Position paper for the Workshop on User Modeling for Context-Aware Applications, UM2001, July 13, 2001, Sonthofen, Germany.

Some Thoughts on Using Context Awareness for Enhancing Knowledge Work Environments

Anders Broberg (*bopspe@cs.umu.se*), Thomas Pederson (*top@cs.umu.se*)
Department of Computing Science, Umeå University, SE-90187 Umeå, Sweden

Introduction

As early as 1973, Peter Drucker described a shift in the structure of society in which knowledge workers were pointed out as the workers of the future.

Definition: A knowledge worker is a person principally concerned with data, information, and knowledge as working objects, often working with these in both the physical world and the virtual world (digital information spaces), and sometimes in the borderland between them. Common work tasks are to create, search, refine, and mediate data, information, and knowledge. (Broberg, 2000) based on Drucker (1973) and Kidd (1994).

As system designers, we take it as our task to provide knowledge workers with cognitive, physical and virtual tools that make their tasks easier, more efficient, fun, and creative. This document describes our conception of the relationship between context and knowledge work, as well as our attempts to create tools for knowledge work in integrated physical-virtual environments.

Aspects on Context in Knowledge Work

What is context, and what is it that makes it relevant to modelling? A quite straightforward definition is that context is the the set of circumstances or events that form the environment where something takes place. There are many relevant aspects on context in a knowledge worker's situation. First, knowledge work takes place in a social, physical, and virtual context where data, information and knowledge entities are the work objects. Second, one and the same artefact can offer different kinds of support, and the social and physical context in which the artefact is used influences how individuals perceive the help or support that the artefact offers. Third, learning is a process strongly connected with knowledge work, and learning is contexts sensitive in many ways (Broberg, 2000). Fourth, knowledge can be viewed as something that individuals construct in a process of interaction with both the social and the physical context. Fifth, the information value for most information is changing all the time, in an information life cycle (Ingwersen, 1994). This fluctuation is caused partly by the time factor, and partly by variations in the individual's way of perceiving and interpreting the potential information in the current context.

A context model is an abstraction of circumstances and events that form the environment in which activities (e.g. knowledge work) take place and things are present. It is necessary with measurable (contextual) parameters in the creation of context models. Some examples of parameters for the use of objects in a knowledge work environment are:

- time-related
  - use frequency, use duration, creation and modification date
  - use sequence
    - temporal vicinity to the use of other objects (objects used before and after)
    - recurrence frequency of object use sequences
    - duration of object use sequences
- place-related
  - assigned location
  - with respect to semantically named places (containers) in the environment
  - Euclidian or topological vicinity to other objects
- object attribute-related
  - creator, textual content, weight, volume, colour etc.

Tools for Active Reading

Text is a medium for communication of ideas, concepts, knowledge, etc. Texts are traditionally, and for obvious technical reasons viewed as very static entities, with respect to both content and appearance. With computers and Internet, totally new conditions for texts as medium for communication are set up. It is very easy to make changes in computer-based texts both for readers and for authors, and the distribution of a new or different version of a text is quite easy. Hypertext exemplifies another feature that computers can add to the texts, the interaction. Hence, computer-mediated texts need not be as static as paper-mediated texts. Our hypothesis is that it is good for the outcome from the reading process if this old, static view of text changes so that texts are viewed as entities that are more dynamic. *TEXT-COL*, *FOCI*, and *CONTEXT* are three projects shortly described below. Common themes for these projects are the use of document-based modelling techniques for modelling context, the view of texts as dynamic entities, and the aim of supporting the readers to be more active in their reading.

TEXT-COL – is a tool designed to support the users with active reading (to interact with texts), by letting them work with the outlook of texts. *TEXT-COL* bases the grey coding of documents on information value files (IV-lexicon). An IV-lexicon is a data file containing information about a set of words. One of the strengths with the *TEXT-COL* tool is the high degree of control that the user has over the behaviour. For example, it is very much up to the user to select the strategy by which the words are categorised. Some examples of strategies for categorisation of words are: key words for an area, the origin of words, the length, random, etc. It is possible for a user of *TEXT-COL* to have a collection IV-lexicons. These IV-lexicons can model different areas of interest, different perspectives of an area of interest. It is also possible to use shared IV-lexicons such as IV-lexicons authorised by an organisation, a colleague, friend, etc. This feature gives the readers the possibility to easily walk between different readers' and persons' valuation of words, or to set the text into different contexts.

FOCI – the basic idea with this project is to create tools/ an environment that supports the user in developing and establishing foci as well as keeping the focus during the information seeking/learning process. One way to offer this support is by providing an environment for visualisation of corpora (information contexts). For example, it is possible to use the dominating dimensions of LSA created semantic spaces (Berry et al., 1994) to create visual representations of information contexts. It is natural to view such environment as an exploration environment for information landscapes. That makes it possible for the user to get an idea of the conceptual similarities among different resources, see a document's conceptual relevance to different foci, use it as a navigation tool, and to trace and predict changes or movements over time in an information landscape. Examples of such changes are: areas that merge or split, the emergence of new areas, the amount of activity in an area, etc.

CONTEXT – the basic idea is to create context-dependent representations of documents, folders, and windows by utilise the algorithms from *TEXT-COL* to produce/create image representations of documents, together with the algorithms from *FOCI* to produce spatial information for the documents. I.e. documents are placed according to conceptual similarity, were similar documents are placed close to each other and vice versa and document icons give an idea of documents' information value from one particular context.

As mention above both LSA&LSI models and IV/lexicons can be used to model area of interests, meta/information, or other kinds of information contexts, and shortly by combining these two more powerful models can be created and thereby new interesting applications can be created.

Designing Physical-Virtual Knowledge Work Environments

Seeing Wellner's DigitalDesk (1993) as a starting point, there has been a continuous interest in merging the physical and virtual worlds in office environments and in more specialised settings (Arias et al., 1997; Mackay et al., 1998). Other sources of inspiration to the work presented below have been the research done on Graspable (Fitzmaurice & Buxton, 1997), Tangible (Ishii & Ullmer, 1997) and Manipulative (Harrison & Dourish, 1996) user interfaces.

Although knowledge work activities often involve extensive use of the virtual environments that modern information technology provide, significant working time is spent on activities in the physical environment as well. However, knowledge work environments equipped with personal computers tend to create a significant gap between the virtual environment offered by the computer system(s) on the one hand, and the surrounding physical environment on the other (Pederson, 1999).

A PHYSICAL-VIRTUAL DESIGN PERSPECTIVE – In order to overcome this gap, a perspective for design and analysis of integrated physical-virtual environments is currently under development, based on analysis of differences and similarities between physical and virtual environments, such as Arias & Fischer (1997) and Pederson (1999). This physical-virtual design perspective emphasises a holistic view on the design of knowledge work environments and the objects within them, in order to break loose

from traditional distinctions made by designers of software, electronics hardware and architecture (Pederson, 1999). A core concept within this design perspective is the concept of Physical-Virtual Artefacts (PVAs), things that consist of both a physical and virtual representation, both tightly linked to each other. Changes done on any of the physical or virtual representation of a specific PVA is assumed to immediately change the state also of the other.

MAGIC TOUCH – Physical-virtual homomorphism is assured by a computer system, Magic Touch (Pederson, 2001), which recognises any alterations on PVA representations and consequently performs the appropriate update to the other representation (see Figure 1). Fully developed (it is still under development), this system will produce much of the object use data described earlier in this paper, ready to be used as a basis for user modelling.

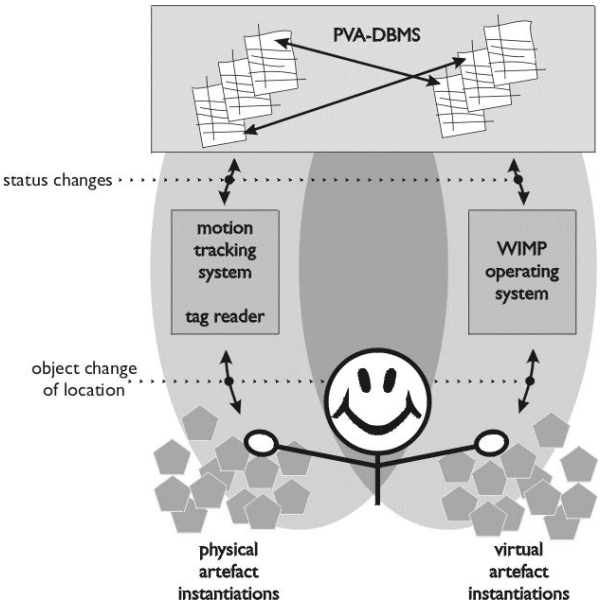

Figure 1: *Magic Touch architecture.*

Among the challenges for the physical-virtual design perspective we find:

- Automatic physical-virtual user modelling: In large a classical Artificial Intelligence problem, although integrated physical-virtual interaction gives new possibilities. A promising approach is to adopt a situative definition of "environment" (inspired by the work of Suchman (1987) allowing the system (and designer) to model knowledge work tasks that span over the physical-virtual gap.
- Painting the physical-virtual border: As a perspective encouraging designers to forget about the differences between physical and virtual environments, probably one of it's most important contributions is to give a clear picture of the border which it is trying to erase. What physical phenomena can't be virtualised? What virtual phenomena cannot be given a physical representation?
- The meaning of physical spaces: As indicated by empirical studies in office environments (Malone, 1983), and as a well-established fact in the area of architecture, much human activity is expressed by moving objects from one place to another. To acknowledge and interpret these "space semantics" (Harrison & Dourish, 1996) has to be part of the design perspective.

Possibilities for Improving Interaction using Context Awareness

Gathering and interpreting information about user activities in knowledge work environments has the potential to improve knowledge work environments in many ways. A few potential user modelling-based contributions could be:

- information/functionality filtering, allowing for minimalistic interaction styles using small interaction devices (small screens, few buttons), possibly wearable
- re-design of the working environment with respect to Euclidian, topological and temporal aspects to better suit most frequent or most time/space/cognition-intense tasks
- incitement for the creation of knowledge work tools that rationalise (compresses, compiles) recurring object use sequences by providing tool functionality applicable on all objects at the same time instant
- on-demand organisation suggestions where the system proposes suitable placement of new/altered objects based on their similarity with objects already existing in the environment

General questions to be addressed include:

- is it possible to merge a social context model, a physical context model and information context model into one model?
- is it possible to cover different levels of context in a model?
- is it relevant to discuss granuality of contexs and context models?

By attending the workshop we hope to come closer to answers to general questions such as the ones above as well as to learn about suitable methods for implementing context awareness algorithms in knowledge work tools and environments.

References

1. Arias, E., Eden, H., & Fischer, G. (1997). Enhancing Communication, Facilitating Shared Understanding, and Creating Better Artifacts by Integrating Physical and Computational Media. *Designing Interactive Systems (DIS 97): Processes, Practices, Methods and Techniques Conference Proceedings* . ACM Press.
2. Berry, M. W., & Dummais, S. T. (1994). *Using Linear Algebra for Intelligent Information Retrieval* (Technical CS-94-270). Knoxville: Computer Science Department, University of Tennessee.
3. Broberg, A. (2000) *Tools for Learners as Knowledge Workers* . PhD Thesis, UMINF-00.01, ISSN-0348-0542. Umeå University, Sweden.
4. Drucker, P. F. (1973) *Management: Tasks, Responsibility and Practices* . New York: Harper & Row.
5. Fitzmaurice, G.W., & Buxton, W. (1997) An Empirical Evaluation of Graspable User Interfaces: towards specialized, space-multiplexed input, in *Proceedings of CHI '97* , ACM Press, 43-50.
6. Harrison S., & Dourish, P. (1996) Re-Place-ing Space: The Roles of Place and Space in Collaborative Environments", in *Proc. ACM Conf. Computer-Supported Cooperative Work CSCW'96* , Boston, November 1996.
7. Ingwersen, P. (1994). Information and information science. In A. Kent (Ed.), *Encyclopedia of Library and Information Science* (Vol. 56,). New York: Marcel Dekker, Inc.
8. Ishii, H., and Ullmer, B. (1997) Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms, in *Proceedings of CHI'97* , ACM Press, 234-241.
9. Kidd, A. (1994) The Mark are on the Knowledge Worker, presented at The Human Factors in Computing Systems (CHI'94), Boston.
10. Mackay, W. E., Fayard, A.-L., Frobert, L., & Médini, L. (1998) Reinventing the Familiar: Exploring an Augmented Reality Design Space for Air Traffic Control, in *Proceedings of CHI'98* , ACM Press, 558-565.
11. Malone, T. W. (1983) How Do People Organize Their Desks? Implications for the Design of Office Information Systems. In *ACM Transactions on Office Information Systems*, Vol. 1, No. 1, January 1983, p99-112.
12. Pederson, T. (1999) Physical-Virtual instead of Physical or Virtual - Designing Artefacts for Future Knowledge Work Environments, in *Proceedings of the 8th International Conference on Human-Computer Interaction* , München 22-26th of August, Lawrence Erlbaum Associates. ISBN 0-8058-3392-7.
13. Pederson, T. (2001) Magic Touch: A Simple Object Location Tracking System Enabling the Development of Physical-Virtual Artefacts in Office Environments. Short paper for the Workshop on Situated Interaction in Ubiquitous Computing, ACM CHI2000. In *Journal of Personal Technologies* , issue 5/1, Feb 2001.
14. Suchman, L. (1987) *Plans and situated actions: the problem of human-machine communication* . Cambridge U.P., 1987.
15. Wellner, P. (1993) Interacting With Paper On the DigitalDesk, in *Communications of the ACM 36* , 7 (July 1993).