphasize the intention in her subsequent moves. The game ends when the observer sees no progression in the game. Then a debriefing session starts with the observer's account of the game followed by player 2's and finally player 1's reflections. The Silent Game is a way of establishing a 'game vocabulary' in a late Wittgensteinian sense. By playing language games such as the Silent Game, the students get familiar with social aspects like team roles, project constraints, design moves, negotiation strategies, rules to follow, and the inner logic of turn-taking. Our experiments show, that the Silent Game is an inspiring interactive frame for training collaborative design processes and reflective design practice in the Schön tradition (Schön, 1987).

In a particular instance in a design class in Aarhus, the students arranged a one-day design activity for professional usability designers. Working from video recordings, they then analysed the activity using game concepts: How can we recognise design moves? Roles? Rules? This gave the students confidence in the applicability of their game vocabulary to real-life design.

Game creation: Exploring design situations

Once students are familiar with the Silent Game, we start modifying the rules (What if there are three players? If players can move no more than one piece at a time?) to simulate real-life collaborative design situations. The restricted communication channel of the Silent Game stresses the communicative challenge of design collaboration. Students learn to use board games as a testbed for exploring social settings (Binder et.al. 1999). Then students start creating their own games to simulate a particular design situation they want to study. Examples of the situations we have worked with are 'A newcomer in the design team'; 'The design team acting in the larger organisation'; and 'Coordinating design across several product divisions'. The game creation in itself becomes a design process.

One group of design students in Sønderborg created a game for exploring the situation in which team members verbalise and negotiate the 'soft' values, they want to realise in their product. The students designed two identical sets of 24 picture cards with images, which can be used to attribute values to a product (strong, fast, organic, easy etc.). Like the Silent Game, this game has two players and an observer and is played in silence. From a stack of 'product cards', the observer picks a product for the first round, e.g. a cellular phone. Each player then selects 5 cards to represent the values they would like to see in a cellular phone design. Now the players compare their selections. If they differ, they take turns suggesting replacement images to negotiate a shared value set. The game ends, when the selections of 5 cards are identical for both players. In the debriefing session, the observer and players relate their understanding of the product values and of the negotiation process. The game proved to be very successful for verbalising the often-unsaid product values and for exploring the process of value negotiation.

Traces of good design games

In the Sønderborg design class, we asked the students to evaluate their own design process and to structure their experience statements using game concepts. This experiment resulted in a challenging list of 'instructions' for a successful design game:

- The material (board and pieces) should be inspiring
- There should be rules to start the game, but they must not be rigid
- You should have the option of expanding your role
- You need to make bold moves
- Respectful turn taking is crucial.

The students also formulated the qualities of a successful game: We play, because it is fun to play, because the game takes surprising turns of events, and because it is a challenge to bring the game to an end. It is evident that the students have learned aspects of collaboration, which transfer directly to 'real' design.

Based on our experiments with design education, we conclude that game playing has great potential in our strive towards extended understanding of design processes and successful training for collaborative design. But there are still lots to explore and lots to learn!

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Acknowledgements: We would like to thank Thomas Binder for introducing us to the MIT tradition of the Silent Game through courses in Aarhus and his work at Danfoss A/S. And we are indebted to the design students in both Aarhus and Sønderborg, who willingly joined experiments and helped expand our understanding of the game metaphor.

Mental Workload in Mouse and Keyboard Input

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Introduction

The background to the work is the incredible proliferation of computers: 60% of the Danish workforce uses a computer every day and more than every sixth employee uses the computer for more than 3/4 of the work day (Burr 1999). The graphical user interface paradigm (GUI) has played a key role in this proliferation due to increased guess-ability and learnability. However, voices are being raised re-garding health risks in extensive computer use (Punnett and Bergqvist 1997) and regarding the inappropriateness of GUI interfaces for expert use (Gentner and Nielsen 1996) as development of highly skilled perfor-mance based on automated processing is hampered due to the visuo-motor co-ordination demands in using the mouse. Against this background, the work reported in this paper aims at identifying essential factors in mental workload and their interplay in mouse and keyboard input work.

Study Design and Method

In a laboratory study we had twelve right-handed, healthy women performing intensive input work using mouse and keyboard in a within-subjects design. The subjects had extensive experience with computers, including keyboard and mouse. Each subject spent a full day in the lab with two intensive 1-hour input sessions, interspersed with rest, instrument calibration, eating, etc. The subjects' primary task was the Stroop-task where a stimulus, a word desig-nating a colour, e.g., 'blue', is presented on the screen in another colour, e.g., red. The subjects' are to report the colour of the stimulus word, i.e. "red" here. We employed four colours: blue, red, green, and yellow. The stimuli were presented at pre-set intervals between 0.6 and 2.0 seconds with a mean of 1.3 seconds; thus, the subjects worked under consi-derable time pressure. With the mouse, the reporting was done by clicking one of four buttons on the screen and with the keyboard by hitting one of four adjacent keys `j` `k` `l` `æ` with one of the four typing fingers on the right hand. Each subject worked with the Stroop task for one hour (with appropriate breaks) with the mouse and one hour with the keyboard in balanced order.

We applied a range of measures of mental workload as our preceeding anal-ysis suggested (Jørgensen et al, 1999):

1. Subjective preference
2. Performance (correct & erroneous answers, time to answer)
3. Subjective measures
 - Task Load Index (Hart and Staveland, 1988)
 - Rating of Perceived Exertion (Borg 1990)
 - Ti-me-estimation
4. Various phy-s-iological measures.

Results and Discussion

Due to space constraints we only address the most salient aspects of subjective and performance measures. The table below summarises the principal findings, shown as the p-values of the statistical tests (binomial test for preference, otherwise Wilcoxon ranked sign test). The p-value appears in the column where the input medium is "best". As an example, 11 out of the 12 subjects preferred the keyboard; this is significant at the 0.006 level.

Measure	Mouse best	Not signif.	Keyb'd best
Preference			0.006
Correct answers			0.003
Erroneous answrs	0.003		
Time to answer			0.003
TLX total			0.003
- mental		0.35	
- temporal dem'd			0.013
- performance			0.031
- effort			0.010
- frustration			0.013
RPE R-hand-wrist	0.036		
- R forearm-elbow		0.11	
- right shoulder		0.40	
- neck		0.67	
Time Estimation		0.15	

The table shows a considerable superiority associated with the keyboard. Not only did 11 subjects prefer the keyboard, but of the remaining 9 significant measures, 7 were in favour of the keyboard. This includes two aspects of performance, where for example the mean time to answer with the mouse was 1.09 ± 0.08s and with the keyboard 0.70 ± 0.06s (avg. ± s.d.) – a very considerable difference. The same pattern is seen with the TLX components (except the mental component), where for example the rating of the frustration com-ponent on an 18 point scale (where 1 is low load) in the mouse condition was 13.4 ± 3.0 and in the keyboard con-di-tion 9.2 ± 4.0 (avg. ± s.d.).

As to the RPE measures only one com-ponent is significant: the right hand-wrist region where the rated exertion is lower in the mouse than in the keyboard. This may be due to the rather fixed position of the right hand in the keyboard condition whereas in the mouse condition the hand is moved around – in spite of the generally higher mental workload associated with the mouse. Finally, it should be noted that at a first impression, the keyboard may seem to be favoured by the set-up of the task. This is not the case as the primary tasks were identical in the two conditions. In addition, note that there was a con-si-de-rable "hidden" obstacle in the keyboard condition, namely learning the four keys on the keyboard corresponding to the four colours which took place under considerable time pressure.

In conclusion, the study is an indication that in input-intensive, highly attentive IT-work the keyboard has definite advan-tages over the mouse in terms of mental workload as measured by performance and subjective measures.

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Analysis and Modeling of Changing Information Needs in Process Control – The Case of Maritime Operations

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Introduction

Human actors engaged in the supervision and control of complex dynamic processes—e.g. power plants, petrochemical plants, and maritime operations—are faced with changing information during the course of their work. In order to perform supervision and control in a safe and efficient way, the operator must be provided with focused information corresponding to the control task at hand. However, contemporary design of supervision and control systems suffers from excessive rigidity—broadly speaking, they provide the operator with the same information no matter what the work task at hand. Our work is aimed at establishing the empirical and theoretical basis for the design of flexible computer based human supervisory control systems; systems that support the operator in handling work tasks featuring highly diverse information needs. Let us exemplify the challenges of analyzing and designing such systems within the work domain of maritime operations.

The case of maritime operations

The movements of a seagoing vessel are determined by the complex interaction between controllable and uncontrollable physical forces acting on it. The movements of the vessel will be affected by the forces of nature (wind, current, etc.) and these must be counteracted by the controllable force of the propeller, rudder, etc. in order perform safe and effective maritime operations (maneuvering). However, when we want to understand the supervision and control tasks in maritime operations it is important to consider vessel *movements* in relation to the constraints and the opportunities for movement offered by *space*. Maritime operations is about goal-directed movements within given spatial constraints (traffic separation schemes, obstacles, foreign ships, quay, etc.). Assessing the spatial layout (with respect to opportunities and constraints) and planning of future trajectories (navigation) is an integrated part of the control problem in maritime operations. Navigation and maneuvering represent different levels of control.

Both complex force interactions and the spatial limitations must be made accessible to the navigating crew in order to support them in their control work. A traditional supervisory control system would do this in a fixed and inflexible manner which would be ok if not for the fact that control is performed during a multitude of operational phases. When a vessel sets out on a journey the first activity is to untie the lines and move it away from the quay. Then the passage goes through the harbor basin and into the narrow fairway off the harbor. The vessel moves into coastal waters and finally enters the unrestricted open waters. The individual operational phases are characterized by different work objectives which in turn form the need for specific information on the bridge of the vessel. For example, a detailed and coherent picture of the interaction between rudder and propeller is needed during low-speed operations in and around the harbor area, while considerations like fuel consumption and timeliness call for different information during a transatlantic voyage.

Analyzing and modeling changing information needs in process control

The core of flexible control systems is a deep understanding of the operators' information needs during different operational phases and specific work situations within these phases. We must understand the significance of different work conditions (water depth, speed, manning, etc.) in order to formulate operational phases, and we must understand these phases in even greater detail in order to delimit and group specific objectives, goals and work conditions into delimited and well defined situations.

We are working to establish the knowledge base for flexible control systems which will not only honor the user in his choice of information but systems that will also suggest to the user essential information in different control situations. We investigate what information is needed in order inform the design of flexible supervisory control systems and we aim at developing the analytical tools and modeling techniques required to arrive at the desired knowledge base.

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From model-user to character – an investigation into user-descriptions in scenarios

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One of the first film scripts I ever read was Thelma and Louise and I was immediately drawn into the story. I imagined the characters as real persons and was so interested in what happened to them that I continued reading until the end. Long time before the script gave me any clues, I tried to figure out in my imagination, why Thelma and Louise acted as they did and what motivated them. This script is - what in film terms is called – a good read.

When I later came to work with and study scenarios, I was surprised to find that the scenarios never presented the users as vivid characters. At best they were stereotypes and made me laugh, at worst they only existed as a name.

It raised some question from both a writer's and a reader's point of view: How can you predict the goals and actions of a user, when you don't know anything about the user as a person? Why use descriptions of users that the reader can't engage in? What does it take to do a good description of users in writing?

The balance between use and user. In this paper I look at three different scenarios written by three different authors of articles and books about the scenario-based design methods: John M. Carroll, Susanne Bødker and Alan Cooper. I try to deduce from some of their writings and from the examples they give of scenarios, how they depict the process of describing the users and writing the scenarios. Carroll and Bødker both have emphasis on the use of the products to be designed and highlights how scenarios can describe situations for use and the user's goals. Of the authors Cooper is the only one who has a focus on the description of the user (personas, is his term).

The user-descriptions are embedded in the scenarios and I look into these. It is my aim to provide a brief overview of: The authors' attitude towards the model-user. A definition of what constitutes a character. An attempt to look into what it takes to write and describe "a good character".

Finally I hope to give some rules of thumb for the process of creating model-users, derived from "the good character writing".

The process of writing. In the film script, the character has to be established on the first page of the script, s/he has to grasp the reader immediately so the reader should be urged to read on and be interested in what happens to the character. Writing a scenario has a similar pattern, the description of the model-user must be vivid and the model-user should be described in such a manner that during the reading process it becomes clear how and why the model-user acts the way s/he does.

The film script writing has a lot of rules established because of the act of transformation from paper to screen. One such rule is only to describe what can be seen. This forces the reader to imagine the transformation of visual information in the script. But is also forces the author to be aware of what lies behind the visual expression. The pattern is similar for the reader of a scenario s/he is forced to imagine the user, the users actions and the motivation behind the action and the system's events.

The character's function in the story. In the plot-driven – or a-psychological - narrative the character has few traits and the traits function as a catalyst for the action. When a trait is mentioned the character immediately acts on the trait. This makes the character highly predictable and creates flat characters.

In the character-driven - or psychological – narrative, the character has a number of traits and a number of voices that interacts with and against each other. This makes the character's action non-predictable and creates rounded characters. In the character-centred screenplay the character creates the story development.

The character construction. It is important to distinguish between analysis of fictive narratives and the creation of fictive narratives. I focus on two attitudes towards the writing process of characters that can be labelled as rounded. The character includes both personal (inner) and inter-personal (social, public, professional) elements. All characters have inner needs and goals as well as interpersonal desires and professional ambitions that help characterize them and impose their own requirements, restrictions and privileges. Bakhtin's concept of the carnival can explain the character.

The rounded character. Looking for the rounded character will be looking for: Multiple traits. Psychology. Physiology and sociology. Inner needs and goal, interpersonal desires, professional ambitions

An engaging character. When the character is engaging the reader takes an interest. This will, in the scenario writing process, be equally important for the team doing the writing. When the writer engages in a model-user and the traits and goals of the user, the prediction of the writing will become much more grounded. Doing so will require a thorough insight into the user and into what distinguish different groups of users from each other.

Creating vivid and rounded characters trigger our imagination and helps the designers use their understanding and background in the design process. This can create a more rich and varied understanding of the user. At the same time it should make the prediction of the future use based on a more solid material.

To me it seems important to know and be conscious of the character. It will create an involvement in the character especially when the character's experiences are far from yours. And give the writer a better foundation to be involved in and predict the user's goals and acts.

Designing for Learnability of Domestic Technology: From Mental Models to Learning Artifacts

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As new technologies penetrate our lives at an increasing rate, we no longer know what functionality to expect from our refrigerator, our car, our heating control system etc. There is a trend towards product integration and we see an increased complexity of especially domestic technology. Thus our expectations become challenged in the meeting with new products and they are formed and modified as we gain experiences with using the new technology. This exploration does not stop after the first hours or day of use. Our use continuously develops over time, new possibilities emerge and others fade away. Unfortunately, present usability engineering methodologies provide little support in understanding how use develops right from the first meeting with the whole product till we later discover small facets of the technology and more importantly how this development in use may be supported by the design of the technology.

In contrast to existing approaches, activity theory provides a solid starting point for implementing designs tailored to supporting development in use by offering a design-oriented framework that accounts for the dynamic nature of artefacts in use, right from motive formation to the detailed interaction with the material artefact. The work presented here should be seen as a part of a more extensive series of efforts in using human activity theory as a theoretical basis for HCI and design work [Bannon and Bødker 1991; Bødker 1991; Bødker and Petersen 2000; Bardram 1997; Bertelsen 1998; Nardi 1996].

In the perspective developed by Engeström [1990] artefacts are seen as accompanied by several kinds of models or learning artefacts, which reflect and provide guidance for the use of the artefact. These encompass different aspects of artefact ranging right from the overall vision and purpose of an artefact to the models e.g. interaction principles supporting the interaction itself and onto the material character of the artefact. According to Engestrom [1990], it is important to ensure a coherence in the design of these different kinds of learning artefacts.

Adopting this framework, the traditional work on mental models within HCI is revisited and an alternative to the mechanistic and predictive types of mental models, which has dominated the area is sought through developing a dialectical approach to mental models, i.e. to understand them as different types of learning artefacts.

A case study, concerning a long-term study of two families' use of a new television set with an integrated video recorder has been analysed using the framework of learning artefacts. Apart from pointing to specific problems with an existing device, this activity also contributes towards making the framework of learning artefacts a means of analysis when designing for learnability of domestic technology thus broadening the scope of usability and design work.

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Design Anthropology – When opposites attract

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Design anthropology is a bricolage of design and anthropology. While the term design anthropology can mean the anthropology of design our focus here is on anthropology in design. Design anthropology tries to combine making sense of what is there with remaking what is there into something new.

Observation and Interpretation

Within the field of user centred design ethnographic observation has become increasingly popular. The involvement with users is not a neutral action taking place in a space and time of its own. Therefore it is necessary to pay attention to what is observed, and how this intervention in everyday practice is interpreted and described. Ethnographic observation is a fundamental element of anthropology. But what is anthropological, and hereby ethnographic, observation and description?

Clifford Geertz (1973) has characterised ethnographic description as interpretive; what it is interpretive of is the flow of social discourse. The ethnographic description is trying to rescue the "said" of such discourse from its perishing occasions and fix it in perusable terms, Geertz' uses the term thick description in this regard. Therefore to capture what is "said" on the many perishable levels of the flowing discourse one requires more than superficial thin observation.

When meeting users the understanding is created through a piecing-together of what is at hand, the established interpretation becomes a bricolage of the meeting with a specific situated practice. If this meeting is only positioned as thin observation, the multiple layers of the thick description derived from the situated practice of the users is lost and forgotten.

Situated practice

User centred design is interested in observing and understanding everyday practice. In anthropological terms this is situated practice. The concept of situated practice can be discussed respectively in terms of situatedness and practice. First; situatedness consists of the specific context of the situation including the various actors who are present - and the non-present actors who manifest themselves in the discourse of the given situation. The situation emerges through the individual presentations that take place. The combined expression taking form in the situation is the product of individual knowledge, plans and schemas. Secondly; practice is what you do, socially and individually. It is the everyday activities that often are of an unconscious character, taking place without conscious interpretation. The observed practice has to be recognised as the product of a dialectic relationship between cultural habitus (Bourdieu 1977) and individual biography. Cultural habitus is, amongst other, represented via norms, social values, cultural constructions of gender positions and so forth. This implies that the observed individual practice often is different from (or not equal to) the expected cultural practice. For design anthropology it becomes important to incorporate individual biography, experiences and cultural habitus.

Perspective and reflection

Anthropology is about understanding the others point of view, trying to see the world through the eyes of the people studied .The anthropologist starts as an outsider, through fieldwork and participant observation s/he gradually obtains an insider perspective. From this combination of outsider and insider perspectives new understanding is born. Within participatory design the same process is happening in reverse. Through participation in the design activities and reflecting upon their own work practice users see themselves through the eyes of the designers hereby obtaining an outsider perspective. From this combined insider and outsider perspective they are able to conceive new ideas for future work practices. Design anthropology is a point of view: Not our (the designers) point of view not their (the users) point of view, but an additional point of view, a double perspective.

Video as design material can be a valuable contribution to such a double perspective, both as tool and as metaphoric device for thought and ideas. The videotaped material can be used to make sense of ambiguous situations or to represent ideas for design. The camera itself can function as a catalyst for actions through provocation, as a tool for working with and filming of scenarios or through letting the user control the camera. Though video material is always situated, some things only emerge in certain contexts, or emerge differently in different contexts, and those watching shape the context as well.

Opposites attract

Design and anthropology both has to do with getting involved in social settings and the gathering of data. Anthropology tries to make sense of what is there in the present, whereas design wants to remake what is there into something new. The attraction between these opposites is to be recognised as an extension of both points of view through a merging.

There are different levels of intervention in the field with users, but design is always a social activity. Involvement in situated practice is about people and their activities, and understanding ones social intervention through a piecing-together. The process of piecing-together does suggest a merging of design and anthropology into a double perspective, into the shape of a bricolage of its own.

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Data Warehouse and Distribution of Organizational Knowledge

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The proposal is to investigate into the success of data warehouse development in Danish firms. A common approach view the data warehouse as a simple conglomerate and centralization of data within the firm and that the data is considered as synonymous with information and knowledge crucial for the firm. Often the isolated implementation of a data warehouse is considered as a sufficient condition for organizational success. Furthermore the description of data warehouse often has an extreme score on the positive-buzz-word-factor e.g.: "*Access* to *consistent* organizational data that can be *combined* for *query*, *analysis*, and *presentation* of *published* data with a *quality* that will act as a *driver* of *business reengineering*" (Kimball, 1996, p. xxiii).

In real life it is expected that the data warehouse is similar to other implementations of information technology and organizational transformation and the data warehouse is expected to be an excellent test-bed because it accentuates the view of the organization as an information processing entity, as when Galbraith (1977, p. 3) defines the organization as integrated by information-based decision processes and later argues how this leads to a formalization of data. The data warehouse could be the organizational attempt to balance uncertainty and complexity and avoiding being flooded by further acquisition of information. Thus 1) uncertainty - also considering the Burton and Obel distinction between uncertainty (where the value of the variables are unknown) and equivocality (where the existence of important variables are unknown or ignored) (1998, p. 174) - 2) complexity - also considering the view of Axelrod and Cohen (1999, p. 15) that complexity results in emergent properties - and 3) formalization becomes important variables for the implementation of the data warehouse.

Moving from the organizational view to a view of system development the same dimensions can be found among theoretists when it is argued that in a rational and formalistic constructivist view the complexity is reduced by abstraction and decomposition (Dahlbom and Matthiassen, 1993, p. 103). This could develop a technical success of coherent design, but the system would turn out to be an organizational failure because of its ignorance of the real world complexity. On the other hand, the evolutionary approach will attempt to tackle the uncertainty by involving refined experiments thus producing extra variables and thus generating more complexity. A condensate in practical terms of these thoughts could direct the attention of applying much user involvement in the development of the user interface and much organizational strategy in the structural design. Dahlbom and Matthiassen (ibid., p. 99) points with some elegance to Simon's term of "satisficing" rather than optimizing for a final solution because the system and the problem will undergo further development by a continuous interpretation and restating.

Another dimension to balance is the organizational explorative and exploitative efforts as introduced by March (1991) when addressing the aspects of organizational learning.

In the data warehouse both concepts are present as planned decision making support for management (exploitation) as well as the frontier breaking attempts to gain new knowledge through data mining (exploration). Thus data warehousing can be expected to be a vehicle for balancing exploration and exploitation in the organization.

Aspects of centralization are included in the mentioned organizational work (Galbraith, 1977 and 1994) and (March, 1991). Typically the establishment of the data warehouse is considered to represent an aspect of organizational centralization while the thoroughly validation of the data included in the data warehouse will demand scrubbing of data and draw demand the expertise of employees with detailed knowledge of the transaction system and "their" data in detail thus creating meaning through context (Checkland and Holwell, 1997, p. 90).

It is the intention of the research to further define success and to investigate successful data warehouse implementation by drawing on these dimensions.

Work Practices for Usability Testing of Computerized Systems and Mobile Devices

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Design of multimedia systems

The first activities in this stream have dealt with studies of designers working with highly interactive systems. These studies compared different software engineering approaches (Skov & Stage 2001a). To complement this picture, we have used a general method for object-oriented analysis and design (Mathiassen, Munk-Madsen, Nielsen & Stage 2000) to support the design of multimedia systems. This involves both conducting design processes ourselves as well as studying how other designers have worked (Eriksen, Skov & Stage 2000, Skov & Stage 2001b, Skov & Stage 2002). We have primarily dealt with multimedia systems that simulate a certain real world environment in order to train and assess the decision-making capabilities of persons operating in that specific setting. In addition, we have conducted empirical studies of industrial design processes (Skov & Andersen 2001).

Design of a usability laboratory for testing mobile devices

The second stream of work is dealing with design of a laboratory for making usability testing of communication systems and small mobile devices. The usability laboratory was originally designed and established in 1999 to facilitate a broad range of tests and products, including software running on a works station or PC. The shapes, sizes, and physical positions of the rooms available were given in advance. Otherwise there were no major restrictions on the design. The design of this laboratory was based on general descriptions of usability laboratories (Rubin) and experince from existing facilities (Kommunedata). Yet it was quickly realized that the testing of devices and communication based on devices raised new problems. These experiences were the basis for designing the second laboratory. In the spring of 2001, it became possible to move the usability laboratory to a place much closer to the research group using it. In this setting, we are experimenting with work practices for two kinds of usability tests. The first is testing of small mobile devices. The size and lack of a fixed physical position raises several practical problems. The second is testing of communication based on either computerized systems or mobile devices.

Human-computer interaction with new technologies

Software tools for implementing virtual 3D-worlds have been established as a new stream. We have described and evaluated two types of tools for implementation of software applications for a six-sided cave. The first type employs an interaction style that is comparable to classical programming. The second type employs graphical representation and direct manipulation. The evaluation of these interaction styles is based on an empirical study of two implementation processes where a tool embodying each style was used to develop the same virtual 3D-world. The programming tool was very flexible and facilitated an even distribution of progress over time. On the other hand, debugging and identification of errors was very difficult. The direct manipulation tool enabled faster implementation of a first prototype but did not facilitate a shorter implementation process as a whole (Kjeldskov 2002, Kjeldskov & Stage 2002).

Development of a simple usability testing method

In the last stream of activity, we have conducted two empirical studies of web-site usability testing carried out by a diverse group of people with no formal education in software development or usability testing. 36 teams of four to eight first-year university students with an interest but no education in information technology were trained in a simple approach to web-site usability testing that can be taught in one week. It is concluded that basic usability testing skills can be developed in a week. We have described how they applied this approach for planning, conducting, and interpreting a usability evaluation of the same web site. The student teams gained competence in defining good task assignments and ability to express the problems they found. They found, howver, quite few problems, and they seemed to lack an understanding of the characteristics that makes a problem list applicable (Skov & Stage 2001c, 2001d).

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Why user manuals should go electronic

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Introduction

In today's world, it is important to share documentation about goods and services. Electronic documents are meant for the user to review relevant documentation in a fast, easy and appropiate way. Nowadays existing technical literature in electronic format is created from existing electronic data, CAD Drawings, or other paper-based documents currently in use. User manuals, reference manuals, product catalogs, and technical manuals, are some typical opportunities to use electronic documents.

Electronic documents allow to search for text, make notes, extract information, view graphics close up, incorporate video, sound and other capabilities. It is also imaginable to integrate several languages in one application so software can be used simultaneously in various countries. In an electronic format the information can be made instantly available using portable computers, shop floor computers, Internet appliances, and more.

Research questions

Which new technology is socially credible? Which is most practically acceptable? What kind of system is socially and practically acceptable out on the refrigeration shop floor or in the heating room? What is the most forseeable way to get beyond Acrobats .pdf document format? What are the desirable challenges for software architectures when acces and publication in a database format, via the Internet or WWW pages, and even intra-nets is desired?

The case study

The age of the Internet and mobile communication is upon us. Manuals are already produced electronically, but they are used as paper. Thus the aim of this vision project for the Danfoss company was to survey optimal electronic use of manuals, their design, production and their maintenance in order to assimilate optimal results for both users and producers of electronic manuals.

As a joint effort between Refrigeration Controls Division, Building Comfort Division and User Centred Design the goal was to investigate the potential of electronic user manuals and database user manual production. The project ran for 6 months from August 2000 onwards. User research with a set of conceptual prototyping experiments has been carried out in different work environments in Denmark, Germany and the US. Research activities and testing prototype concepts ran in parallel to prompt user opinions. Investigations in database production tools were accompanied with a hands-on pilot database. A series of workshops tied the project together.

The users point of view

Information and guidance should be accessible via a controller itself, either as download online service or as embedded software. Such controllers could be for heating, refrigeration, motion, or any other kind of controls where steering and regulation is desired. Controllers with online potential will give access to information where information is needed. Index help to support trouble-shooting on-site is almost inevitably necessary. Even a selection guide as direction for purchase of application related items could be an important item. The load on service desks of unnecessary customer call-ins will decrease.

Most users will not be taking mobile technology bigger than pocket size with them. Transportable media, like CD-ROM, are thought to be for office storage. This media could be best used for educational purposes as a training or sales tool, where illustrations and text are combined with video.

One promising way to employ electronic media is the voice guide. Listening is sometimes better than reading – a installers hands will be free! Sound and visualisation at the same time is a good combination. Voice guidance could be an important aid for installation or set-up.

Any innovative development that considers the optimal care of users must also be capable of assimilating future paper manuals. Nowadays paper manuals are mostly stored twice, in the office and on-site. Installers want 'their own' manual. Electronic manual technology can personalize data by making notes, amending the text, and changing fonts and font sizes to improve readability. Bookmarking, searching, and cross-referencing will be important features for electronic manuals. Customization is required.

Paper- and electronic-based literature has to get integrated in the product development process from the beginning. Today's literature is handled as a secondary aspect. Products get more and more complex, which means a need for consequent relationship between product and explaining literature.

Any new electronic technology starts with a database. Proper organization of data and the possibility for searching in databases requires metadata to be put onto every element in it. Modularization and back-end reuse of information across product variants and across different media (paper, web) should serve single-sourcing. Aspects of database production and of delivery system should be considered in a global Danfoss text writer commission.

The challenge

A new innovative user manual concept will give way for a whole new generation of technical literature, one that will change current ways of working and current ways of organising work. It will in the end change a text-writers concern and obligation, if not the working routine in general. Technical writers will turn into information providers with new roles and new profiles. Users and customers will be supplied with new technology for preparing work, installing tools, operating machinery, and problem solving for systems.

Design History for Information Design

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Introduction

To form a deep understanding of any design artifact, we need to understand how it came to be. This is especially the case within information design such as affinity diagramming performed for early-stage web design or phenomenon analysis performed in early-stage object-oriented development. In this poster, we present an informal history system that assists collaborative, early-stage information design though a number of interesting capture and retrieval mechanisms.

The history system is currently embodied in the context of the Designers' Outpost [1], a wall-scale, tangible interface for collaborative web site design that supports information design for the web. The design of the Designers' Outpost is centered around the existing – and effective – praxis of information design using plain paper and whiteboards, and thus users have the same fundamental capabilities in the Outpost system as in a paper and whiteboard system: One can create new pages by writing on new Post-it notes, and add them to the electronic wall and organize a site by physically moving Post-it notes around on the board (see Figure 1).

This provides the user with a light-weight, non-distracting interface where paper in the physical world becomes an input device for the electronic world. The physical Post-It notes integrate with the electronic board through two cameras: A rear camera mounted inside the board captures the location of notes, detecting when notes are added, removed, or moved, and a front camera captures the contents on the physical notes so that electronic counterparts can be created by means of a rear-mounted projector that outputs electronic information back onto the wall surface in the physical world (see Figure 2).

Figure 1. The wall-scale, tangible interface

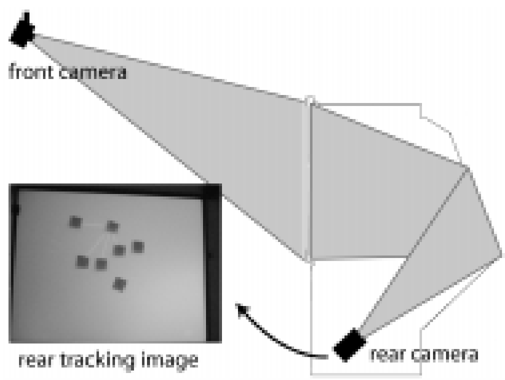

Figure 2. The two cameras used to track and capture contents

Thus, The Designers' Outpost provides the user with an interface that is familiar, and yet the system has the potential of offering the user with much more advanced behavior though the endless possibilities offered by the electronic world.

Exploiting the Electronic: Capturing the Design History

One problem with the existing paper-based praxis is keeping track of changes over time. As the design progresses changes are frequently made: notes are added, removed, moved, grouped, linked, etc. Much of the basis for understanding the design at a given point in time often lies in understanding how it came to be, yet this information is not easily captured and it is certainly not automatically captured in the paper-based world. Enter the electronic world: As the electronic board continuously monitors the physical artifacts, the system not only records the artifacts, it also records the changes that occur on and around them. Thus, in our history system the complete design history is captured continuously and automatically.

Capturing information only solves part of the problem, though. A design history is only useful if it is used. For this end we have designed a number of lightweight, yet powerful, mechanisms for interacting with the design history: a *main timeline*, a *local timeline*, and a *synopsis view*. The *main timeline* is a visually navigable set of design thumbnails organized on a timeline. As displaying the complete design history would lead to information overload, this view can be filtered in a number of ways as by activity (command, time, meeting) or by property (author, note). Also the captured branched history is presented with emphasis on simplicity: Instead of presenting all branches only the current branch is displayed in full detail resulting in a pseudo-linear history. The *local timeline* presents information for a particular note *in situ*, and thus provides detailed information in the context of the individual items. Finally, the *synopsis view* presents a visualization of the design history that is radically different from the two others: The design is presented in a tabular fashion that is suitable for e.g. printouts.

Conclusion

We have presented a design history system for early-stage information design. The system has been implemented as an extension of the Designers' Outpost, and has been evaluated successfully experimentally: As demonstrated by an informal lab study with six professional web site designers, this history system enhances the design process itself, and provides new opportunities for reasoning about the design of complex artifacts. Besides supporting web design, our work on design history should in many aspects be transferable to other information design practices and we thus hope that this work will inspire work in other professional domains as well.

Based on work in collaboration with Scott R. Klemmer , Ethan Phelps-Goodman, and James A. Landay (Group for User Interface Research, UC Berkeley, USA)

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Interaction Techniques for Spatial Organization of Digital and Physical materials - the Topos Approach

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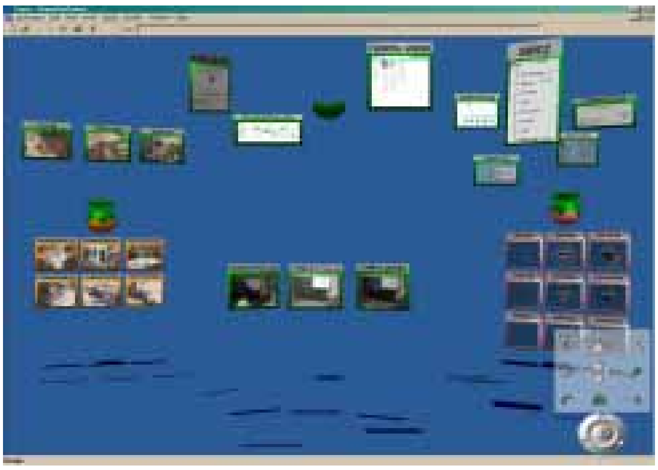
We are working in the domain of interactive workspaces supporting distributed organisation of and collaboration on diverse digital and physical materials. For this purpose we have developed a spatial computing infrastructure called Topos. Topos is instantiated in a a variety of prototypes providing a 3D environment supporting handling, relating, sharing, and arranging of diverse materials (drawings, pictures, 3D models, spreadsheets, etc.). It has been designed for use on desktops as well as for interactive walls, tables, and mobile devices. Topos has been designed from the outset to alleviate the burdens of finite 2D screen space via the use of 3D. The 3D interface of Topos provides a natural and physical interface metaphor by exploiting users' intuition about 3D space. Topos and its applications are being developed within the WorkSPACE project EU, FET programme on The Disappearing Computer, and utilizes ideas and concepts from the EU, LTR, Desarte project and the Danish Center for Multimedia, DMM project. The development is carried out in close collaboration with potential user groups, most prominently landscape architects.

Topos allows for manipulation and maintenance of relationships among materials in a 3D environment. It integrates with existing applications on the given platform, supports collaboration among people across the Internet and runs on Windows 2000, SGI IRIX and Linux. The figure below shows a screen shot of a Topos client. It depicts an open workspace containing a set of documents and sub-workspaces with more documents.



Double clicking any of the documents will launch the document in its appropriate application, and changes to the document will be reflected within Topos in near-real time. The two-colored spheres represent open sub-workspaces. The upper hemispheres are proxies referring to the workspace underneath. The 3D objects can be moved, sized, rotated etc; light effects may be applied; documents may be made semi-transparent; manipulated as groups and so forth.

Grouping materials in 3D space is familiar to us all from our daily lives: we build heaps of related documents on our desks; we place related materials together on shelves, etc. A main point of the Topos prototype is to reflect and support such grouping of materials in digital form and potentially the intermixing of physical and digital materials. Topos also supports grouping and organization of materials by means that are not possible in the physical world: groups can be moved and placed as a whole; sub-groups can be closed to unclutter the space; gravity does not apply, space is less limited; etc.

Topos supports informal grouping of related documents and models within 3D workspaces. Being three dimensional, the workspaces allow for much more freedom in placement of work materials and allows the users to oversee much larger collections of materials at a time than would be possible in two dimensions. Documents and objects may simultaneously reside in many contexts where flexible and fluent support between focal and peripheral awareness of them is supported.

Topos supports several physical interaction devices: traditional keyboard and mouse, pens for use at an interactive whiteboard, spaceballs for finegrained 3D manipulation, PDAs via infrared communication, large tabletop stereo displays, interaction with laser pens at a distance, etc. The many different interaction devices provide for different interaction styles: what you do at an interactive whiteboard and how you do it, differs from what you do at the desktop. To support these many styles of interaction, Topos supports changeable interaction styles: At the desktop one may use a style taking full advantage of all mouse buttons, scroll wheels and keyboard. While standing in front of a whiteboard a style allowing all interaction using only one pen-button together with gestures may be more suitable.

Our live demo/interactive poster will demonstrate Topos interaction techniques together with the collaborative and information organization facilities of the infrastructure.

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Doctoral Colloquium

26. November, 2001

Organised by Susanne Bødker

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Learning from design reflection: Retrospective stories of industrial development processes

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Abstract

This paper reports on a study of how industrial product developers obtain knowledge about the product development process through design reflection. Two design reflection sessions have been organised in an action research tradition, the sessions provide design teams with the opportunity to discuss their design process and at the same time the sessions support both the establishment of a shared understanding of the project, and the exchange of design experience among the designers. The participating designers are highly satisfied with the design reflection sessions and suggest that they become a recurring element in their product development projects.

Dimensional analysis of the video material recorded has been used to deepen insight into how product developers learn about the design process through learning dialogues. By expanding the understanding of how product developers learn I believe it is possible to adapt development methodology to support the development process. The design reflection activity reported upon here is meant as a contribution to this.

A learning approach to product development

Prescriptive product development models tend to relate the design team activities to the product: Specification, conceptual design, prototype design etc. They build on the assumption that innovative design projects can be conducted using normative design procedures. As pointed out by Blessing [Blessing 1996] these models have a poor fit with what is actually going on in industrial product development projects.

Collaborative product development [Brandt 2000] on the other hand, supports collaboration between participants with those different competences relevant for the development of the product to be. The focus is here on staging collaborative team events that allow an open exchange of views in the design process [Buur and Bødker 2000].

To further expand the collaborative approach in the direction of a learning paradigm this work focuses on the learning that takes place in the design team through collaboration. From design practice in the User Centred Design group it is recognized that if the product development team has a profound engagement, curiosity and openness towards learning about the product to be, about the application and the potential technical solutions, then the project is almost certain to become a success. This recognition has encouraged to approach product development from a learning perspective, i.e. to try to support this willingness to learn throughout the product development process.

I use the concept of learning to describe a process that results in changes of behaviour, attitude, and values of people; in doing so I lean towards an understanding of learning process theories expressed by Hermansen [Hermansen 1998]: Learning process theory concerns how to understand the meaning of reflection in development (the term "development" understood in a wide sense.) With this focus on reflection as a fundamental aspect in the learning process I have set out to explore designers' reflection on industrial design processes.

Two cases of design reflection sessions

The material for this paper stems from two action research experiments in ongoing development projects in the Danish manufacturing company Danfoss. Inspired by Schön's concept of reflection-on-action [Schön 1987] I organised two design reflection sessions within the Danfoss User Centred Design group for the designers to reflect upon their own process, and for me as researcher, to study the learning processes involved. Each of the two sessions ran for almost a day. They focused on two different projects and were set two months apart. The group of participants were almost identical: Members of the respective design teams and colleagues from the group.

The Valve Handle case

The first design reflection session takes place at a time when a 6-month design project on new handles for industrial valves is almost completed: The design is finished and accepted by the organisation, and only a few practical issues remain to be solved.

Present at the event are Henrik (anthropologist) and Anders (industrial designer), the two main actors in the project; Lene (HCI scientist) and Peter (mechatronic engineer), who have been partly involved in project activities; John G. and John M. (mechanical engineers), who are visiting Ph.D. students, and I, who facilitate the event. The session is organised in the groups' meeting area, the programme of the day holds the following activities:

1. Introducing the project

Anders briefly explains the starting point of the project and the results achieved.

2. Establishing the project timeline

Participants are asked to illustrate the sequence of activities in the project on a large display of wallpaper; they do this by sketching and attaching photos and documents to it.

3. Reflecting on what was learned

Subsequently all participants are encouraged to think about what was learned during this project. They write statements on post-it notes, attach them to the timeline according to when the learning took place, and study each other's notes.

4. Discussing learning statements in relation to Nonaka's framework

Next I briefly introduce a framework concerning the development of new knowledge from combining tacit and explicit knowledge [Nonaka 1994]. Participants are asked to pick up at least one of their post-it notes, read the learning statement that is on it aloud and place it in the Nonaka structure, while, at the same time explaining why they want to place it at this particular point in the framework.

5. Future learning activities

With two Ph.D. students just arrived in the group, we take the opportunity to discuss, what they would like to learn about user centred design during their guest visit in Denmark, and how this could be accomplished.

The Refrigeration Electronics case

The second design reflection session is organized when the team is halfway through another 5-month project on the design of enclosures for electronic refrigeration controllers for supermarkets.

The participants are almost the same as in the last session, but now Anders, John G. and John M. form the design team, and besides that Peter and Henrik have joined a few of the project activities. Ulla (industrial design engineer), another member of the group, participates instead of Lene. The first three steps of the programme are identical to those in the first session, but the last two activities are changed, because this project is still in progress. The intention is to use the reflection session to catalyse a talk about the plan for the second half of the project; therefore the following activities are added to the program:

4. *Developing criteria for success*

Participants are asked to spell out the stakeholders in the client organisation, and to develop a list of success criteria for the project.

5. Discussing future activities

Finally we work in three groups to discuss how the process should continue to become a success for the client, the User Centred Design group, and the two visiting PhD. researchers.

How participants evaluate the sessions

Towards the end of both design reflection sessions, we evaluate the session and formulate if and how it has been beneficial for them to participate:

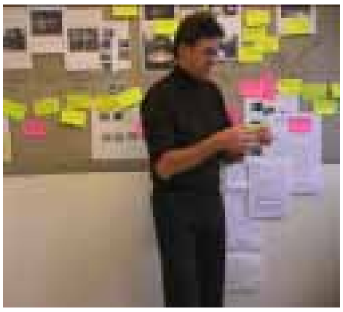
> Design reflection session 1:
>
> Henrik: “I think it is essential to formulate what we have seen for our colleagues and of course also to get some feedback, things we have not thought about before”.
>
> Birgit: “What helps you formulate these things?”
>
> Henrik: “Their questions”
>
> Lene: “And it is also important for us [who have not been directly involved in the project] to learn something about the project, to be able to take part in planning future activities like a workshop or planning a video card game”.
>
> Henrik: “It is the way of being forced by their questions, being forced to formulate [your experience] by your colleagues’ questions”.

> Design reflection session 2:
>
> Birgit: “What would it have been like if we had just started here [pointing to the point representing “now” on the timeline]?”
>
> Anders: “It would just mean nothing, you have to have the story […]”
>
> Henrik: “The left part [which is the preceding three months on the timeline] that is about establishing a common understanding and establishing a common

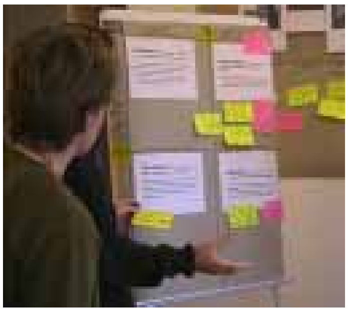
consciousness about the project, how it did proceed, and we need to be in agreement, we need to agree in common on how the project developed so we are actually developing or inventing a story about the project – this project story is essential [in order for us] to look into the future”.

In session 1 the designers articulate the benefit of having to formulate and communicate personal experience. In session 2 the designers are very content with the way the reflection session supported them in building a shared picture of the design process and they find it extremely beneficial to focus the discussion on future design activities in the process.

Having established that the design reflection sessions were a success with the design teams we moved on to deepen our insight into how the good experiences expressed by the designers had come about.



Henrik reads a learning statement aloud before he places it on the time line.



John M. discuss with Birgit in front of the Nonaka framework.

Anders sums up criteria of success for the refrigeration electronics project.

Patterns in design reflection dialogues

To approach an understanding of the learning that takes place among designers when they reflect on their design process I have analysed the video recorded material. In total the material covers 10 hours, from which 57 sequences of a few minutes duration each were selected; these sequences represent what I regard as potential learning situations the participants are very concentrated and the situations are intense.

A group of experienced designers were invited for a Video Card Game with the purpose of establishing an overview of possible categorisations. The Video Card Game is a method for collective video analysis developed by the Danfoss User Centred Design group [Buur J. and Søndergaard 2000]. During the game the players group video clips into favourite families and give each family a headline. This grouping and subsequent naming of card families was used as input for a Dimensional Analysis. Dimensional Analysis [Kools et al. 1996] expands the approach to Grounded Theory introduced by Glaser and Strauss [Glaser and Strauss A.1967].

Through the analysis it became clear that there were patterns in the way the designers talked together in the design reflection sessions; at the end of the analysis it was possible to distinguish five patterns of dialogue that all contribute to collective learning in the design team:

(1) Verbalising individual experiences: The participants support each other in articulating what they have experienced in the design process. Putting words on their observations and feelings initiate individual reflection. Supported by design colleagues,

participants arrive at a verbalised description of personal experiences.

(2) Categorising similar experiences: *When participants realise that they have experienced similar situations, they try to find categories or "headlines" to describe the familiarity of their experiences and they arrive at an extended understanding.*

(3) Negotiating understandings of shared experiences: *When participants have attended the same activity, but have vastly different experiences of what happened. They may recognize this in a type of dialogue where they voice their own interpretation and come to accept that of the others'.*

(4) Clarifying interpretations of concepts: *Sometimes participants realise that they do not share the same understanding of terms or concepts. They discuss the meaning of the specific words, and they arrive at an attuned understanding that all can agree on.*

(5) Suggesting hypothesis: *When several participants come to agree on experiences and interpretations, and these are in agreement with experiences from previous projects, they sometimes volunteer a hypothesis: A cause and effect statement of general validity.*

These dialogues all take individual or collective experiences as a starting point. They seek to formulate, negotiate, or generalise them into concepts or possible hypothesis. It is characteristic for these dialogues that they represent a progression in either a personal or collective understanding of an experience or an abstract concept. Therefore the term *learning dialogues* is used.

Learning dialogues in design reflection

In the following I will present examples of the first and the third type of learning dialogues.

Verbalizing individual experiences

During the Valve Handle project, the HCI scientist Lene at one point was asked by Henrik and Anders to facilitate a design workshop, even though she was not actually part of the team. The workshop had participants both from the design team and the French subsidiary of Danfoss, and in contrast to Henrik and Anders, Lene had an extensive experience with facilitating such events.

While placing learning statements in the Nonaka framework, Lene comments on one of her statements concerning the planning of this workshop which is depicted on the timeline:

> Lene: "I had difficulties explaining what I think I learned [when I wrote this learning statement] – I understood that I learned something! I think I learned that bringing your ideas about solutions, you have in your head – ideas about what the solution could be – in the open in the planning phase, in front of other colleagues, that will give you feedback on both process and product. I think that this is what I learned in the planning phase that I had not expected to learn".
>
> Anders: "When you say planning, planning for what?"
>
> Lene: "Planning the workshop"
>
> Anders: "This one here?" Anders points to a particular workshop on the timeline.
>
> Lene: "Yes"
>
> Birgit: "Lene does that mean that ideas for the product also influences the process?"

Lene: ” Exactly, very much”.

Anders: “What did you say?”

Birgit: “The ideas you come up with in the planning phases also influence the rest of the process, the continuation of the process.”

Anders: “Didn’t you say ideas about the product?”

Birgit repeats what she just said

Anders: ” Oh yes sure”.

Peter: “But wasn’t the product here the posters?”

Lene: “No, because I had the feeling that especially Henrik and Anders had some ideas for solutions, design ideas, which for me in the planning phase… I had to understand part of it to plan the workshop”.

Peter: “Yes, yes, yes”

Birgit: “Okay”.

Lene: “If you do not bring these ideas in the open...”

John: “…You go down a wrong path?”

Lene: “You may plan a workshop that isn’t working”

From having an unclear, perhaps intuitive feeling of a link between design ideas for the new product and the workshop process, Lene articulates her experience into an understanding that she can share with others. This happens through the dialogue with Anders, Peter and Birgit.

In this category of learning dialogues the designers support each other in verbalising personal experiences. The dialogue starts out with a very loosely formulated recognition; during the dialogue a clearer content evolves, partly due to the internal personal reflections that come about while formulating and verbalizing the experience, and partly due to contributions and clarifying questions from design colleagues.

The second example stems from the category of learning dialogs called Negotiating understandings of shared experiences.

Negotiating understandings of shared experiences

Early on in the session, when establishing the timeline, the anthropologist Henrik explains how he felt after completing user field studies in Norway, Germany and France, and finally conducting a video card game to analyse the outcome:

Birgit: “Was it some kind of frustration?”

Henrik: “Not frustration, I perceived it as emptiness, you have done a big thing and then aaahhh – [Henrik acts exhausted] – you have to go on”.

Anders [with a lot of enthusiasm]: “ That is where we differ, ‘cause I was by no means empty – I had all this [pointing to items on the timeline on the wall] going on in my head at the same time as we were doing this and doing this, so I was very, very full and I needed to get to this stage here [pointing to a place further down the timeline] to start getting it out”.

Henrik and Anders have both experienced the same field studies and they have collaborated in the video analysis session, but they obviously felt very different at this particular point in time that they refer to on the time line.

In these dialogues the verbalisation of personal perceptions of shared experiences are developed and exchanged. There are no rights or wrongs, the participants refer to individual experiences or feelings, and the dialogue ends with a mutual recognition of the fact, that different people may perceive the same situations differently.

Triggering learning dialogues

The examples show how learning dialogues support personal experiences and perceptions in being developed – via reflection and iterative verbalization – into recognitions that can be communicated to others. In the analysis it became clear that certain activities during the design reflection sessions seem to afford particular types of dialogue, i.e. that it is possible to trigger fruitful learning dialogue with particular means. The examples above illustrates how establishing the chronology of the project and placing learning statements on the timeline invites participants to reason about: What happened and when? And further more: What did I learn? When did I learn this?

Conclusions

The study has provided access to the *informal learning* that takes place during product development processes. The concept of learning dialogues is used to describe how learning takes place among professional designers in design reflection sessions in contrast to the *formal learning* about the design process, that depict the product development process by prescriptive models and normative design procedures.

A Grounded Theory approach to the analysis of video material from design reflection sessions has served to generate insight into how designers collaboratively learn about the design process through *learning dialogues*. Different types of learning dialogues can be triggered by particular activities in design reflection sessions. The theory evolves from the research field itself, namely the field of industrial product development. - It is remarkable that during the 10 hours of video recordings of designers reflecting on the industrial product development process, lack of technical competence is not mentioned at all; neither is the problem of getting good ideas. When regarding product development from a learning perspective, the ability to learn and the knowledge about how to support learning becomes equally valuable as technical skills.

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Experimental Modelling
Object-Oriented Modelling in Experimental System Development

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Abstract

Modelling is an essential activity in object-oriented system development. Through models, an understanding of a problem domain is represented in the solution domain. In experimental system development, solutions to complex and uncertain problems are collaboratively and iteratively developed. This thesis tries to inform and combine the practices of object-oriented modelling and experimental system development from three perspectives: theory, techniques, and tools.

Introduction

What is "Experimental System Development"?

Traditional specification-oriented methods have severe limitations since they are based on a detached, observation-based feed-forward approach to system development that seldom matches the complex and continually evolving work practices that many systems have to support [6]. Prototyping approaches try to overcome this by focusing on the construction of a set of prototypes that can be evaluated (or even co-constructed) by potential users of the system under development. Participatory design techniques try to involve potential users in the development process for moral and practical reasons but seldom consider implementation of the system under construction. *(Cooperative) Experimental System Development* [8] tries to combine prototyping and participatory design techniques by focusing on active user involvement throughout the entire development process. Experimental system development separates *activities* and *concerns* analytically: Activities (workshops, cooperative prototyping, modelling) are what goes on concretely in a project and they contribute to more abstract concerns (management, realization, design). It is stressed that since concerns are not activities they cannot be finished but only continually elaborated through various activities.

What is "Object-Oriented Modelling"?

Simplistically, *object-oriented modelling* can be seen as a mapping between concepts, phenomena, and their relationships in a perceived real world to classes, objects, and their relationships in a software system (Figure 2) [12].

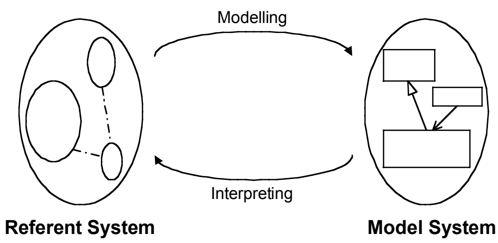

Figure 2. Modelling and interpretation.

However, the modelling process is much more complicated than that: It is iterative:

models are constructed and de-constructed (interpreted) continually during development. It is multi-perspective and collaborative: developers and end users often collaborate to produce a working system – and thus a model of that system. It is heterogeneous: models are represented in various ways (as class diagrams, as prototypes, as software architectures) and as the result of various inputs (user stories, studies of work practice, previous systems).

What are the Problems?

On the one hand, object-oriented modelling in experimental system development, *experimental modelling,* is a conceptual mismatch: modelling mainly supports specification-based development that provides a fixed set of views on a problem domain. On the other hand, if systems are to be realized in such a way that they are sound software engineering-wise, object-oriented development and thus modelling should be considered.

This thesis proposes that object-oriented modelling techniques and tools can be adapted to experimental system development in an effective and efficient way.

Structure of this Summary

The thesis itself will be an extended summary of [2], [3], [5], [4], [7], and [9]. This thesis summary follows the proposed outline of the thesis: First, this introduction has discussed background and presented the problems that we try to solve. Second, we present empirical studies of experimental modelling and discuss implications for tools and techniques for modelling. Next, we present two validated sets of techniques for experimental modelling: an architectural strategy to cope with uncertainty and techniques to represent models based on uncertain knowledge. The Knight tool for collaborative, experimental object-oriented modelling is then presented and discussed as an example of a tool that handles most of our proposed implications for tools and techniques for experimental modelling. Finally, we summarize.

Experimental System Development & Object-Oriented Modelling

The material in this section is based on extensive studies of modelling practice particularly in connection to the Centre for Object Technology (COT, http://www.cit.dk/COT) projects. The method used has been ethnographically inspired observations coupled with active participation in some of the studies. Three aspects of the activities studied were of particular interest to us:

- *Cooperation*. How does the developers communicate, coordinate, and collaborate?
- *Actions.* How does the developers physically interact with their tools?
- *Use.* What are the semantics of the developers' results?

The 'action' and 'use' categories are inspired by Bly et al.'s observations of shared drawing [1].

Based on these observations, we see experimental modelling as:

- *Collaborative.* Models are created in collaboration between many people: developers have to collaborate with developers and users and vice versa.
- *Multi-perspective.* People within a development team have different competencies: they may, e.g., be software engineers, participatory designers, or

ethnographers [2]. The intersection of perspectives is also necessary when considering the development team and external stakeholders: developers, end users, and management, e.g., need to collaborate in order to make system development successful.

- *Iterative and incremental.* Each activity in experimental system development contributes to a more satisfactory understanding of the system to be developed and the context it is to be implemented in. Consequently, models need to be iteratively and incrementally refined in order to fit this understanding.
- *Parallel.* Activities contribute to different concerns and activities are often carried out in parallel. Ethnographical studies may, e.g., continue to investigate new areas of a work practice while prototypes are being constructed for what is the current understanding of problems and solutions.
- *Heterogeneous.* Models are represented in heterogeneous ways and the sources of models are heterogeneous: Models may, e.g., be shown graphically in the form of Unified Modeling Language (UML, [13]) diagrams on whiteboards, they may be embedded in code, or they may be communicated verbally as shared understanding between developers. Models may, e.g., be created using observations, interviews, work artefacts, or previous systems as sources.
- *Open-ended.* During modelling, situations occur in which any given (formal) modelling notation is not able to express what its users need it to express. UML, e.g., cannot show illustrative freehand drawings or images but practitioners often adopt the UML to do so.
- *Creative.* Expressing an understanding of a problem domain through a model is also a design of a solution domain: innovative models have to be created in order to express an emerging understanding of a solution.

Tools and techniques for experimental modelling should support – or at least not hinder – modelling processes as above.

Techniques for Modelling

We have chosen to look mainly at two areas of modelling techniques: that of creating models that can appropriately adapt to changes due to the parallel, iterative and incremental nature of experimental modelling and that of notationally representing such models.

Changing Models

The UML is the most prominent modelling notation used by system developers. For experimental modelling it has a number of problems, however, in that it provides a single level of "formality". Its expressiveness lays somewhere in between what is possible on a whiteboard and what is needed when translating models to code. It is, e.g., not possible to represent classes without names or connect classes to illustrative drawings.

To remedy this, we have restructured the UML based on a conceptualization of levels of "formality" as matching levels of expressiveness of "diagrams" and "models". (The UML distinguishes between "diagrams" that are graphical representations and "models" that provide the logical structure (classes, objects, associations, etc) behind diagrams. A meta-model describes (using the UML) the legal UML models. A meta-diagram describes the legal UML diagrams.) On a whiteboard, drawings can be seen as elements in a very expressive meta-diagram while UML diagrams in a UML tool typically are very restricted. [11] relates that models may beneficially be presented in a “sketchy” way in order to make people more willing to suggest changes to it. Such a model is an instance of an expressive meta-diagram and a restrictive meta-model.

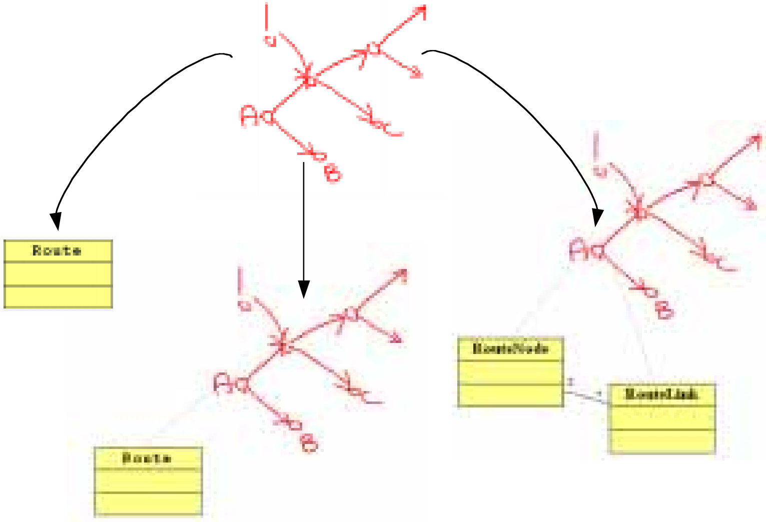

Figure 3. Restrictive transformations of a freehand drawing

To support experimental modelling it is important to be able to freely shift between levels of restrictions (Figure 3) and to be able to define extensible levels of restriction of meta-models and meta-diagrams. We have implemented and demonstrated techniques for this in the Knight tool (described later).

Modelling Change

One way of coping with the uncertainties of experimental system development is to build models in which changes are localized in order to minimize the impact of changes. We have investigated this on the software architecture level of system development. Based on these investigations, we have introduced a software architectural notation (Figure 4) to show software architectures and how they handle the areas that are most likely to change.

This notation was used as part of the Dragon Project [2] in order to analyze the impact of changes and how changes were handled. The result of this is an architectural strategy and a set of associated software architecture patterns [10] that isolate changes to the user interface of an application and its problem domain object model, respectively.

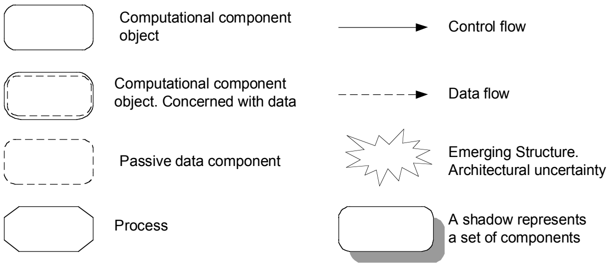

Figure 4. Software architectural notation for representing uncertainty

Tool Support for Modelling

Ordinary whiteboards are strikingly effective tools for modelling: they are continually available, provide natural affordances for diagramming, enable collaboration, and are easy to use. For modelling they also have problems: it is difficult to manipulate the contents of the whiteboard, to save and restore the contents, and it is necessary to fully understanding a formal notation such as the UML in order to use whiteboards efficiently for modelling.

The *Knight* tool tries to combine the benefits of whiteboard and computerized tools while avoiding most of their problems. The tool supports UML and the extensions discussed above and is primarily used on electronic whiteboards (Figure 5). The large, physical size of electronic whiteboards naturally supports co-located collaboration.

Figure 5. Collaborative modelling using the Knight tool

The user interface (Figure 6) is a large white surface on which users draw gestures using dry pens. In order to, e.g., create a UML class symbol, the user draws a gestural stroke that resembles a rectangle. The Knight tool then automatically transforms the gesture. Gestural interfaces have several advantages over traditional window-icon-pointer-menu interfaces: they allow input directly on the workspace, are fast to draw, and have a low cognitive overhead.

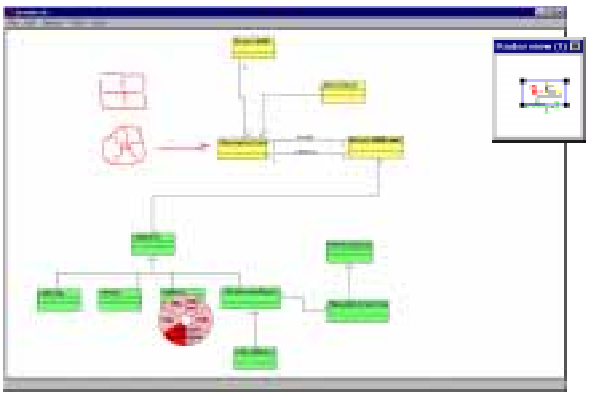

Figure 6. Knight user interface

The Knight tool was initially evaluated positively in a number of formal user tests. Later it has been commercialized by Ideogramic (http://www.ideogramic.com) in close cooperation with “beta” customers who continually used the tool for production work.

Expected Contributions

The contributions of this thesis are expected to be within three perspectives on models and modelling in experimental system development:

Theory

We have developed an empirically based conceptualisation of modelling and use of models in experimental system development characterized by a high degree of uncertainty and pointed to implications for tools and techniques for modelling in such a setting.

Techniques

We have introduced and discussed techniques for handling uncertainty while modelling during experimental system development. These techniques use existing techniques, i.e., software patterns and architectural styles, in new ways as well as extensions to existing modelling notations, i.e., the Unified Modeling Language (UML), to cope with uncertainty in object-oriented software architectures.

Tools

We have presented the Knight tool designed for collaborative modelling in experimental system development, and discussed its design, implementation, evaluation, and eventual commercialisation. Furthermore, we have discussed its integration with the Topos tool.

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Kontekstbaseret Informationssøgning
– Social Navigation og Usability

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Projektet [2001-2005] har til formål at undersøge hvordan konteksten, herunder sociale aspekter, indvirker på brugeres søgeadfærd, problemløsning samt accept af et givent informationssystem (usability).

Projektet søger at samtænke teorier og metoder fra såvel Information Retrieval (IR) som Human Computer Interaction (HCI), men med vægt på samspillet mellem bruger, system og kontekst.

Informationssøgning og informationssystemer er i dag ofte en integreret del af arbejdsdomæner og –processer, som enten direkte eller indirekte betinger og forudsætter kvaliteten af den enkeltes arbejde, herunder de aktiviteter der udføres i samarbejde med andre inden for en given organisation eller arbejdsdomæne.

I det daglige benytter vi bevidst eller ubevidst social viden eller omgang med andre som hjælp til problemløsning: vi påvirkes eller lærer af andres holdninger, adfærd m.v. Sociale aspekter er dermed et vigtigt kontekstafhængigt element ved problemløsning, som her er forstået som:

> ”A process in which humans purposely engage in order to change their state of knowledge” (Marchionini, 1995).

Der findes adskillige forsøg på at forstå informationssøgningens natur bedre (fx Ingwersen, 1992; Marchionini, 1995, Kulthau, 1996 og Golovchinsky and Belkin, 1999), som bla. har bidraget til en større forståelse blandt systemdesignere af brugeradfærd. Meget af forskningen inden for interaktiv informationsformidling har imidlertid fokuseret på individuelle og kognitive aspekter af informationssøgning, mens mere affektive og sociale aspekter først inden for de senere år har gjort sig gældende. Sociale aspekter skal her forståes bredt som krydsfeltet mellem socialpsykologi og social viden (socialitet, social interaktion m.v.)

Ligeledes har forskningen inden for menneske-maskine-interaktion traditionelt fokuseret på psykologiske og individrelaterede aspekter af brugbarhed (usability) og i mindre grad de sociale og kontekstafhængige aspekter som væsentlige for brugeres accept af systemet.

Som et relativt nyt område beskæftiger social navigation sig med det sociale aspekt af informationsrum og –systemer – hvordan information her genereres og anvendes.

Social information kan bla. benyttes til at filtrere information, fremfinde kvalitetsinformation eller etablere sociale fordringer (affordance) i interaktionen, som sammen med en forståelse af brugerne, deres opgaver og mål kan medvirke til at skabe mere brugbare informationssystemer.

Projektet fokuserer således på at undersøge hvordan konteksten kan/skal benyttes mhp. at understøtte problemløsning eller give brugerne opgaverelevant information og/eller tjenester.

Udgangspunktet er, at kontekstinformation i form af social viden har en kognitiv autoritet, der vil påvirke brugeres søgeadfærd og problemløsning; at sociale aspekter vil påvirke brugerens accept af et givent system samt at indvirkningen på brugeren vil variere med brugerens videns- og erfaringsniveau. Det kan formuleres mere specifikt til en undersøgelse af:

- Sammenhængen mellem sociale aspekter og søgeadfærd
- Sammenhængen mellem social navigation og usability
- Sammenhængen mellem social navigation og brugeres forskellige videns- og erfaringsniveauer
- Analysemetoder og –teknikker, der kan afdække social navigation og brugen af kontekstinformation ved informationssøgning

Projektet afgrænses til et givent domæne og kontekst, som på nuværende tidspunkt ikke ligger helt fast og vil overvejende basere sig på kvalitative studier. Metoderne vil variere mellem laboratorieforsøg og mere etnografisk inspirerede tilgange med brug af teknikker som fx fokusgrupper, observation, verbale protokoller, scenarioteknik og logfiler.

Målet med projektet er i sidste ende at *kunne udsige noget om hvilken effekt kontekst, sociale faktorer og forskellige brugerkarakteristika har på interaktion og brugerens accept af systemet* for derved at kunne bidrage til design og evaluering af brugbare informationssystemer. Det søges nærmere opfyldt ved at:

- Bidrage til forståelsen af sociale aspekters inflydelse på problemløsning via interaktive informationssystemer inden for et given domæne eller kontekst
- Udvikle en teoretisk referenceramme mhp. studiet af sociale aspekter ved menneske-maskine-interaktion og dermed også at supplere den individbaserede HCI-forskning
- Udvikle empiriske undersøgelsesmetoder til evaluering af kontekstbaseret informationssøgning, herunder sociale aspekters indflydelse på søgeadfærden og usability

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